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Price Prediction of Staples with Simultaneous Fourier Series Estimator as a Contribution to Solve the National Food Problem

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Abstract: *This study provides an overview related to the prediction of prices for staples that are widely consumed by the Indonesian people and often experience price fluctuations at certain times, namely cooking oil, chili, and chicken eggs. Based on the Market Monitoring System and Staples of the Ministry of Trade, the national average price of cooking oil as of January 3, 2022, reached USD 1.17 per liter. The average price of chicken eggs reached USD 1,98 per kilogram, an increase of 20.16% at the same time. In addition, based on the National Strategic Food Price Information Center, the average price of chili in traditional markets throughout the province rose by USD 0.19 or about 3.16% and reached USD 6.29 per kilogram. The prediction of staple food prices in this study was formed using a nonparametric regression model of the Fourier series estimator. This regression model has high flexibility in forming the model and estimating the fluctuation data pattern, which is not known in the form of time-series data. The data in this study is sourced from the National Strategic Food Price Information Center website with the response variables used being the daily prices of cooking oil, chicken eggs, and chili from September 1, 2021, to December 31, 2021, as training data. In addition, the same commodity data from January 1, 2022, to January 10, 2022, is used as testing data. The best model from the estimation results with the Fourier series is a model with an oscillation parameter of 25 which contains a sine cosine basis with a coefficient of determination of 83.05% and an MSE value of 1.628. The selected model also has a very good performance predicting the prices of the three staples with a MAPE value of 1.082%.*

Keywords: Fourier series, Staples, Cooking oil, Chili, Chicken eggs, Price prediction, Time series

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1. Introduction

In this modern era, humans have various levels of needs, one of which is staples. Staples are the main needs or so-called primary needs, namely, human needs that cannot be postponed. Humans have three staples, namely the need for clothing, food, and shelter. Indonesia is an agricultural country that has the potential for the availability of very large food diversity.

Therefore, staple food has the potential to increase market demand in both local, regional, and export markets. Staples are one of the important issues in the design and strategy of sustainable development through the Sustainable Development Goals (SDGs) agenda. The SDGs are designed using three pillars and are detailed with 17 goals to be achieved. One of the goal indicators in the SDGs described in the first point is the reduction of the poverty rate in the poorest areas of Indonesia (No Poverty) (Indonesia, 2017). As a poverty alleviation policy, the government needs to pay attention to macroeconomic stability, namely controlling growth and inflation, especially the prices of staples. In addition, decent work and economic growth is the eighth point of the SDGs, which is one of the indicators of the 17 sustainable development goals. The goal of sustainable development in point eight is to improve people's welfare and increase economic growth, one of which is through efforts to maintain domestic price stability and international competitiveness as well as increase economic productivity. One of the pieces of information that is often the subject of discussion in Indonesian society is related to the price of staples.

Prices of staples have a considerable influence on the stability of the Indonesian economy. According to the Director-General of Domestic Trade, Ministry of Trade, Oke Nurwan, in general, prices for staples are relatively stable. However, three commodities increased significantly compared to the previous month. Those commodities were bulk and packaged cooking oil, chili peppers, and chicken eggs (Indonesia, 2022a). Cooking oil, chili, and chicken eggs are the three products that are most often consumed by the Indonesian people and they often experience price fluctuations at certain times.

The fluctuations in commodity prices were triggered by reduced supply and decreased production in several areas. Prolonged and irregular fluctuations can result in a trader's risk of greater losses and uncertain profits. In addition, the unstable amount of expenditure and household income that needs to be reduced have resulted in the disruption of household economic stability. These price fluctuations often cause problems from the household level to national inflation problems that can disrupt economic stability. Fluctuations in food commodity prices have a very close relationship with rising inflation. Inflation that occurs makes it difficult to determine the price of staples; the price set can be too large or too small (Faradilla et al., 2021). Based on data from the Central Statistics Agency on its official website, the highest inflation occurred in 2017 at 3.61%, and the lowest inflation occurred in 2020 at 1.68% (Statistics, 2022). The increase in the price of staples in Indonesia affects inflation. It is recorded that in the last five years (2017-2021), the inflation rate in Indonesia tended to fluctuate. The cause of the high inflation in 2017 was the increase in the price of staples. Some of the staples that experienced inflation were red chilies, broiler meat, broiler eggs, fresh fish, and rice. In 2021, cooking oil will contribute to general inflation of 0.31% (Statistics, 2022).

According to the Leader of the Food Security Agency, Sarwo Edhy, explaining that the occurrence of fluctuations in food prices made his party intervene to maintain price stability and food supply measurably, among others, through balance calculation instruments and national strategic food price predictions to estimate the balance and food prices per month (Indonesia, 2022b). Based on these reasons and descriptions, it is important to know the prediction of prices for staples in the future to maintain economic stability so that the government can provide credible and significant information to the public. The prediction of staple food prices in this study was formed using a nonparametric regression model of the Fourier series estimator. This regression model has high flexibility in forming the model and estimating the fluctuation data pattern, which is not known in the form of time-series data. Previous research was limited to predicting the price of staples using the ARIMA time series method and parametric regression models. There has been no previous research that focuses on predicting the price of staples on three main commodities consumed by the Indonesian people, namely cooking oil, chicken eggs, and chili. The issues discussed in this study are problems that are very close to the community every day, so it is expected to be able to provide recommendations for the Indonesian government in formulating appropriate economic policies.

2. Literature Review

The following section is a collection of literature that provides reviews on staples and the prices of staples in Indonesia, as well as statistical theories regarding the Fourier series method used in this research.

2.1 Staples

Staples are very important human survival needs, including individual consumption needs such as food, shelter, and clothing (Nelson, 2009). These three types of staples are the main needs that cannot be abandoned. Food needs are a source of food for humans, which plays an important role in human life. According to the website of the National Strategic Food Price Information Center (PIHPS), Indonesian people support their daily lives with their main food needs, namely rice, meat, chicken eggs, onions, chilies, cooking oil, and sugar (Center, 2022). The provision of these basic commodities is mandatory and freely available in traditional markets so that they can be easily accessed by the public. The staples that are the focus of this research are stapled commodities that are consumed by many Indonesian people, namely cooking oil, chicken eggs, and chili.

2.2 Prices of Staples

The price of staples has been a crucial factor in determining food security and poverty levels worldwide. The fluctuation of staple prices can have a significant impact on household income, especially in low-income countries where people often spend a large proportion of their income on food. In general, prices are formed because of the interaction between supply and demand. If supply is high and demand is low, prices will fall. On the other hand, if supply is low and demand is high, prices will rise. However, this concept is slightly different from staples, especially for agricultural products. Staples are very important for life, so that the demand for staples tends to be stable (inelastic) to price changes (Rasyidi, 2017). This causes the price of staples to be very volatile when there is a change in supply.

2.3 Fourier Series Estimator

Fourier series is a trigonometric polynomial function that has a very high level of flexibility to deal with data that has repeating patterns. The Fourier series estimator is generally used if the data used after investigating the pattern is unknown and there is a tendency to repeat (Folland, 2009). This is because the Fourier series is a curve that shows the sine cosine function (Prahutama, 2013). For example, with observational data (t_r, y_r) that follows the regression model:

$$y_r = m(t_r) + \varepsilon_r; \quad \varepsilon_r \sim IID\ (0, \sigma^2) \tag{1}$$

With:

$r = 1,2, \dots, n$

The form of the regression function $m(t_r)$ in equation (1) is unknown and will be estimated using a Fourier series estimator approach. $m(t_r)$ can be expressed as follows:

$$\widehat{m}(t_r) = \hat{\gamma}_0 + \sum_{j=1}^{k} \left[\hat{\alpha}_j \cos\left(\frac{2\pi j(r-1)}{n}\right) + \hat{\beta}_j \sin\left(\frac{2\pi j(r-1)}{n}\right) \right] \tag{2}$$

With:

$\hat{\gamma}_0$: Constant value
$\hat{\alpha}_j$ and $\hat{\beta}_j$: Parameter of the *j*-th regression coefficient which has a scalar value
k : Positive integer that represents the value of the oscillation parameter

2.4 Best Model Indicator

In nonparametric regression with the Fourier series estimator, it is important to determine the optimal k value to obtain the best model. The optimal k value was chosen based on the Generalized Cross-Validation (GCV), which is the minimum GCV (Mardianto et al., 2020).

After determining the best model based on GCV and considering the parsimony model, another important indicator to look at is the value of the coefficient of determination or R2 which represents the contribution of the predictor variable to the response variable. A good model is a model that has a high R2 value. The quality of the model is also determined by the value of the Mean Square Error (MSE), which has the smallest MSE value (Faraway, 2016). These three indicators are criteria that can be used to get the best model so that it can be continued to hold predictions.

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2.5 Mean Absolute Percentage Error (MAPE)

The best predictive model is a model with good accuracy. The accuracy value is measured through the difference between the observed and predicted values which is known as the error value. Mean Absolute Percentage Error (MAPE) is a measure of relative error that states the percentage of error forecasting results to the observed value. Mathematically the calculation of the MAPE value is based on equation (3) (Chang, 2007).

$$MAPE = \frac{1}{n}\sum_{t=1}^{n}\left(\frac{|Y_t - \hat{Y}_t|}{Y_t} \times 100\%\right) \quad (3)$$

Where Y_t is the observation data in period t, $\hat{Y}_t$ is the forecast value in period t, and n is the number of forecasting periods. The categorization of MAPE values is presented in Table 1 below.

Table 1. MAPE Criteria

MAPE	Definition
$MAPE < 10\%$	Very good forecasting ability
$10\% < MAPE < 20\%$	Good forecasting ability
$20\% < MAPE < 50\%$	Sufficient forecasting ability
$MAPE$ 50%	Poor forecasting ability

Source: Arnaud et al., 2016

3. Methods and Data

The scope of this research study is a quantitative method with the use of advanced and new statistical modeling in nonparametric regression for simultaneous or multiresponse cases with a Fourier series estimator.

3.1 Data

In this study, the data used to conduct the analysis is secondary data obtained from the official website of the National Strategy for Food Price Information Center of the Ministry of Trade of the Republic of Indonesia. Secondary data has been collected by data collection agencies and published to the user community (Activities, 2013). The data taken is related to the daily prices of cooking oil, chicken eggs, and chili as of September 1, 2021, to December 31, 2021, as training data. In addition, the same commodity data from January 1, 2022, to January 10, 2022, is used as testing data.

Based on the Market Monitoring System and Staples of the Ministry of Trade, the national average price of bulk cooking oil as of February 7, 2022, reached USD 1.12 per liter and decreased by 1.16% compared to the previous month, while the average price of oil packaged fried foods nationally reached USD 1.10, a decrease of 1.17% compared to the previous month (Indonesia, 2022a). On 18 January 2022, the Indonesian Palm Oil Associations (IPOA) explained that the price of CPO had reached USD 0.97 per kg, which is the highest so far in mid-January 2022 (Association, 2022). However, as of February 1, 2022, the price of cooking oil fell again. This was due to the Ministry of Trade implementing the Domestic Market Obligation (DMO) and Domestic Price Obligation (DPO) policies.

The average price of purebred chicken eggs, according to the Market Monitoring System and Staples of the Ministry of Trade as of February 7, 2022, reached USD 1.64 per kilogram, down 0.79% compared to the previous month. Based on data sourced from the Food Task Force of the Republic of Indonesia Police in 2021, the number of broiler egg production increased at the end of 2021, which is 447,587 tons (Indonesia, 2022b). This is one of the factors in the decline in the price of broiler eggs in early 2022. In addition, based on the National Strategic Food Price Information Center, the average price of chili in traditional markets throughout the province rose by USD 0.17 or around 5.06% and reached USD 3.41 per kilogram (Center, 2022). The average price of chili, which has increased at the end of the year and the beginning of the year, is something that often happens in one year of the growing season. The price increase was caused by several factors, including extreme rainfall that has continued since the beginning of November 2021, resulting in reduced farmer yields; in other words, production is not optimal, resulting in a decrease in supply which has an impact on surplus and minus conditions nationally. During the last five years, namely 2017-2021, the national chili production rate, especially the production of chili and large chili, has always increased by around 3% - 7% per year. However, due to various factors, the price of this food commodity also often fluctuates.

3.2 Research Variables

Research variables are attributes of a person or object that have variations from one another (Kerri, 2016). The variables in this study consisted of predictor variables and response variables (Table 2). The predictor variable used is the daily time expressed by t, which is the same commodity data from January 1, 2022, to January 10, 2022. In contrast, the response variable used is the daily price of cooking oil, chicken eggs, and chili from September 1, 2021, until December 31, 2021.

Table 2. Research Variables

Variable Type	Information	Scale
Independent	Time	Ratio
Dependent	Cooking oil price	Ratio
	Chicken egg price	Ratio
	Chili price	Ratio

Source: Authors' Compilation

3.3 Analysis Procedure

The steps of analysis in this research are as follows:

1. Conduct descriptive statistical analysis to find out the description of the data used.

2. Perform analysis using a nonparametric regression approach to the Fourier series estimator:
   a. Define daily time data (t) as a predictor variable (X) and daily data on staples per September 1, 2021, to December 31, 2021, as a response variable with details on prices of cooking oil (Y_1), chicken eggs (Y_2), and chili (Y_3).
   b. Divide the data into 2 parts, namely training data and testing data.
   c. Determining the optimum k value based on training data using the GCV method, in which the GCV value must be minimum.
   d. Compare the oscillation parameters and the best trigonometric functions to be used in the model.
   e. Calculating the value of R2 from the model estimation results.
   f. Predicting the price of staples using the best model that has been obtained.
   g. Calculates the MAPE value from the predicted results.

4. Results and Discussion

Indonesia is a developing country with a large population, and its economy is heavily dependent on agriculture. This dependence on agriculture makes Indonesia particularly vulnerable to fluctuations in staple prices, as the supply of these goods is heavily influenced by weather patterns, which can be unpredictable. Furthermore, Indonesia is a net importer of some staple goods, such as cooking oil, which can be subject to price fluctuations on the international market.
The price of staples has significant economic impacts in Indonesia. For instance, high prices for cooking oil can increase the cost of food production, which can lead to higher prices for consumers. This can have a ripple effect throughout the economy, as higher prices for staples can reduce consumer purchasing power, leading to decreased demand for other goods and services. Additionally, high prices for staples can reduce the competitiveness of Indonesian goods on the international market, which can lead to decreased exports and decreased economic growth (Purwanto & Jati, 2020).

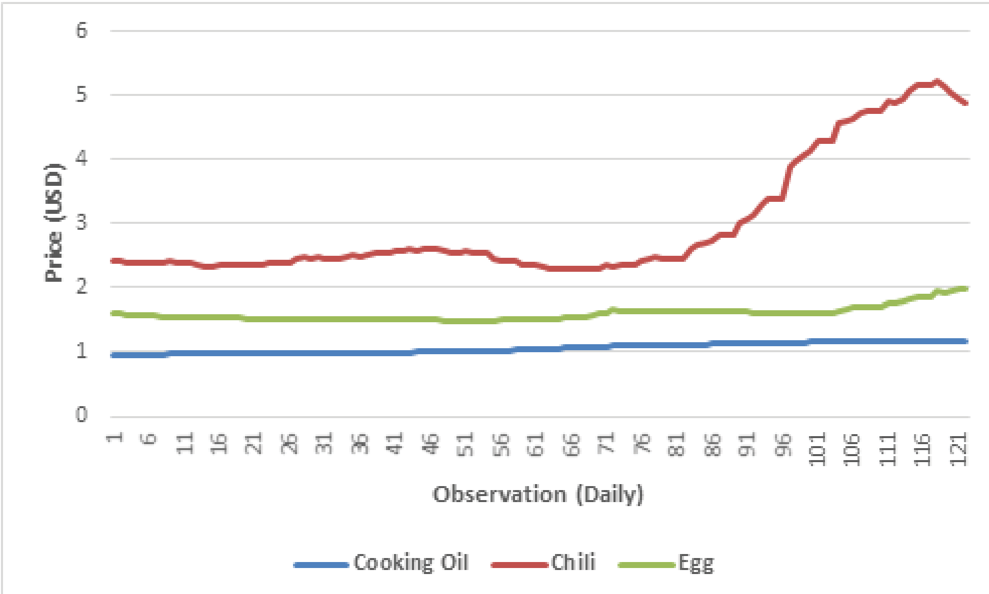
The price of staples also has significant societal impacts in Indonesia. High prices for staple goods can lead to food insecurity, as low-income families may struggle to afford enough food to meet their basic needs. Additionally, high prices for cooking oil can make it difficult for small-scale food producers to compete with larger producers, leading to decreased economic opportunities for these producers (Suhud & Arief, 2018).

Despite the challenges of predicting staple prices, it is possible to make some predictions about the future prices of cooking oil, chili, and eggs in Indonesia. The scope of this research study is a quantitative method with the use of advanced and new statistical modeling in nonparametric regression for simultaneous or multiresponse cases with a Fourier series estimator.

4.1 Descriptive Statistics

In general, fluctuations related to national commodity prices during the COVID-19 pandemic were still under control, and some fluctuations in commodity prices were stable. Price fluctuations for agricultural commodities and the national staple industry are cooking oil, and national strategic commodities in the livestock sector are chicken eggs and chili peppers for horticultural crops. The unstable price of cooking oil per liter indicates an upward trend in prices in the mid to late period of observation. The price of cooking oil per liter ranges from USD 0.96 to USD 1.18, with a fluctuating range of USD 0.22. The price of chili per kg ranges from USD 2.42 to USD 4.89, with a high fluctuation range of USD 2.47. The price of chicken eggs per kg is unstable between USD 1.60 to USD 1.98, with a fluctuation range of USD 0.37. Fluctuations in national commodity prices are shown in Figure 1.

Figure 1. National Commodity Prices from September 2021 to December 2021



Source: Ministry of Trade of the Republic of Indonesia

4.2 Fourier Series Estimation Results

The results of GCV calculations with Fourier sine cosine, sine, and cosine estimators using open-source software R using training data are shown in Table 3, Table 4, and Table 5. There was a decrease in the GCV value until the optimal oscillation parameter, followed by an increase. For the sine cosine of the Fourier series, k = 25, the minimum GCV value is 26,282,633, with an MSE value of 1.628355 and a coefficient of determination of 83.04711%. For the sine of the Fourier series, k = 76, the minimum GCV value is 10,547,146, with an MSE value of 1.581198 and a coefficient of determination of 80.21789%. For the Fourier cosine series k = 44, the minimum GCV value is 35,324,343, with an MSE value of 1.856621 and a coefficient of determination of 88.35876%.

Table 3. Changes in the Value of GCV on the Sine Cosine Estimator of the Fourier Series

k	GCV value	k	GCV value	k	GCV value
1	97,210,631	11	61,579,867	21	35,263,560
2	93,423,887	12	58,880,261	22	33,461,864
3	89,608,223	13	56,201,658	23	31,715,250
4	86,071,777	14	53,802,868	24	30,026,572
5	83,058,748	15	51,487,254	25	26,282,633
6	75,918,061	16	49,198,636		
7	72,677,705	17	46,862,269		
8	69,864,669	18	44,446,512		
9	67,039,082	19	39,003,096		
10	64,315,686	20	37,120,648		

Source: Authors' Compilation

Table 4. Changes in the Value of GCV on the Sine Estimator of the Fourier Series

k	GCV value	k	GCV value	k	GCV value	k	GCV value
1	179,041,002	21	96,271,201	41	60,551,703	61	23,336,868
2	178,477,378	22	94,344,794	42	59,039,080	62	22,538,249
3	174,459,024	23	92,408,643	43	57,580,507	63	20,145,080
4	168,448,857	24	90,616,109	44	40,518,024	64	19,448,379
5	166,008,266	25	87,229,576	45	39,371,941	65	18,762,527

6	157,944,237	26	85,206,050	46	38,312,092	66	18,095,064
7	472,179,616	27	83,382,222	47	37,286,799	67	17,443,153
8	165,108,035	28	81,654,001	48	36,281,582	68	16,774,824
9	160,529,047	29	79,943,008	49	35,261,894	69	14,773,096
10	156,559,165	30	78,234,747	50	33,160,780	70	14,129,170
11	150,032,581	31	76,543,260	51	32,159,097	71	13,572,691
12	137,216,779	32	75,118,399	52	31,220,246	72	13,029,842
13	132,352,765	33	73,524,038	53	30,312,737	73	12,492,577
14	128,965,866	34	71,852,577	54	29,413,629	74	11,965,553
15	126,254,040	35	70,169,830	55	28,520,518	75	11,132,815
16	123,649,416	36	68,571,691	56	27,560,134	76	10,547,146
17	121,241,336	37	67,058,096	57	26,573,724		
18	118,474,126	38	65,102,449	58	25,744,152		
19	100,376,321	39	63,583,018	59	24,931,857		
20	98,181,843	40	62,075,253	60	24,133,184		

Source: Authors' Compilation

Table 5. Changes in the Value of GCV on the Cosine Estimator of the Fourier Series

k	GCV value	k	GCV value	k	GCV value	k	GCV value
1	97,210,631	12	58,880,261	23	31,715,250	34	14,458,462
2	93,423,887	13	56,201,658	24	30,026,572	35	13,370,021

3	89,608,223	14	53,802,868	25	26,282,633	36	12,311,490
4	86,071,777	15	51,487,254	26	24,855,672	37	11,281,571
5	83,058,748	16	49,198,636	27	23,401,991	38	10,124,886
6	75,918,061	17	46,862,269	28	21,998,216	39	9,218,210
7	72,677,705	18	44,446,512	29	20,631,900	40	8,355,176
8	69,864,669	19	39,003,096	30	19,317,565	41	7,536,555
9	67,039,082	20	37,120,648	31	18,006,057	42	6,761,082
10	64,315,686	21	35,263,560	32	16,772,865	43	6,009,858
11	61,579,867	22	33,461,864	33	15,595,631	44	4,986,932

Source: Authors' Compilation

4.3. Best Estimator Comparison

The results of the Fourier series estimator are compared to obtain the selected estimator for the prediction of national commodity prices in Table 6.

Table 6. Comparison of Performance Estimators for Fourier Series

Fourier Series Estimator	k	GCV	MSE	R-Square
Sine Cosine	25	26,282,633	1.628355	0.8304711
Sine	76	10,547,146	1.581198	0.8021789
Cosine	44	35,324,343	1.856621	0.8835876

Source:Authors' Compilation

By using the best model principles, such as the smallest MSE value and the largest R^2, the estimator chosen for prediction is the Fourier Sine Cosine series estimator. The Fourier series estimator with a sine cosine component is selected with three comparison measures: smaller values of GCV and MSE and larger values of R^2. Then, predictions of future national commodity prices will be carried out by testing the data based on the Fourier series estimator with the smoothing measure, the oscillation parameter k = 25 with MAPE value of data testing is 0.01081964.

4.4 Commodity Price Prediction

Prediction of commodity prices of cooking oil, chili, and eggs is carried out simultaneously based on test data. The prediction uses the Sine Cosine estimator of the Fourier series for multiresponse cases with three responses. The estimated value for each parameter with three responses and with the optimal oscillation parameter value equal to 25 is shown in Table 7. Comparison of test data with prediction results for the period 123 to 132 or commodity price data on January 1, 2022, to January 10, 2022, was conducted to determine the performance of the model in making predictions, as shown in Table 8.

The prediction results for the three commodities are very good, as can be seen from the MAPE value of 1.082%, which means that the predicted value is close to the value of the test data. Furthermore, based on Table 1, if the MAPE is less than 10%, then the model has a very accurate forecast. Therefore, the Fourier Sinus Cosine Series estimator for multiresponse can be used to predict the commodity prices of cooking oil, chili, and eggs in Indonesia.

Table 7. Parameter Estimate Value

Parameter	j =1	j =2	j =3	Parameter	j =1	j =2	j =3
Intercept	14,312,040	31,015,870	22,089,780	α_{25j}	-72.920	-573.157	-1401.809
γ_j	31.903	228.430	37.732	β_{1j}	5.094	40.671	82.118

α_{1j}	-14.021	-89.091	-13.427	β_{2j}	3.871	-21.929	-14.311
α_{2j}	-3.520	-70.235	-19.076	β_{3j}	-2.308	-5.321	33.228
α_{3j}	-3.781	-24.867	-18.583	β_{4j}	-6.724	-47.944	-29.192
α_{4j}	-4.143	-44.906	3.403	β_{5j}	-12.636	-5.799	4.472
α_{5j}	-4.631	20.635	-17.099	β_{6j}	-71.566	-389.702	-236.047
α_{6j}	24.647	-113.371	-69.505	β_{7j}	36.129	129.080	51.975
α_{7j}	-5.970	30.694	5.530	β_{8j}	1.370	101.652	46.431
α_{8j}	-11.289	-77.150	-21.789	β_{9j}	8.051	-65.634	-5.018
α_{9j}	3.443	-37.432	16.935	β_{10j}	-2.164	13.159	-21.661
α_{10j}	-12.178	-32.554	-20.570	β_{11j}	-12.397	-77.645	-31.169
α_{11j}	-4.070	-35.673	-23.288	β_{12j}	-50.495	253.961	21.601
α_{12j}	2.904	195.572	-13.090	β_{13j}	60.915	247.544	183.198
α_{13j}	-3.949	436.401	49.272	β_{14j}	11.915	37.132	12.531
α_{14j}	-9.740	-67.199	-26.990	β_{15j}	1.285	27.931	-5.115
α_{15j}	-5.814	-69.876	-0.630	β_{16j}	1.548	-12.820	-22.138
α_{16j}	-5.111	-114.080	-40.846	β_{17j}	-8.832	21.055	17.192
α_{17j}	-7.041	-19.759	-7.693	β_{18j}	-22.809	-153.015	-46.768
α_{18j}	5.466	-82.434	-57.219	β_{19j}	47.515	-5000.831	189.458

α_{19j}	189.775	4540.910	1789.829	β_{20j}	22.509	390.282	128.923
α_{20j}	-12.016	271.678	4.467	β_{21j}	13.290	-75.489	0.015
α_{21j}	-5.039	-9.494	-40.012	β_{22j}	8.858	64.631	82.212
α_{22j}	-6.082	-23.205	-38.555	β_{23j}	6.569	-121.637	-1.300
α_{23j}	-7.197	-30.882	-13.376	β_{24j}	3.095	46.099	39.571
α_{24j}	-6.932	-243.076	-71.732	β_{25j}	-256.355	-8329.652	-1216.636

Source: Authors' Compilation

Table 8. Prediction Testing Data Results (USD)

t	Cooking Oil		Chili		Egg	
	Test.	Pred.	Test.	Pred.	Test.	Pred.
123	1.3	1.3	4.79375	4.79375	1.96625	1.96625
124	1.3	1.3	4.79375	4.79375	1.96625	1.96625
125	1.3	1.3	4.79375	4.79375	1.96625	1.96625
126	1.3	1.3	4.77425	4.77425	1.95325	1.95325
127	1.30325	1.30325	4.6605	4.6605	1.97275	1.97275
128	1.30325	1.30325	4.537	4.537	1.9435	1.9435
129	1.3065	1.3065	4.446	4.446	1.93375	1.93375
130	1.3065	1.3065	4.446	4.446	1.93375	1.93375
131	1.3065	1.3065	4.446	4.446	1.93375	1.93375
132	1.30975	1.30975	4.14375	4.14375	1.898	1.898

Source: Authors' Compilation

Based on the prediction results shown in Table 8, it can be seen that the prices of cooking oil, chili, and eggs still experience an increase but tend to be more stable. The government is expected to monitor and understand the trends and factors affecting the prices of staple foods. The COVID-19 pandemic, weather-related events, trade restrictions, and market failures are some of the factors that can lead to fluctuations in prices. These fluctuations can have significant negative impacts on household welfare, particularly in low-income countries. Therefore, policymakers should consider implementing measures to mitigate the effects of price fluctuations on vulnerable populations.

Therefore, the results of national food commodity predictions that have been obtained can be disseminated to the public through the media as a form of statistical role in supporting the acceleration of digital transformation in Indonesia. In addition, the prediction results can also be used as a reference for the government to formulate policies in order to maintain national economic stability. The following are several economic field recommendations formulated by the author in responding to the fluctuations in staple food prices in Indonesia (Table 9).

Table 9. Policy Recommendations for the Government

No	Recommendations
1	Maintaining stability of staple food prices through fiscal policies
2	Publishing real-time predictions of staple food prices through the official government website or mobile application

Source: Authors' Compilation

5. Conclusion

Fluctuations in the price of staples in Indonesia often occur at certain times. After simultaneous modeling with Fourier series sine, cosine, and sine cosine, it was found that the estimator of the Fourier series with a sine cosine component is better than the estimator of the Fourier series with a sine component and the estimator of the Fourier series with a cosine component. Using a Fourier series estimator with a sine cosine component, the price of cooking oil, chili, and eggs with an optimal oscillation parameter value of 25 produces a minimum GCV value of 26,282,633, with an MSE value of 1.6283 and a coefficient of determination of 83.0471%. The Fourier series estimator with a sine cosine component has very good predictive performance because it has a small MAPE value of 1.082%. Thus, the Fourier series estimator with a sine cosine component for multiresponse can be used to predict commodity prices for cooking oil, chili, and eggs. The prediction results are expected to help the government to maintain commodity price stability in Indonesia.

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