Journal of Engineering Science and Technology
ICIST2024, Vol. 20, No. 5 (2025) 106 - 116

INDONESIA FOOD COMMODITY PRICE PREDICTION INFORMATION SYSTEM USING LEAST SQUARE TO SUPPORT SMART ECONOMY

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Abstract

The main basic need for humans that must be met at all times is adequate food. Food availability that is less than needed can create economic instability. BPN data shows that the price comparison between 2023 and 2024 for all food commodities has increased, especially for premium rice and medium rice commodities. If food commodity prices are unable to stabilize in the future, Indonesian people will experience a decline in real income. More than that, rising prices result in a decline in people's purchasing power which has an impact on Indonesia's economic growth. With large areas and large data, technology is needed that can process large amounts of data to produce information in the form of predictions of food commodity prices throughout Indonesia. The process of predicting rice prices in Indonesia uses the machine learning. The least squares method produces food commodity price predictions for 2024 which can be seen in real-time on the website. The implementation of the php-ai/php-ml library is able to produce prediction data according to least square equation 1. The MAPE results for predicting medium rice prices in all provinces of Indonesia are very good, namely 2.23%. The accuracy of predicting medium rice prices in Indonesia using the least squares method is 97.77%. MAPE from calculating the prediction error for the price of pure beef in the province of West Java, Indonesia in 2024, is very good, namely 1.20% with a prediction accuracy of 98.8%.

Keywords: Food commodity price prediction, Information systems, Least square, MAPE, Smart economy.

1. Introduction

The main basic need for humans that must be met at all times is adequate food [1]. Meeting food needs is regulated in Law Number 7 of 1996 [2]. Food availability that is less than needed can create economic instability [3]. Various social and political upheavals can also occur if food security is disrupted [4]. This critical food condition can even endanger economic stability and national stability [5].

Food commodities according to the directorate of food supply and price stabilization, deputy for Indonesian food availability and stabilization, are: premium rice, medium rice, dry seed soybeans (imported), shallots, head garlic, curly red chilies, red cayenne peppers, pure beef, purebred chicken meat, purebred chicken eggs, consumption sugar, simple packaged cooking oil, wheat flour (bulk), bulk cooking oil, breeder's corn, mackerel, tuna fish, milkfish, fine iodized salt, and packaged wheat flour (non- bulk).

You can access the price of each commodity via the page https://panelharga.badanpangan.go.id. Data shows that the price comparison between 2023 and 2024 for all food commodities has increased, especially for premium rice and medium rice commodities.

Food commodity prices have increased from year to year in Indonesia [6]. If food commodity prices are unable to stabilize in the future, Indonesian people will experience a decline in real income [7]. More than that, rising prices result in a decline in people's purchasing power which has an impact on Indonesia's economic growth [8].

Indonesia's territory is very large, of course the more data analysis used [9]. Moreover, the BPN price panel system website is only able to present data in the form of tables and graphs of food commodity prices. So, policy makers cannot yet analyse future trends in food commodity prices. A technology is needed that can process large amounts of data to produce information in the form of predictions of food commodity prices throughout Indonesia [10, 11]. One technology that can be used is an information system [12].

The use of information systems is now widely used as a medium for the availability and ease of access to information widely and in real-time [13]. It does not stop with data management; information systems can provide information in the form of graphs and are able to make predictions based on analysis of past data [14].

One of the methods used is applying parameter estimation in regression analysis based on minimizing the sum of the squares of the residuals created in the results of each individual equation, namely Least Square [15]. With the advantage of forecasting/production with relatively small error values, many researchers apply the least squares method to predict sales of rosi soybean juice [16], Prediction of total income [17], forecasting prices of basic commodities [18].

The proposed solution to overcome existing problems in predicting food commodity prices in Indonesia is to build an information system for predicting Indonesian food commodity prices using least squares. This research aims to display predicted trends in food commodity prices for each province as well as average prices throughout Indonesia. Apart from that, this research also aims to analyse how accurate the least squares method is in predicting food commodity prices throughout Indonesia.

2. Literature Review

2.1. Least square

The least squares method is a method that can be used to predict data using data contained in the past/time series [19] to serve as a guide for the future [14]. The process of implementing the least square method can be done using the following Eq. (1) [14].

$$Y' = a + bx \tag{1}$$

Eq. (1), steps are needed to carry out calculations using the least squares method [14]:

1. Look for lots of data (n).
2. Find the value of the parameter. Parameter X is an index of training data starting from number 1 onwards.
3. Find the values of a and b. Calculation of the values of a and b can be done using the elimination or substitution equation as follows [20]:

$$\sum Y = n.a + b\sum X \tag{2}$$

$$\sum XY = a\sum X + b\sum X^2 \tag{3}$$

2.2. Mean absolute percent error (MAPE)

MAPE is a percentage form of the results of each absolute value calculation in a period which will be divided by the sum of the actual data in a certain period and an average of the errors is produced. To find the mean absolute percent error (MAPE) value, it can be calculated using the following equation [21]:

$$MAPE = \frac{\sum^{\frac{|Y_1 - Y_t|}{Y_1}}}{n} x\ 100\% \tag{4}$$

The MAPE value is used to analyse the error level in forecasting produced by the least squares method. The analysis can be concluded based on the range of MAPE values produced. The MAPE value can be said to be accurate or not based on Table 1.

Table 1. Range MAPE value.

MAPE (%)	Information
< 10	Very good
10-20	Good
20-50	Decent/adequate
> 50	Very bad

The lower the MAPE value, it means that the predicted value is close to the actual value, or it can be said that the prediction model has very good capabilities. The range of values for MAPE can be seen in Table 1.

3. Research Method

The steps in conducting research on an Indonesian food commodity price prediction information system using least squares to support a smart economy can be seen in Fig. 1.

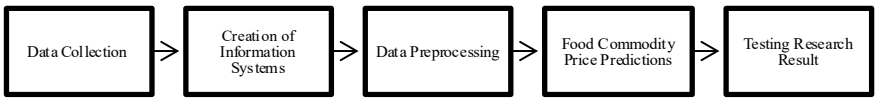


Fig. 1. Research method.

Step 1, data collection is a process where researchers look for data on food commodity prices in Indonesia nationally. Data was obtained from the national food agency website with the URL address: https://panelharga.badanpangan.go.id/harga-eceran. The data collected is a table of daily retail prices for food commodities from January 1, 2024, to, 2024,31 2024 in 38 Indonesian Provinces. The data is then downloaded in the form of an excel file.

Step 2, creation of information systems is the process of creating a website using the PHP programming language version 8.2.4 running on the Apache 2.0 web server. The software used for the information system creation process is: XAMPP v3.3.0, Visual Code Studio version 1.89.1, and Mozilla Firefox 126.0. The library used to perform forecasting in PHP is php-ai/php-ml version 0.10.0. Apart from that, it also makes the design easier using the Bootstrap v5.3 framework. Visualization of forecasting data and rice production trends carried out by the information system using the Highcharts v11.4.1 library

Step 3, data preprocessing is the process where the data from step 1 is processed for the purposes of data cleaning, data integration, and data transformation. This process is carried out systemically through importing Excel into the information system that has been built. Data cleansing is used to remove empty price data. Data integration is carried out to combine Excel data into a database. Data transformation is used to change the price number format to numeric or integer. In the stage of ensuring how the data used can be analysed in step 4.

Step 4, food commodity price predictions is a data processing process for the purpose of finding useful information that can be used as a basis for decision making to solve a problem. Data processing was carried out by applying the least squares method which was developed using a web-based information system. The system displays information in the form of trend charts for food commodity prices at national and provincial levels in 2024 in Indonesia.

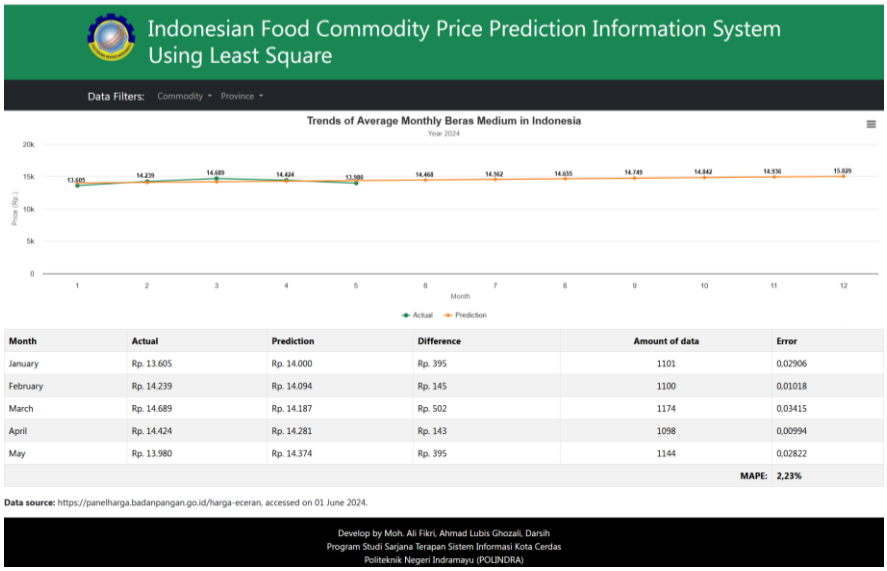
Step 5, testing research results is the process of analysing the results of MAPE calculations in predicting food commodity prices using the Lear Square method. The accuracy value of a prediction can be calculated by 100% minus the MAPE value.

4. Results and Discussion

The results of research on the Indonesian food commodity price prediction information system using least squares to support the smart economy can be accessed via https://prediksihargapagan.com as follows:

Based on Fig. 2, it shows that the predicted trend for the price of medium rice in Indonesia in 2024 will increase every month. The training data used is the average daily price from January to March in all Indonesian provinces in 2024. Monthly daily prices are calculated as an average to produce actual prices. The amount of training data can be seen in the Amount of data column. The predicted price for medium rice in January is IDR. 14,000 with the actual price being IDR.

13,605, and has a prediction error of 0.02906. The predicted price for medium rice in February is IDR. 14,094 with the actual price Rp. 14,239, and has a prediction error of 0.01018. The predicted price for medium rice in March is IDR. 14,187 with the actual price Rp. 14,689, and has a prediction error of 0.03415. The predicted price for medium rice in April is IDR. 14,281 with the actual price Rp. 14,424, and has a prediction error of 0.00994. The predicted price for medium rice in May is IDR. 14,374 with the actual price Rp. 13,980, and has a prediction error of 0.02822. The predicted price for medium rice in June is IDR. 14,468. The predicted price for medium rice in July is IDR. 14,562. The predicted price for medium rice in August is Rp. 14,655. The predicted price for medium rice in September is IDR. 14,749. The predicted price for medium rice in October is IDR. 14,842. The predicted price for medium rice in November is IDR. 14,936. The predicted price for medium rice in December is Rp. 14,029. So, the results of predicting medium rice prices in Indonesia using the least squares method obtained a very good MAPE, namely 2.23%. The accuracy of predicting medium rice prices in Indonesia using the least squares method is 97.77%.



Month	Actual	Prediction	Difference	Amount of data	Error
January	Rp. 13.605	Rp. 14.000	Rp. 395	1101	0,02906
February	Rp. 14.239	Rp. 14.094	Rp. 145	1100	0,01018
March	Rp. 14.689	Rp. 14.187	Rp. 502	1174	0,03415
April	Rp. 14.424	Rp. 14.281	Rp. 143	1098	0,00994
May	Rp. 13.980	Rp. 14.374	Rp. 395	1144	0,02822
				MAPE:	2,23%

Fig. 2. Medium rice price prediction results in Indonesia in 2024.

The information system built can filter predictions based on food commodities and provincial areas in Indonesia. The number of food commodities in Indonesia is 20 types of food as shown in Table 2. One of the 20 food commodities is pure beef. Filters can be determined by selecting the navigation provided on the website. For example, here is the prediction of the price of pure beef in the province of West Java, Indonesia in 2024 via the URL: https://prediksihargapangan.com/prediksi/Daging-Sapi-Murni/Jawa-Barat.

MAPE from calculating the prediction error for the price of pure beef in the province of West Java, Indonesia in 2024, was very good, namely 1.20% with a prediction accuracy of 98.8%. Application of the least squares method in the price prediction calculation process using the php-ai/php-ml tools. So, the results obtained will be tested using manual calculations based on Eq. (1) below.

First, look for several values to calculate elimination and substitution first as in Table 2.

Table 2. Results of testing predictions for food commodity prices in Indonesia in 2024.

No.	Commodity	MAPE	Accuracy
1.	Red onion	6,59%	93,41%
2.	Garlic Bulbs	0,76%	99,24%
3.	Medium Rice	2,23%	97,77%
4.	Premium Rice	2,78%	97,22%
5.	Curly Red Chilies	5,15%	94,85%
6.	Red Cayenne Pepper	2,43%	97,57%
7.	Purebred Chicken Meat	0,98%	99,02%
8.	Pure Beef	0,38%	99,62%
9.	Fine Iodized Salt	0,85%	99,15%
10.	Sugar Consumption	0,29%	99,71%
11.	Milkfish	1,03%	98,97%
12.	Mackerel	0,89%	99,11%
13.	Mackarel tuna	1,08%	98,92%
14.	Breeder Kindergarten Corn	10,37%	89,63%
15.	Dried Soybeans (Imported)	2,44%	97,56%
16.	Bulk Cooking Oil	0,95%	99,05%
17.	Simple Packaged Cooking Oil	1,14%	98,86%
18.	Purebred Chicken Eggs	2,32%	97,68%
19.	Trigu Flour (Bulk)	1,50%	98,5%
20.	Packaged Trigu Flour (non-bulk)	0,75%	99,25%

Next, the results from Table 3 are used as the basis for calculating Eqs. (2) and (3). These equations are elimination or substitution equations to find the values of a and b.

$$674438 = (5a + 15b) \times 15$$
$$2034553 = (15a + 55b) \times 5$$

So that the calculation results obtained are as follows:

$$\begin{array}{l} 10116570 = 75a + 225b \\ 10172765 = 75a + 275b \quad - \\ \hline -56195 = 0 + -50b \end{array}$$

Table 3. Data on pure beef in the province of West Java, Indonesia in 2024.

Month	Year (X)	Pure Beef (Y)	XY	X^2
January	1	132636	132636	1
February	2	132184	264368	4
March	3	135559	406677	9
April	4	139423	557692	16
May	5	134636	673180	25
5	15	674438	2034553	55
n	$\sum X$	$\sum Y$	$\sum XY$	$\sum X^2$

Next, the results of elimination and substitution can be used to find the value of b as follows:

$$b = \frac{-56195}{-50}$$
$$b = 1123{,}90$$

Find the value of a by entering the value of b into one of the equations as follows:

$$674438 = 5a + 15b$$
$$674438 = 5a + 15 \times 1123{,}90$$
$$a = \frac{674438 - (15 \times 1123{,}90)}{5}$$
$$a = 131515{,}9$$

After obtaining the values a and b, the prediction process using the least squares method in Eq. (1) can be carried out.

In January 2024, the price of pure beef (Y) is IDR. 132,636. The month is the 1st (n) index (one). So the process for calculating the predicted price of pure beef for January is as follows:

$$Y' = 131515{,}90 + (1123{,}90 \times 1)$$
$$Y' = 132640$$

In February 2024, the price of pure beef (Y) is IDR. 132,184. February is the 2nd (n) index. So the process for calculating the predicted price of pure beef for February is as follows:

$$Y' = 131515{,}90 + (1123{,}90 \times 2)$$
$$Y' = 133764$$

In March 2024, the price of pure beef (Y) is IDR. 135,559. March is the third (n) index. So the process for calculating the predicted price of pure beef for March is as follows:

$$Y' = 131515{,}90 + (1123{,}90 \times 3)$$
$$Y' = 134888$$

In April 2024, the price of pure beef (Y) is IDR. 139,423. April is the fourth (n) index. So the process for calculating the predicted price of pure beef for April is as follows:

$$Y' = 131515{,}90 + (1123{,}90 \times 4)$$
$$Y' = 136012$$

In May 2024 there will not be a price for pure beef (Y) of IDR. 134,636. The month of May is the 5th (n) index. So the process for calculating the predicted price of pure beef for May is as follows:

$$Y' = 131515{,}90 + (1123{,}90 \times 5)$$
$$Y' = 137135$$

June 2024 does not yet have a pure beef price (Y), but the predicted price can already be calculated. June is the 6th (n) index. So the process for calculating the predicted price of pure beef for June is as follows:

$$Y' = 131515{,}90 + (1123{,}90 \times 6)$$
$$Y' = 138259$$

July 2024 does not yet have a pure beef price (Y), but the predicted price can already be calculated. July is the 7th (n) index. So, the process for calculating the predicted price of pure beef for July is as follows:

$Y' = 131515{,}90 + (1123{,}90 \times 7)$
$Y' = 139.383$

August 2024 does not yet have a pure beef price (Y), but the predicted price can already be calculated. August is the 8th (seventh) (n) index. So the process for calculating the predicted price of pure beef for August is as follows:

$Y' = 131515{,}90 + (1123{,}90 \times 8)$
$Y' = 140.507$

September 2024 does not yet have a pure beef price (Y), but the predicted price can already be calculated. September is the 9th (n) index. So, the process for calculating the predicted price of pure beef for September is as follows:

$Y' = 131515{,}90 + (1123{,}90 \times 9)$
$Y' = 141.631$

October 2024 does not yet have a pure beef price (Y), but the predicted price can already be calculated. October is the 10th (ninth) (n) index. So, the process for calculating the predicted price of pure beef for October is as follows:

$Y' = 131515{,}90 + (1123{,}90 \times 10)$
$Y' = 142755$

November 2024 does not yet have a pure beef price (Y), but the predicted price can already be calculated. November is the 11th (eleventh) (n) index. So the process for calculating the predicted price of pure beef for November is as follows:

$Y' = 131515{,}90 + (1123{,}90 \times 11)$
$Y' = 143879$

December 2024 does not yet have a pure beef price (Y), but the predicted price can already be calculated. December is the 12th (twelfth) (n) index. So the process for calculating the predicted price of pure beef for December is as follows:

$Y' = 131515{,}90 + (1123{,}90 \times 12)$
$Y' = 145003$

The results of manual calculations for the average prediction of pure beef in 2024 using the least squares method obtained the same value as in Fig. 3. So, the implementation of the php-ai/php-ml library is able to produce prediction data according to Eq. (1). Moreover, with the use of the system Web-based information is capable of processing data that can produce pure beef predictions dynamically.

January 2024 has actual pure beef data of Rp. 132,636 and a prediction of Rp. 132,640, then we can calculate the error with the actual subtraction results with predictions as follows:

$Error = |132636 - 132640|$
$Error = \left|\frac{3{,}80}{132636}\right|$
$Error = |\ 0{,}00003\ |$

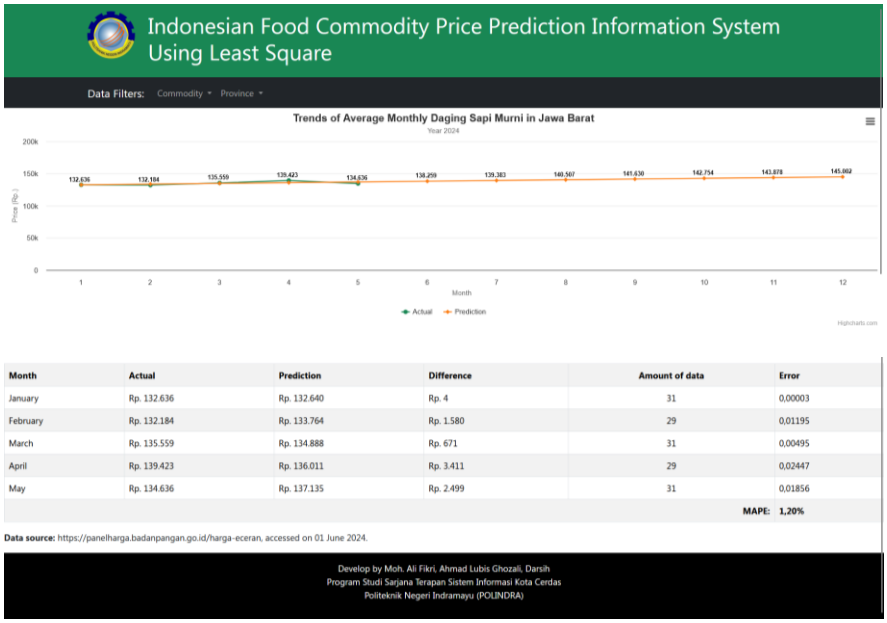


Fig. 3. Pure beef price prediction results in west java province, Indonesia in 2024.

The process of searching for prediction errors from February to May 2024 is carried out in the same way as in January 2024. The results can be seen in Fig. 3. After calculating the prediction error is complete, the next step is to calculate MAPE using Eq. (4).

$$MAPE = \frac{0{,}00003+0{,}01195+0{,}00495+0{,}02447+0{,}01856}{5} \times 100\%$$

$$MAPE = 1{,}20\%$$

Based on the range of MAPE percentage values, Table 1 shows that the accuracy results of research on implementing the least squares method for predicting pure beef prices are very good, with a MAPE value of less than 10 percent.

Based on the range of MAPE percentage values in Table 2, the price prediction test for 20 (twenty) food commodities in Indonesia in 2024 shows that it is very good with a MAPE value of less than 10%. Only one food commodity has a MAPE value of more than 10% (Good), namely Tk Corn. Breeder. Thus, research on the Indonesian food commodity price prediction information system using least squares to support the smart economy is very good.

5. Conclusions

Research on an Indonesian food commodity price prediction information system using least squares to support a smart economy has been successfully built using the PHP programming language. The process of predicting rice prices in Indonesia uses the php-ai/php-ml and highcharts libraries. The least squares method produces food commodity price predictions for 2024 which can be seen in real-time at the address https://prediksihargapangan.com. The implementation of the php-ai/php-ml library is able to produce prediction data according to least square Eq. (1). The

MAPE results for predicting medium rice prices in all provinces of Indonesia are very good, namely 2.23%. The accuracy of predicting medium rice prices in Indonesia using the least squares method is 97.77%. MAPE from calculating the prediction error for the price of pure beef in the province of West Java, Indonesia in 2024, was very good, namely 1.20% with a prediction accuracy of 98.8%.

Greek Symbols	
a	constant
b	linear regression direction coefficient
Y'	variable values based on the regression line
x	independent variable
$\sum_Y$	total commodity prices
n	lots of data
$\sum_X$	number of index data/year
$\sum_{XY}$	the number of multiplications between the data index and commodity prices
$\sum_{X^2}$	sum of squares of data indices
n	total amount of actual data
$\sum_{Y_1}$	amount of data in a certain period
$\sum_{Y_t}$	number of predictions for a certain period
$\lvert \ \rvert$	absolute value

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