

## Autoregressive Vector (VAR) Method in Analyzing Inflation Persistence in Indonesia



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**ABSTRACT:** One of the most important economic variables is inflation. It is known that some changes in each major variable in the economy are caused by the rate of inflation, such as unemployment and future economic conditions. This is what makes inflation a variable that is often observed and tested, both theoretically and empirically. Economic development is said to run well if supported by stable inflation values, which will later serve to make the population more prosperous in the future. This research is a quantitative research using secondary data, namely inflation and CPI data from January 2018 to December 2022. Data obtained from Bank Indonesia and the Indonesian Central Bureau of Statistics. This study aims to see persistence in Indonesia and see the effect of CPI on inflation both in the long and short term. Where the model used in this study is using the VAR model of differential levels, because the data is not stationary at the level level. Determination of the optimal *lag* length is obtained from the lowest *Akaike Information Criterion* (AIC) value. The results of the analysis show that the persistence of inflation in Indonesia is fairly high. This is because the *lag* value in inflation is close to 1 or even more, which is 6.71. The high persistence of inflation is expected to cause *shocks* that affect the inflation rate in Indonesia. Then the length of time it takes for inflation to return to the *equilibrium* position is about 1 year and a half or 18 months. Furthermore, for the effect of inflation on CPI, in this case it has an influence in the long run, while for the short term influence is only influenced by its own variables.

**KEYWORDS:** Persistence, Inflation, *Autoregressive Vectors*

### INTRODUCTION

During the war between Russia and Ukraine in the second month of 2022, one of the economic impacts caused by the conflict on the world economy was soaring energy and commodity prices. This then adds to inflationary pressures in several countries around the world as a result of supply chain disruptions. It is undeniable that Russia is the third-largest producer of oil in the world, the second-largest natural gas producer, and the third-largest coal distributor. Meanwhile, Ukraine is no less important in fulfilling the world market as the fifth-largest distributor of wheat and the fourth-largest producer of corn in the world. Where these two countries are very important suppliers for deficit countries, such as in the Southeast Asian region. This is because more than 37% of oil and gas imports go to Southeast Asia. (Bakrie et al., 2022; Fuad Anshari et al., 2017).

Especially in the Southeast Asian region, countries such as Indonesia, Malaysia, the Philippines, and other countries that have the characteristics of a middle-income economy are very sensitive to the impact of external shocks such as those caused by rising oil prices and food prices (Khaliq, 2017). With the increase in food and oil prices, the Indonesian economy experienced inflation at that time of 4–5%. This value has exceeded the inflation target of 3+1% in 2022 based on data released by Bank Indonesia. Therefore, to control inflation, an action or policy is needed, such as launching optimal monetary policy (Michau, 2019; Pil et al., n.d.; Salunkhe & Patnaik, 2019). In addition, the need for optimal monetary policy is not only used to control inflation due to external shocks but also due to internal economic shocks (Khaliq, 2017). In this case, a country that can be said to be successful can be seen from the level of persistence of inflation. Persistence of inflation is a condition of the length of time it takes for inflation to return to the value of *equilibrium* when a shock occurs (Bems et al., 2021; Bilici, 2020; Two, 2021; Gil-Alana & Gupta, 2019; Isoardi, 2019; Jung, 2019). To ascertain the magnitude and source of persistence of inflation, it is important to know whether inflation has *backward-looking* elements or is determined by *forward-looking* pricing (Dua, 2021). Furthermore, to be able to prepare an optimal monetary policy strategy for a persistent inflation rate, a broader understanding is needed, starting from knowing the symptoms of inflation persistence itself, understanding the mechanisms and factors that cause the emergence of symptoms of inflation persistence, microactions that control persistence of inflation, and the effect of *trade-offs* between

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stable and elevated prices on persistence of inflation (Hakim et al., 2017).

Previous research has examined a lot of issues related to the persistence of inflation in a region or country. Where the results of the study some relate it to economic variables that are variables in measuring the level of persistence of inflation, such as exchange rate shocks (Bems, 2021; Dua, 2021), the way monetary policy is conducted (Bilici, 2020; Granville, 2019; Hakim et al., 2017; City & Lazaretou, 2011; Van Doorslaer & Vermeiren, 2021), differences in regional layout (Gajewski, 2018), due to exchange rate regimes (Caporale & Gil-Alana, 2020; Wu, 2018), goods and services inflation (Boaretto, 2019), oil price shocks (Oloko, 2021; Salunkhe & Patnaik, 2019), agricultural output in GDP (Duran, 2021), increased taxation progressivity (Geronikolaou et al., 2020), agricultural commodity prices (Tule et al., 2020), and unemployment rate (Albulescu & Tiwari, 2018; Alogoskoufis, 2018; Ashley, 2020). Meanwhile, in this study, researchers will later use the Consumer Price Index (CPI) as a variable to see the level of persistence of inflation that occurs in Indonesia. As we know, the Consumer Price Index (CPI) is one of the economic indicators used to measure the rate of price change and whether there will be inflation or deflation at the consumer level. With changes in people's consumption patterns, starting January 2020, inflation measurement in Indonesia uses CPI for the base year (2018 = 100) compared to CPI 2012 = 100, which is specifically in terms of coverage, commodity grouping classification, CPI calculation methodology, and hegram weight. The changes are based on the Cost of Living Survey (SBH) conducted by the Indonesian Central Bureau of Statistics in 2018 as one of the main basic ingredients in calculating the CPI.

There are several models or approaches used to test the persistence of inflation. Among them is research conducted by Ida (2020) in Japan using a new Keynesian (NK) theory approach with the persistence of sectoral inflation. However, this Keynesian model is often criticized for producing incorrect predictions of the New Philips Keynesian Curve (NKPC). Meanwhile, hybrid NKPCs that combine lagging inflation are considered one solution to this problem (IDA, 2020). Furthermore, previous researchers have examined the role of inflation, which lags behind in the NKPC, in determining optimal macroeconomic policy. Meanwhile, some researchers, such as Jain (2019; Oloko et al., 2021), also argue the importance of sectoral heterogeneity in inflation persistence. Whereas, research conducted by Tetlow (2019) mostly analyzed its inflation persistence using a Bayesian approach, meaning that policymakers are assumed to have well-identified prior beliefs regarding the possible value of its parameters. Sementara, in this study, will later use the approach of the classical theory of inflation, namely *structuralist theory*, which argues that inflation occurs due to imbalances in the economy. This theory refers to phenomena that occur in countries in the South American region. This approach states that structural factors in the economy are the cause of inflation, especially in developing countries. According to Boediono (1998) in Juliardi & Satria (2019), this theory is commonly referred to as the long-term theory. This is because inflation is associated with structural factors in the economy that change slowly and continuously. According to this theory, the cause of inflation is the structure of the economy, which is less accurate in predicting economic development. This theory suggests that inflation is not only a monetary symptom but also a structural symptom. Such symptoms, such as crop failure due to external factors such as weather or natural disasters, or matters related to foreign countries such as production rigidity, foreign exchange rates, and foreign debt, can cause price instability in the domestic market. Due to these structural causes, the proliferation of goods becomes less rapid than the needs of society. As a result, the supply becomes less than the amount needed by society, so the price of goods and services increases.

As is well known, inflation must be controlled properly in the sense that it is neither too low nor too high. Thus, this study aims to analyze the persistence of inflation in Indonesia by looking at the Consumer Price Index (CPI) as an indicator used to measure the inflation rate. This is because changes in the Consumer Price Index (CPI) over time describe the rate of increase (inflation) or decline (deflation) of goods and services. Previous research using the Consumer Price Index (CPI) as one component in measuring the level of persistence in India (Dua, 2021) and in some developed and developing countries (Bems et al., 2021) showed that consumer price responses to trade exchange rate shocks have a significant and persistent effect on consumer price inflation when expectations are poorly met. In addition to looking at the level of inflation persistence in Indonesia, this study also aims to see the effect of CPI on inflation both in the long and short term.

## RESEARCH METHODS

The initial stage in this analysis method is to test the condition of variable stationarity. Testing the stationarity level of the variable by comparing the *augmented Dickey-Fuller* value with the error value (0.05). Then, if the data is not stationary, then differential is carried out, so that stationary is fulfilled by stationary *differencing*. Next, determine the *value of the Akaike Information Criterion (AIC)* against some *work* that has been done. The determination of the VAR order will be based on the smallest AIC value from several *lags* that have been done before. The next step is the *Impulse Response Function (IRF)* test. This VAR model has previously been widely used by previous researchers in analyzing inflation persistence, such as research conducted by Dua (2021) in India, Tule et al. (2020) in Nigeria, Duran (2021) in Turkey, and Salunkhe & Patnaik (2019) in India, while research conducted by

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Oloko (2021) related to the persistence of inflation in the top 10 oil exporting and importing countries.

Before discussing further related to the VAR or *Autoregressive Vector* model that will be used in this study, we must first know whether the data we have is stationary or not. A stationarity test must be performed to find out whether the data is stationary or not. This test can be recognized using the *Augmented Dickey Fuller* (ADF) test. This test will determine whether the model contains the root unit or not. Another way to look at the root unit is with a stationary test. This is due to the fact that the main purpose of this test is to determine whether a particular *predictive autoregressive* model has a value of 1 or not. ADF calculations can be used to calculate test statistics for stationary tests. The ADF test can be done using the following steps:

1. If there is a root unit, then the data is not stationary ( $H_0 : \rho = 1$ )
2. If there is no root unit, then the data is stationary ( $H_1 : |\rho| < 1$ )

Furthermore, if the data is stationary, then the VAR model is ready for use. In general, the Vector Autoregressive (VAR) model can be formulated as follows:

$$Y_t = B_j + \sum_{i=1}^p Y_{ji} Y_{1t} - i \sum_{i=1}^p P_{\tau_i} Y_{\tau, t-p} + e_{jt} \dots \dots \dots (1)$$

- T = Timeframe required
- T = Number of variables studied
- B<sub>j</sub> = Entity for variable j
- p = Amount of lag, with i:1,2,3 ..... p
- Y<sub>ji</sub> = Standard value on variable 1 i-th inertia
- P<sub>ti</sub> = Standard value on the i-th inertial variable T
- E<sub>jt</sub> = Difference between the observation value and the predicted value at the t-th time

After the VAR test is carried out, the optimal *lag* length has been determined. Lag checking is used to determine the optimal *lag* length to be used in future analyses and will find parameter estimates for the Vector Autoregressive (VAR) model. The best model is the one with the smallest *Akaike Information Criterion* (AIC) value. The criteria are formulated as follows:

$$AIC(k) = T \ln \left( \frac{SSR(k)}{T} \right) + 2n \dots \dots \dots (2)$$

Where:

- T = Number of variables
- k = Lag length
- SSR = Number of residual
- n = Number of data periods used

It then performs an *Impulse Response Function* (IRF) to describe how *shock* the variable receives, both from the variable itself and other variables. In addition, the IRF test aims to see how long the *shock* received by a variable (Febrianti et al., 2021). The IRF formula is as follows:

$$IRF(h) = r^h \dots \dots \dots (3)$$

With:

- r = Parameter matrix of the VAR model
- h = Estimated period

## RESULTS AND DISCUSSION

In this study, stationarity testing was carried out using the *Augmented Dickey Fuller* (ADF) method. The results showed that inflation and CPI data are not stationary at the level because the probability is above 0.05, the following stationary test results can be seen in the table below:

**Table 1. Inflation Data Level Stationary Test Results**

	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	0.241967	0.9731
<b>Test critical values:</b>		
1% level	-3.546099	
5% level	-2.911730	
10% level	-2.593551	

\*MacKinnon (1996) one-sided p-values.

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Table 2. Results of Stationary Rate Data CPI

	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-1.391134</b>	<b>0.5807</b>
Test critical values: 1% level	-3.546099	
5% level	-2.911730	
10% level	-2.593551	

\*MacKinnon (1996) one-sided p-values.

Because inflation and CPI data are not stationary at the level level, *differencing* is carried out at the first level (1<sup>st</sup> Defference) and a probability result below 0.05 is obtained. Here are the test results in table form:

Table 3. Stationary Test Results Level 1<sup>st</sup> Defference Inflation Data

	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-6.536129</b>	<b>0.0000</b>
Test critical values: 1% level	-3.548208	
5% level	-2.912631	
10% level	-2.594027	

\*MacKinnon (1996) one-sided p-values

Table 4. Stasional Test Results Level 1<sup>st</sup> Defference Data IHK

	t-Statistic	Prob.*
<b>Augmented Dickey-Fuller test statistic</b>	<b>-7.650626</b>	<b>0.0000</b>
Test critical values: 1% level	-3.548208	
5% level	-2.912631	
10% level	-2.594027	

\*MacKinnon (1996) one-sided p-values.

After stationary testing, the next step is to perform an optimal *lag* test . The optimal lag length used in this study was from lag value 1 to *lag* 5. Based on the tests that have been done, the following results are obtained:

Table 5. Optimum Lag Test Results

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-176.7340	NA*	2.570322*	6.619777*	6.693443*	6.648187*
1	-175.3704	2.575650	2.834589	6.717422	6.938420	6.802653
2	-174.5491	1.490589	3.191401	6.835150	7.203481	6.977201
3	-169.9845	7.945741	3.131211	6.814240	7.329903	7.013111
4	-165.3050	7.799203	3.063617	6.789073	7.452067	7.044764
5	-164.8078	0.791822	3.506476	6.918806	7.729133	7.231317

Based on Table 5, the criteria that indicate the optimum lag is lag 1 which has the minimum *Akaike Information Criterion* (AIC) value or the lowest value of 6.71. Where, theoretically the persistence of inflation is said to be high if the inflation value is determined by its lag value with its coefficient will be close to number one (1). In this study to determine the lag of inflation used AIC and obtained the smallest value of 6.71, where this figure has been more than number 1. So it can be said that the persistence of inflation in Indonesia is high. Furthermore, to see how quickly inflation returns to the equilibrium point or equilibrium, it can be seen from the response of inflation in responding to shocks or shocks due to external and internal factors. In this case, the inflation response in this study will be seen in the next test.

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After obtaining the smallest AIC value, the next step is to estimate the *Vector Autoregressive* (VAR) model, and the following results are obtained:

**Table 5. VAR Model Estimation Results**

	D(INFLASI)	D(IHK)
D(INFLASI(-1))	0.145168 (0.13301) [ 1.09139]	1.979322 (1.91856) [ 1.03167]
D(IHK(-1))	-0.008328 (0.00929) [-0.89615]	-0.034026 (0.13404) [-0.25386]
C	0.032002 (0.04275) [ 0.74865]	-0.407937 (0.61658) [-0.66161]

After obtaining the results of the VAR model estimation, it is then necessary to test the stability of VAR to conduct further analysis. The VAR model is declared stable if the root has a modulus value of less than 1 (one). As for this study, it was found that the VAR model is stable, because the root test results have a modulus value of less than 1 (one). The following can be seen in the table below:

**Table 6. VAR**

Root	Modulus
0.055571 - 0.091952i	0.107440
0.055571 + 0.091952i	0.107440

Because the data has stabilized at the VAR level, then conduct a Cointegration test to find out whether there will be a balance in the long run, namely there is an equation of movement and stability of relationships between variables in this study or not. Where the cointegration test is carried out using *Johansen's Cointegration Test* method. If there is a probability value of  $< 0.05$ , it means that there is a cointegration equation which means it has a long-term equilibrium. As for this study, the following results were obtained:

**Table 6. VAR Stability Test Results**

Unrestricted Cointegration Rank Test (Trace)

Hypothesized	No. of	Trace Statistic	0.05	
CE(s)	Eigenvalue		Critical Value	Prob.**
None *	0.351702	40.53641	15.49471	0.0000
At most 1 *	0.242522	15.83238	3.841465	0.0001

Trace test indicates 2 cointegrating eqn(s) at the 0.05 level

When viewed from the results of data analysis in table 6, it can be seen that there is a correlation which means that inflation and CPI data have similar movements in the long run, because they have a probability value of  $< 0.05$ . Furthermore, because the researchers' data is stationary at the *level of differencing* at the first level (1<sup>st</sup> Defference), the model we use uses VECM and obtained the following results:

**Table 7. Long-Term VECM Test Results**

Cointegrating Eq:	CointEq1
D(INFLASI(-1))	1.000000
D(IHK(-1))	-0.277876 (0.05234) [-5.30881]
C	-0.134039

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It is known that the results of the VECM test in the long term have a calculated t value of 5.30. When compared with the table T which is 2.001717, then the calculated t value is greater than the table T value. This shows that inflation has an effect on CPI in the long run. Previously, minus in t count did not indicate the amount, but rather the direction of the relationship. Because this study only looks at the influence, not the direction of the relationship. Meanwhile, when viewed from short-term influences, the results of the analysis can be seen as follows:

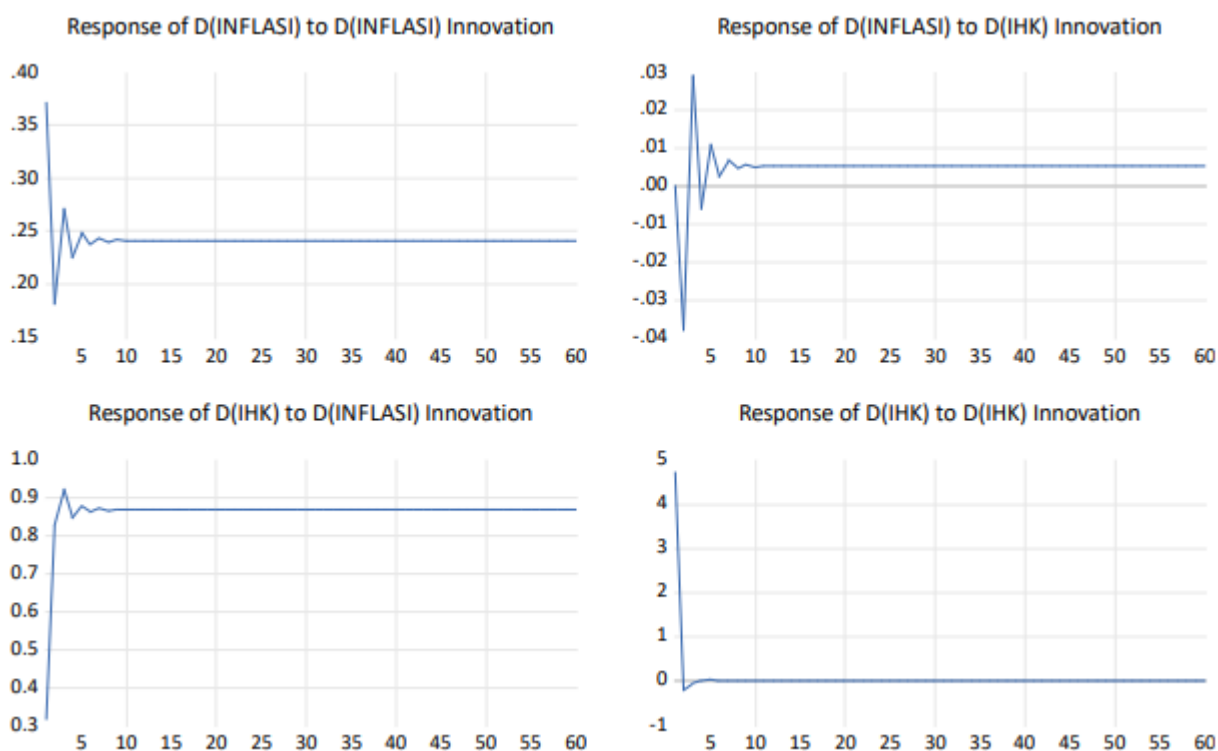
**Table 8. Short-Term VECM Test Results**

Error Correction:	D(INFLASI,2)	D(IHK,2)
CointEq1	-0.006534 (0.05490) [-0.11901]	3.732052 (0.69881) [ 5.34059]
D(INFLASI(-1),2)	-0.495611 (0.12526) [-3.95670]	-1.463768 (1.59430) [-0.91813]
D(IHK(-1),2)	-0.009868 (0.01057) [-0.93327]	-0.005191 (0.13458) [-0.03858]
C	-0.004213 (0.04918) [-0.08566]	0.002247 (0.62601) [ 0.00359]

As for when viewed from its effect in the short term, inflation on inflation affects itself, because the calculated t value is greater than the table T. While inflation against CPI, CPI against inflation, and CPI against CPI do not affect each other in the short term, because the calculated t value is smaller than the table T value.

To see the *shock* response of the inflation rate to the Consumer Price Index (CPI), it is necessary to estimate the *impulse response* function. The impulse response image will show the response of one variable due to the shock of other variables up to several periods after the *shock*. If the *impulse response* image shows a movement that is getting closer to the *equilibrium* point or returning to the previous equilibrium, it means that the response of a variable due to a shock will disappear over time so that the shock does not leave a constant influence against those variables. The following are the results of the estimated impulse response that researchers have done regarding the persistence of inflation against CPI and vice versa:

### Response to Cholesky One S.D. (d.f. adjusted) Innovations

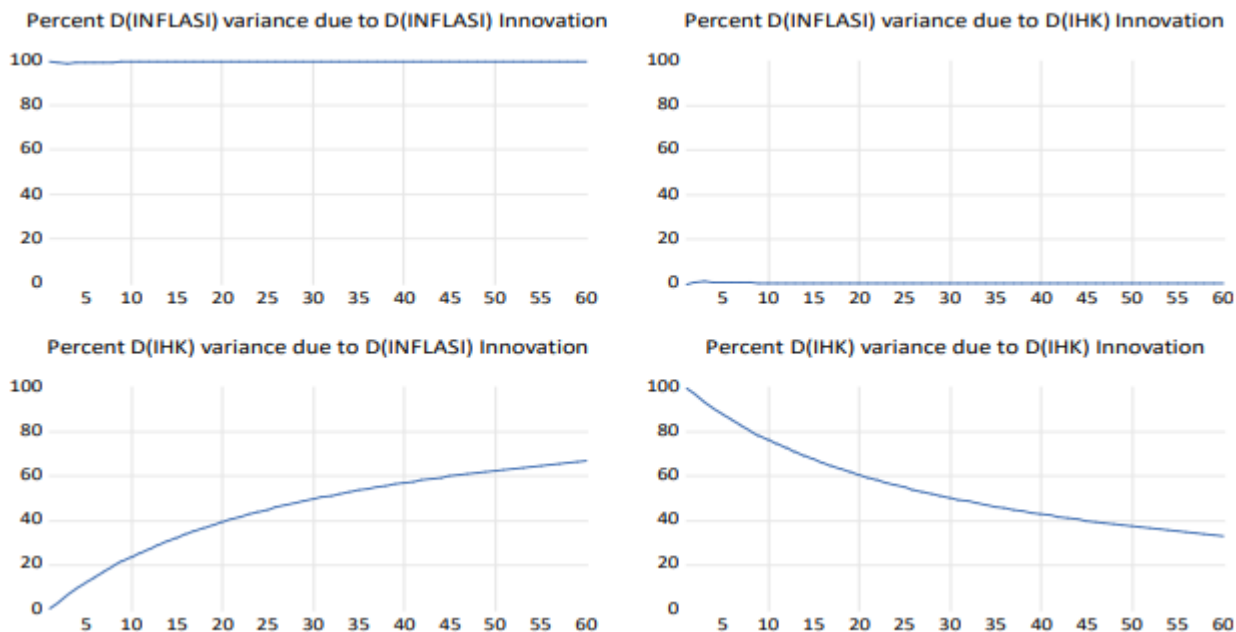


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In the 18-month period, from 2018 to the middle of 2019, the inflation response to itself fluctuated as well as the inflation response to CPI, after which it began to stabilize until December 2022. This means that the more periods of data used, the more stable the response. Thus, it can be seen that to achieve a stable value it takes 18 months in responding to *shocks* or shocks caused by external and internal factors.

Furthermore, a *forecast error decomposition of variance* was carried out. Where variance *decomposition decomposes* the variation of one endogenous variable in the shock component of another endogenous variable in the VAR system. This variance decomposition describes the proportion of movement of a series due to the shock of the variable itself compared to the shock of another variable. The results of *the forecast error decomposition of variance* in this research data are as follows:

### Variance Decomposition using Cholesky (d.f. adjusted) Factors



If You look at the results of the analysis, it is greater the influence of inflation on itself than the influence of inflation on CPI. Meanwhile, the influence of CPI on inflation from the early period of 2018 to 2022 has increased, while the influence of CPI on itself has increased. This suggests that the persistence of structural inflation studied using the VAR model suggests that the CPI inflation response varies over time, with variations observed due to its own shocks and shocks from other variables.

## CONCLUSION

Based on the research that has been done, several conclusions have been drawn, including: first, the persistence of inflation in Indonesia can be said to be high. This can be seen from the optimal lag value obtained from the lowest *Akaike Information Criterion* (AIC) value close to number 1 (one) or even more, which is 6.71. The high persistence of inflation can be seen from the period of time it takes inflation to return to its equilibrium point,

Which is about one and a half years, or 18 months. Second, based on the VAR model of the *differential* level using the VECM test, it is known that inflation against CPI has an effect when viewed in the long term because it has a calculated t value greater than the table T value. In the short run, inflation against CPI or vice versa has no effect, which only affects inflation in the short run, namely the variable itself.

The results of this study are expected to be able to provide recommendations on the need for cooperation between the government, Bank Indonesia, and other institutions in controlling prices to be stable. This is because price stability is determined by demand and supply. Thus, what has been planned will be achieved if the cooperation is carried out in the form of carrying out each task according to its role. In this case, the government regulates prices in the field of supply while Bank Indonesia regulates prices in the field of demand. In the field of supply, the government can provide various programs and stimuli for business actors to produce quality goods. Meanwhile, in terms of demand, Bank Indonesia, through interest rates, can control individual behavior in negotiation activities. Moreover, it is known that during the research period conducted by researchers, namely from 2018 to 2022, there have been many phenomena that have occurred in Indonesia, ranging from *shocks* caused by nature around the third quarter of 2018 when there were earthquakes in several regions in Indonesia, continuing with the end of 2019 and the beginning

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of 2020. Affected by the COVID-19 outbreak, and in 2021, Indonesia made a recovery in its economy. Especially in the midst of improving the economy, there were external shocks caused by the Russia-Ukraine war, which caused world oil prices to increase, so that the Indonesian government at that time inevitably increased fuel prices. Therefore, in dealing with this, good cooperation between the government, Bank Indonesia, and other institutions is needed.

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