Anticipating the Scarcity of Food Commodity to Sufficient Availability for the Community in East Java with a Comparison Approach to Forecasting Artificial Neural Networks and Exponential Smoothing

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Abstract. This research was conducted to predict food commodity prices which include beef prices, medium quality rice price data, chicken egg prices, sugar prices, branded cooking oil prices, bulk cooking oil prices, curly red chili prices, garlic prices, shallot prices and price of grilled chicken the research carried out has a contribution to the commodity variables which are added as part of the factors causing food shortages in 2021, whereas in research related to predictions as was done by previous researchers that variables related to activity objects become a reference in the prediction process. This research was conducted by analyzing food commodity price data taken from the weekly period, namely December 2020 (IV)–April 2022 (I) in East Java Province using the exponential smoothing method. From the results of the analysis it is known that the smallest MAPE (Mean Absolute Percentage Error) ranges from 0.22%–2.44%, which means that the prediction accuracy of food ingredients using the triple exponential smoothing method is very high, which is greater than 97.66% so that it can be used as a recommendations in forecasting food commodity prices for the next period.

Keywords: Price · Food Commodities · East Java · Exponential Smoothing

1 Introduction

Food is anything that comes from biological sources of agricultural, plantation, forestry, fishery, animal husbandry, water and water products, both processed and unprocessed, which is intended as food or drink for human consumption, including food additives, food raw materials, and other materials used in the process of preparing, processing, and/or making food or beverages.

As a country with a large population and on the other hand, has natural resources and diverse food sources, Indonesia must be able to meet its food needs in a sovereign and independent manner, as well as in East Java.

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Prices of staple foods fluctuate. Changes in food ingredients are usually influenced by several factors including season, weather, human needs for food itself [1]. To overcome these problems, it is necessary to have forecasts of food commodity prices which can later be used as a reference in planning policies related to food commodity prices.

Forecasting or what is commonly referred to as forecasting is part of a decision support system that provides predictions or estimates on things that have not happened or will happen in the future [2] using a number of previously available data [3]. In this study, the results of the forecasting [4, 5] of food commodity prices will be compared using the artificial neural network method and the exponential smoothing method [6].

2 Research Method

In this study, the exponential smoothing [7] method is used. The following is the algorithm for exponential smoothing (Fig. 1). In the algorithm, it can be explained that:

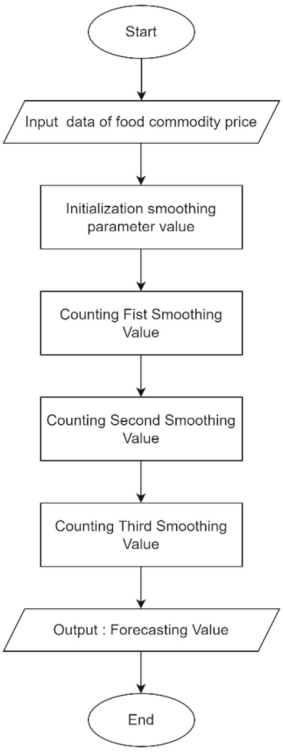

Fig. 1. Flowchart of Calculation of the Triple Exponential Smoothing Method

1. Start
2. Enter food commodity price data (in this case, beef price data, medium quality rice price data, chicken egg price, sugar price, branded cooking oil price, bulk cooking oil price, curly red chili price, garlic price, onion price, red and the price of purebred chicken)
3. Furthermore, the determination of smoothing parameters $0 < \propto < 1$.
4. After initializing the $\propto$ parameters, the next step is to calculate the first smoothing value with the formula: $S'_t = aX_t + (1 - \alpha)\, S'_{t-1}$
5. Calculation of the second smoothing value with the formula: $S''_t = aS'_t + (1 - \alpha)\, S''_{t-1}$
6. Calculation of the third smoothing value with the formula: $S'''_t = \alpha\, S''_t + (1 - \alpha)\, S'''_{t-1}$
7. After getting the value of single, double, and triple, it can be calculated the value of $a_t, b_t, and\ c_t$.
8. After that, the forecasting calculation for the next period is carried out with the formula: $F_{t+1} = a_t + b_t m + 0.5\, c_t m^2$

After completing the forecasting calculations, then calculating the MAPE (Mean Absolute Percentage Error) [8, 9] value with the formula.

3 Results and Discussion

In this study, the data on food commodity prices will be analyzed for data patterns [10]. It can be seen in Table 1 that the prices of food commodities from every week have an irregular increase or decrease, it can be concluded that the data pattern is a fluctuating pattern. Thus, a suitable forecasting method for forecasting food commodity [3, 11] price data is the triple exponential smoothing method.

3.1 Data Analysis

In this study, the data used are food commodity price data, namely beef price data, medium quality rice price data, chicken egg prices, granulated sugar prices, branded cooking oil prices, bulk cooking oil prices, curly red chili prices, and onion prices. The price of white onion, the price of onion, and the price of purebred chicken. The data was taken from the NATIONAL STRATEGIC FOOD PRICE INFORMATION CENTER for the weekly period, namely December 2020 (IV)–March 2022 (IV) in East Java Province. Henceforth, the data on food commodity prices are analyzed for data patterns. The following is the data pattern for each of these food commodity prices, which is shown in Figs. 2, 3, 4, 5 and 6.

From Figs. 2, 3, 4, 5 and 6, it can be analyzed that food commodity prices have an irregular increase or decrease every week. It can be concluded by looking at the data pattern as a fluctuating pattern. Thus, a suitable forecasting method for forecasting food commodity price data is the triple exponential smoothing method.

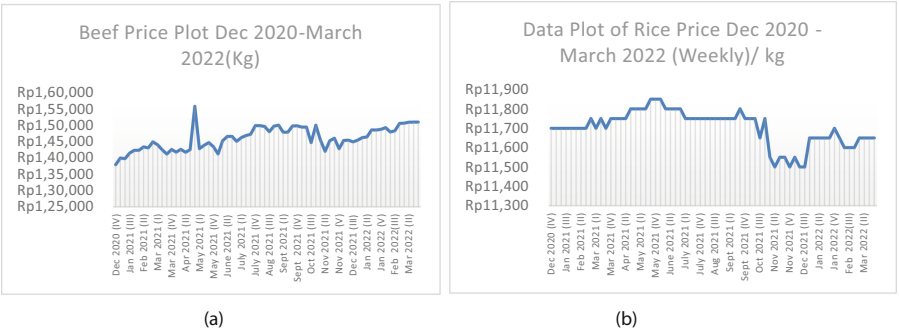

Fig. 2. (a) Graph of Beef Price Data Patterns for the Period December 2020 (IV)–March 2022 (IV), (b) Graph of Medium Quality Rice Price Data Patterns for the Period December 2020 (IV)–March 2022 (IV).

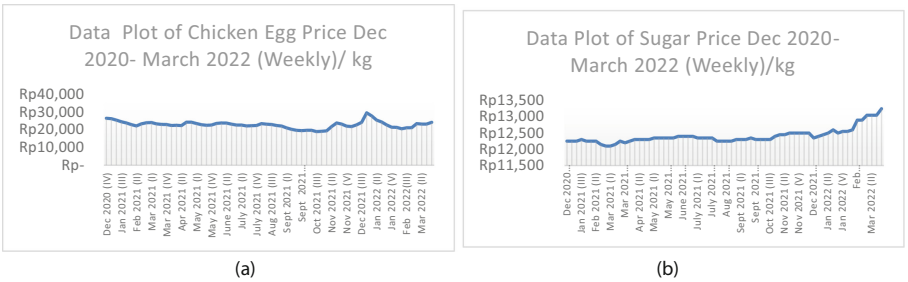

Fig. 3. (a) Graph of Chicken Egg Price Data Patterns for the Period December 2020 (IV)–March 2022 (IV), (b) Graph of Sugar Price Data Patterns for the Period of December 2020 (IV)–March 2022 (IV)

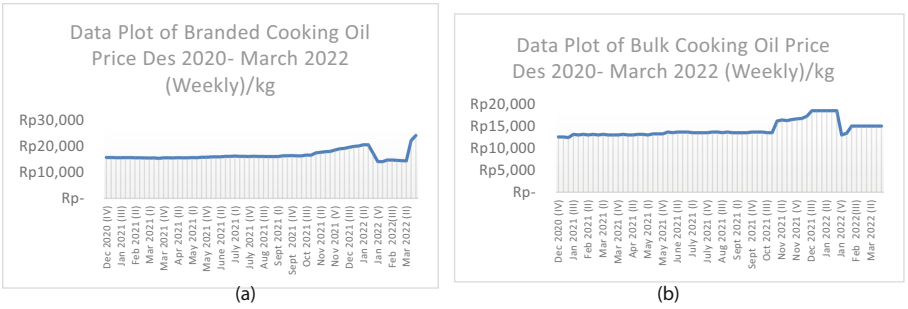

Fig. 4. (a) Graph of Branded Cooking Oil Price Data Patterns for the Period December 2020 (IV)–March 2022 (IV), (b) Graph of Bulk Cooking Oil Price Data for the Period December 2020 (IV)–March 2022 (IV)

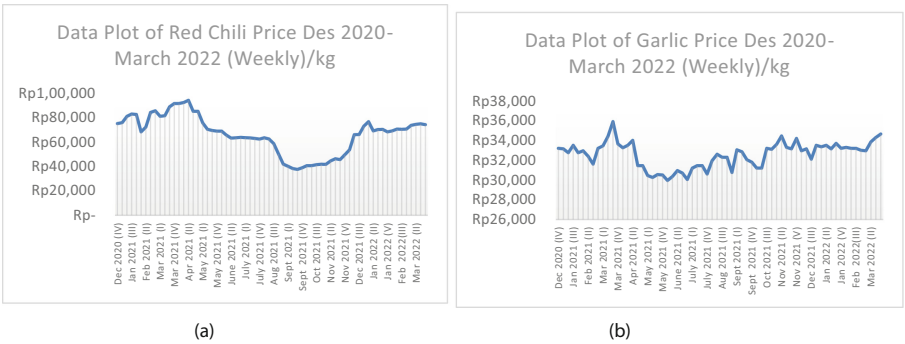

Fig. 5. (a) Graph of Curly Red Chili Price Data for the Period December 2020 (IV)–March 2022 (IV), (b) Graph of Garlic Price Data Patterns for the Period of December 2020 (IV)–March 2022 (IV)

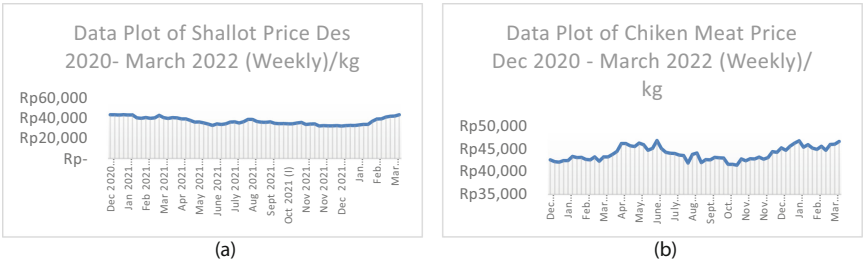

Fig. 6. (a) Graph of Shallot Price Data for the Period December 2020 (IV)–March 2022 (IV), (b) Graph of Data Patterns for Chicken Meat Prices for the Period December 2020 (IV)–March 2022 (IV)

3.2 Calculation Process

For the calculation process in forecasting food commodity prices using the triple exponential smoothing method, it is explained in the following description (examples of calculations for beef price data and premium quality rice prices):

3.2.1 Calculation Process for Forecasting Beef Prices

The calculation starts in the fourth week period in December 2020 using the example of alpha 0.5 by looking for the 2nd period, with $X_2 = 139950$ and $S'_{t-1} = 137900$ (taken from price data for the first period, due to smoothing one is not yet known). First, the first or single smoothing value is calculated.

$$S'_2 = \alpha X_2 + (1 - \alpha) S'_1$$
$$S'_2 = 0.5 * 139950 + (1 - 0.5) * 137900$$
$$S'_2 = 138925$$

From the results obtained from the calculation of the first smoothing, the second step is to calculate the value of the second or double smoothing with $S'_2 = 138925$ and

$S''_{t-1} = 137900$ (price data was taken in the first period due to the unknown value of the second smoothing).

$$S''_2 = \alpha S'_2 + (1-\alpha)S''_1$$
$$S''_2 = 0.5 * 138925 + (1-0.5) * 137900$$
$$S''_2 = 138413$$

From the results obtained from the second smoothing calculation, the third step is to calculate the third or triple smoothing value with $S''_2 = 138413$ and $S'''_{t-1} = 137900$ (taken price data in the first period, due to the unknown value for the third smoothing).

$$S'''_2 = \alpha S''_2 + (1-\alpha)S'''$$
$$S'''_2 = 0.5 * 138413 + (1-0.5) * 137900$$
$$S'''_2 = 138156$$

After getting the value of single, double and triple, the value of $a_t, b_t, and\ c_t$. The following can be calculated [12, 13]:

Calculation of value (Average value): a_t

$$a_2 = 3S'_2 - 3S''_2 + S'''_2$$
$$a_2 = (3 * 138925) - (3 * 138413) + 138516$$
$$a_2 = 139694$$

Value calculation (Tendency Value): b_t

$$b_2 = \frac{\alpha}{2(1-\alpha)^2}[(6-5\alpha)S'_2 - (10-8\alpha)S''_2 + (4-3\alpha)S'''_2]$$
$$b_2 = \frac{0.1}{2(1-0.1)^2}[(6-(5*0,5))138925 - (10-(8*0,5))138413$$
$$+(4-(3*0.5))138156]$$
$$b_2 = 72$$

Value calculation (Seasonal component): c_t

$$c_2 = \frac{\alpha^2}{(1-\alpha)^2}(S'_2 - 2S''_2 + S'''_2)$$
$$c_2 = \frac{0,5^2}{(1-0,5)^2}(138925 - (2 * 138413) + 138156)$$
$$c_2 = 256$$

After getting the value and then calculating the forecast, the results are: $a_t, b_t, and\ c_t$

$$F_3 = a_2 + b_2 m + 0.5 c_2 m^2$$
$$F_3 = 139694 + (72 * 1) + (0.5 * (256 * 1^2))$$
$$F_3 = 139894$$

The calculation process above will continue to be repeated until the last period of data and also use different alpha parameters, namely 0.1–0.9. The comparison graph between the actual price data for beef prices and the forecast data can be seen in Fig. 7.

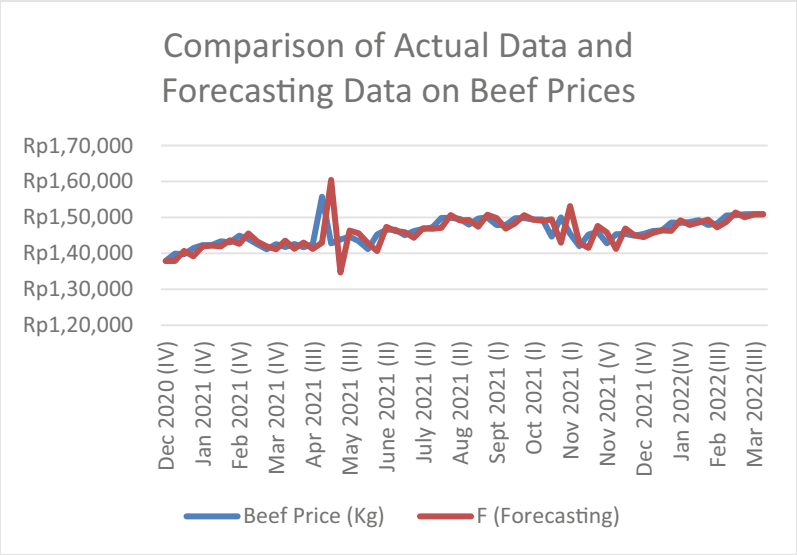

Fig. 7. Graph of Comparison of Actual Data and Forecasting Data on Beef Prices

3.2.2 Calculation Process for Forecasting the Price of Medium-Quality Rice

The calculation starts in the fourth week period in December 2020 using the example of alpha 0.4 by looking for the 2nd period, with $X_2 = 11700$ and $S'_{t-1} = 11700$ (taken from price data for the first period, due to smoothing one is not yet known). First, the first or single smoothing value is calculated.

$$S'_2 = \alpha X_2 + (1-\alpha)S'_1$$
$$S'_2 = 0.4 * 11700 + (1-0.4) * 11700$$
$$S'_2 = 11700$$

From the results obtained from the calculation of the first smoothing, the second step is to calculate the value of the second or double smoothing with $S'_2 = 11700$ and $S''_{t-1} = 11700$ (taken price data in the first period due to the unknown value of the second smoothing).

$$S''_2 = \alpha S'_2 + (1-\alpha)S''_1$$
$$S''_2 = 0.4 * 11700 + (1-0.4) * 11700$$
$$S''_2 = 11700$$

From the results obtained from the second smoothing calculation, the third step is to calculate the third or triple smoothing value with $S''_2 = 11700$ and $S'''_{t-1} = 11700$ (taken price data in the first period, due to the unknown value for the third smoothing).

$$S'''_2 = \alpha S''_2 + (1-\alpha)S'''_1$$
$$S'''_2 = 0.4 * 11700 + (1-0.4) * 11700$$
$$S'''_2 = 11700$$

After getting the value of single, double and triple, the value of $a_t, b_t, and\ c_t$, the following can be calculated:

Calculation of value (Average value): a_t

$$a_2 = 3S_2' - 3S_2'' + S_2'''$$
$$a_2 = (3 * 11700) - (3 * 11700) + 11700$$
$$a_2 = 11700$$

Value calculation (Tendency Value): b_t

$$b_2 = \frac{\alpha}{2(1-\alpha)^2}[(6 - 5\alpha)S_2' - (10 - 8\alpha)S_2'' + (4 - 3\alpha)S_2''']$$
$$b_2 = \frac{0.4}{2(1-0.4)^2}[(6 - (5 * 0.4))11700 - (10 - (8 * 0.4))11700 + (4 - (3 * 0.4))11700]$$
$$b_2 = 0$$

Value calculation (Seasonal component): c_t

$$c_2 = \frac{\alpha^2}{(1-\alpha)^2}(S_2' - 2S_2'' + S_2''')$$
$$c_2 = \frac{0.4^2}{(1-0.4)^2}(11700 - (2 * 11700) + 11700)$$
$$c_2 = 0$$

After getting the value and then calculating the forecast, the results are: $a_t, b_t, and\ c_t$

$$F_3 = a_2 + b_2 m + 0.5 c_2 m^2$$
$$F_3 = 11700 + (0 * 1) + (0.5 * (0 * 1^2))$$
$$F_3 = 11700$$

The calculation process above will continue to be repeated until the last period of data and also use different alpha parameters, namely 0.1–0.9. The comparison graph between the actual price data for the price of medium-quality rice and the forecast data can be seen in Fig. 8.

3.3 Percentage Error (Error)

Forecasting accuracy is a fundamental thing in forecasting, namely how to measure the suitability of a certain forecasting method in a given data set. Accuracy is seen as a refusal criterion to choose a forecasting method. The following describes the manual calculation process for calculating the error value.

1. PE (Percentage Error)
   Forecasting the price of the sample food commodity for the price of beef) (in the 67th period it was Rp. 150492, to get the percentage error value, the actual price data was reduced by the forecast result then divided by the actual price data multiplied by 100.

$$\text{PE} = ((139750 - 139894)/139750)$$
$$= -0.1\%.$$

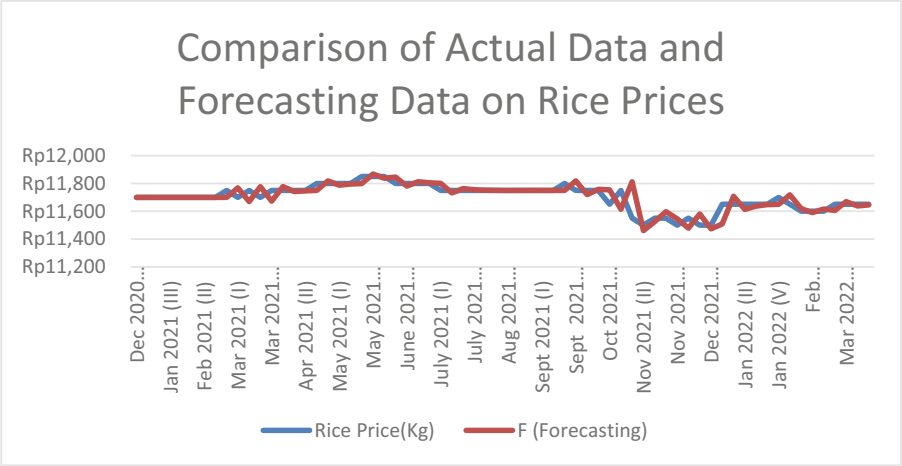

Fig. 8. Graph of Comparison of Actual Data and Forecasting Data for Medium Quality Rice Prices

Table 1. Forecasting Error For Forecasting Beef Prices

No	Period	Alpha	Forecasting	MAPE
1	April 2022 (I)	0.1	Rp. 150,988	1.26
2	April 2022 (I)	0.2	Rp. 151,633	1.13
3	April 2022 (I)	0.3	Rp. 151.254	1.09
4	April 2022 (I)	0.4	Rp. 151.058	1.1
5	April 2022 (I)	0.5	Rp. 150,942	1.12
6	April 2022 (I)	0.6	Rp. 150,881	1.15
7	April 2022 (I)	0.7	Rp. 150,867	1.21
8	April 2022 (I)	0.8	Rp. 150,881	1.29
9	April 2022 (I)	0.9	Rp. 150,903	1.42

2. MAPE (Mean Absolute Percentage Error)

   To get the MAPE value, the average APE is 1.11%.

   The following results of the calculation of the overall error of each food commodity price forecasting from =0.1 to =0.9 are shown in Table 1 and Table 2 (Forecasting Results for forecasting beef prices and medium quality).

From the error table and the triple exponential smoothing table (Table 1), it can be concluded that the smallest error rate seen from MAPE beef prices is at alpha 0.3 [14], with the smallest mean absolute percentage error of 1.09% when compared to the overall MAPE value at an alpha value of 0.1–0.9 with the results of forecasting the price of beef of Rp. 151,254.

Table 2. Forecasting Error For Forecasting Medium Quality Rice Prices

No	Period	Alpha	Forecasting (Rp)	MAPE
1	April 2022 (I)	0.1	11642	0.34
2	April 2022 (I)	0.2	11655	0.27
3	April 2022 (I)	0.3	11653	0.24
4	April 2022 (I)	0.4	11654	0.23
5	April 2022 (I)	0.5	11652	0.22
6	April 2022 (I)	0.6	11649	0.23
7	April 2022 (I)	0.7	11648	0.24
8	April 2022 (I)	0.8	11648	0.26
9	April 2022 (I)	0.9	11649	0.29

From the error table and the triple exponential smoothing table (Table 2), it can be concluded that the smallest error rate seen from the MAPE price of medium-quality rice is at alpha 0.5, with the smallest mean absolute percentage error of 0.22% when compared [15] with the overall MAPE value at an alpha value of 0.1–0.9 with the results of forecasting the price of medium quality rice of Rp. 11,652.

4 Conclusion

Based on the research that has been done, it can be concluded several things including, the results of the predictions made in this study are carried out with technology that can help decision makers. This is in line with the concept of green technology related to environmentally friendly technology and without utilizing components that are detrimental to the environment. The results of research which utilize variables of food commodity price data, namely beef price data, medium quality rice price data, chicken egg prices, sugar prices, branded cooking oil prices, bulk cooking oil prices, curly red chili prices, garlic prices, onion prices and The price of purebred chicken is taken from the NATIONAL STRATEGIC FOOD PRICE INFORMATION CENTER for the weekly period, namely in December 2020 (IV)–April 2022 (I) in East Java Province, the majority of which have fluctuating data patterns. Fluctuating data means that the data has a value that goes up and down in certain periods. In the research on the prediction of food commodity prices, it was found that the prediction of beef prices in the next period was Rp. 151,254. Where the forecasting data is obtained from the smallest MAPE value of 1.09% with a smoothing parameter of 0.3. From this it can be concluded that the prediction accuracy of beef prices is very good, which is 99.1%. So, this prediction of beef prices can be used as a recommendation for prediction of beef prices in the next episode. Likewise with predictions for other foodstuffs, the smallest MAPE obtained is in the range of 0.22%–2.44%. From this it can be concluded that the prediction accuracy of foodstuffs using the triple exponential smoothing method is very high, which is greater than 97.66%.

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