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Analysis System of Forecasting on Egg Production and Demand Using the Least Square Method

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***Abstract* — At now chicken eggs are one of the basic needs of the people of Indonesia. Every month the demand for chicken eggs continues to increase dramatically, especially on major holidays. To meet this demand, chicken egg producers continue to increase their production in hopes of getting a large profit. But the problem that often occurs is the production of chicken eggs is not proportional to the demand from consumers. This is due to the producers being unable to estimate the production of chicken eggs, so producers continue to receive consumer demand without thinking about whether production is sufficient or not. The purpose of this study is to predict chicken egg production in the following months based on the results of production in the previous month. In this study, data processing will be carried out on the production of chicken eggs and demand for chicken eggs taken from January to November. Furthermore, the data will be processed and tested using the Least Square method. The results of the tests that have been done, obtained a prediction accuracy value of 90% with a production prediction in December of 1352 items and a demand prediction of 1391. Then the use of the Least Square method is able to make predictions for chicken egg production and demand prediction for the following month.**

Keywords — ***Forecasting; Time Series; Production & Demand; Eggs; Least Square.***

I. INTRODUCTION

Currently, the culinary industry in Indonesia is experiencing rapid growth. It's no wonder that various new types of food are emerging and even becoming culinary tourist destinations for Indonesian society. Alongside the increasing culinary industry in Indonesia, the demand for chicken eggs is also experiencing a very rapid increase each month. Chicken eggs have become one of the favorite protein sources for Indonesians due to their affordability compared to other animal protein sources [1]. However, the current issue is that egg-producing companies are facing difficulties in meeting the demand for chicken eggs due to this increasing demand. The challenge in meeting the demand for chicken eggs is caused by the companies' inability to estimate the production quantity of chicken eggs, while they continue to receive demand from consumers. This can result in a loss of consumer trust in the company because it cannot meet this demand. Therefore, to address this problem, companies must be able to conduct forecasting analysis. The aim of this research is to forecast the production of chicken eggs at CV. Jaya Abadi in the coming months based on egg production and demand in the previous months.

Forecasting is a process to predict future events with the aim of reducing the risk of failure/errors [2]. Forecasting is essential to determine when or how an event will occur so that appropriate actions by the company can be taken effectively. Forecasting is crucial to assist companies in decision-making and planning for the future [1]. Therefore, with forecasting, companies can manage consumer demand effectively. To conduct forecasting, a set of data supporting the forecasting process is required. This data will then be analyzed using Time Series analysis techniques. Time Series analysis is a quantitative method to analyze past data collected at regular intervals using appropriate techniques, where the results can be used as a reference for forecasting future values [3].

In Time Series analysis, there are several techniques or methods used, namely the Free Hand Method, Semi Average Method, Moving Average Method, and Least Square Method [4]. For this research, the Least Square method is employed to forecast chicken egg production and demand. The Least Square method excels in forecasting to identify trends in time series data [5]. Previous studies have shown that the Least Square method yields smaller error rates compared to other methods. To understand the Least Square method better, one can refer to previous research studies conducted on this topic.

In previous studies, the Least Square method was used to forecast drug sales at Bhayangkara Hospital. The drug sales data used were from the year 2016, totaling 120 samples, and a forecast was made for sales in January 2017. Subsequently, the Least Square method was applied, resulting in an estimated drug sales of 173 items for January 2017 with an error rate of 3%. With such a low error rate, it can be concluded that the forecasted results closely match the factual data [6].

Furthermore, the Least Square method was also compared to Double Exponential Smoothing for forecasting motor vehicle test revenue. The data used spanned from January 2014 to June 2015. Through the process, error values were obtained for each method. The Least Square method yielded an error rate of 17.903%, while Double Exponential Smoothing resulted in an error rate of 20.03%. Therefore, the Least Square method was deemed superior to Double Exponential Smoothing [7].

For forecasting on its own chicken eggs, there is research discussing market price forecasting for commercial chicken eggs in Jember Regency using the Semi Average Trend method. The data used is the price data of eggs in every area within Jember Regency. The dataset obtained from the registration of commercial chicken egg prices in Jember Regency consists of 366 data points, which are the prices of commercial chicken eggs from January 1, 2020, to December 31, 2020. Subsequently, forecasting was carried out using the Semi Average method, where the predicted price value of commercial chicken eggs in Jember Regency for January 1, 2021, was Rp. 22,753 with a MAPE (Mean Absolute Percentage Error) value of 7.21%. From the forecasting conducted using this method, there is still a relatively high error value, which is more than 5% [8].

Therefore, based on the previously discussed research, the use of the Least Squares method is suitable for forecasting chicken egg production and demand. This is because the error values obtained from the predictions using the Least Squares method are very small, almost approaching factual data. It is hoped that the results of the forecasting using the chosen method will closely approach factual values with minimal error.

II. METHOD

In this study, data was obtained by conducting surveys and direct interviews with companies. From the interview results, data was collected as samples for testing. From this research, the steps in the production forecasting and chicken egg demand forecasting process based on historical data using Time Series analysis can be explained. The Time Series analysis is then followed by the use of the Least Squares method for the forecasting process. The process can be seen in Figure 1 below.

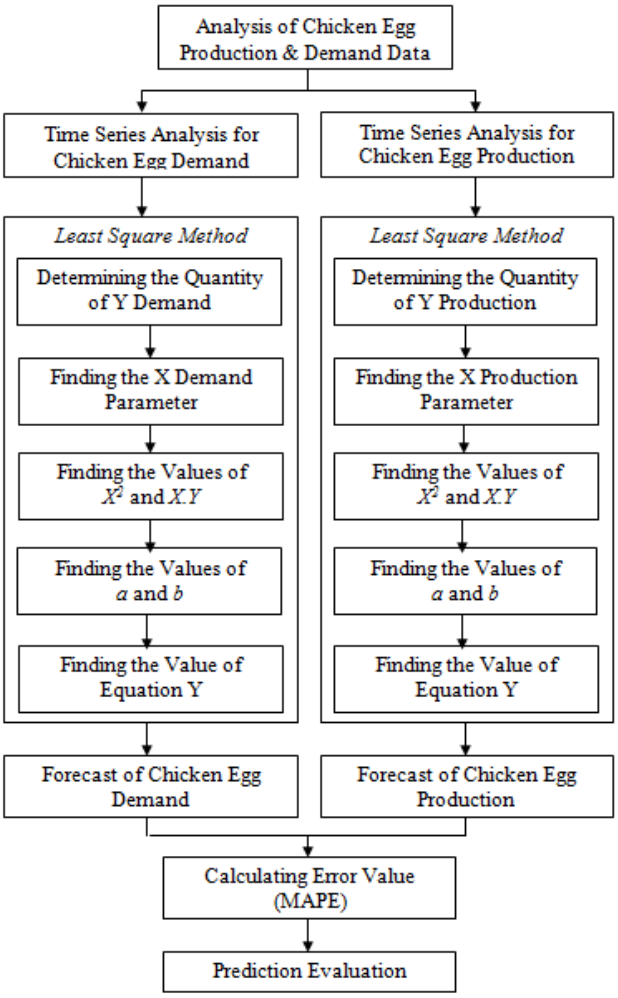

Figure 1. Research Frameworks

Data Analisys

Eggs are one of the livestock products that can fulfill a portion of the nutritional needs of the community [9]. Chicken eggs are a favored source of protein for the Indonesian people because of their affordable price compared to other animal protein sources [1]. Therefore, Indonesian society greatly enjoys consuming eggs.

With the high consumption of eggs, the demand for eggs by the community will also increase. Factors influencing egg demand by the community include [10]:

a. Consumer taste
b. Egg prices
c. Substitute goods prices
d. Household income
e. Increasing local culinary tourism

Meanwhile, the production of chicken eggs itself is influenced by the management of the company. Currently, the company continues to strive to increase chicken egg production due to rising demand from the public. Therefore, the company is seeking ways to meet this demand for chicken eggs. In this study,

the data used consists of chicken egg demand and production data for the period from July 2022 to December 2023 at CV. Jaya Abadi, Cirebon. The production and demand data for chicken eggs can be seen in the following Table 1:

TABLE I. EGG PRODUCTION AND DEMAND

No	Period	Production	Demand
1	July 2022	1234 grain	1120 grain
2	August 2022	1194 grain	1200 grain
3	September 2022	1423 grain	1230 grain
4	October 2022	1367 grain	970 grain
5	November 2022	1285 grain	1100 grain
6	December 2022	1293 grain	1150 grain
7	January 2023	1357 grain	1280 grain
8	February 2023	1245 grain	1235 grain
9	March 2023	1113 grain	1150 grain
10	April 2023	1267 grain	950 grain
11	May 2023	1376 grain	1290 grain
12	June 2023	1351 grain	1400 grain
13	July 2023	1398 grain	1400 grain
14	August 2023	1421 grain	1395 grain
15	September 2023	1352 grain	1360 grain
16	October 2023	1250 grain	1325 grain
17	November 2023	1353 grain	1350 grain
18	December 2023	1367 grain	1355 grain

From the above data, further Time Series analysis was conducted on the demand and production of chicken eggs occurring from July 2022 to December 2023.

Forecasting Using Time Series Analysis

Forecasting is an effort to predict or estimate something that will happen in the future by utilizing various relevant information based on history or experience through a specific method [11]. Forecasting is necessary to determine when or how an event will occur so that appropriate actions by the company can be taken effectively [2]. Therefore, forecasting is crucial to maintain the future sustainability of the company.

The purpose of forecasting is to minimize risks and uncertainties [7]. Additionally, the goal of forecasting is to obtain information about what will happen in the future with the highest probability of occurrence [11]. In its process, forecasting has classifications based on its nature.

Forecasting techniques can be classified into 2 categories, namely Qualitative and Quantitative. Forecasting using the Quantitative classification can be divided into 2 techniques: Causal and Time Series [3]. Meanwhile, Qualitative methods are those used without specific techniques, meaning they rely on the personal opinions of experts in the field [7].

Time Series, or periodic series, is a sequence of observations based on time of quantitative characteristics of one or a set of events taken over a specific period of time [12]. Additionally, Time Series can be defined as forecasting based on the behavior of past data projected into the future utilizing mathematical and statistical equations [7]. The benefits of using Time Series analysis include making current decisions and forecasting future planning based on the developmental patterns of variables studied over time [2].

In Time Series analysis, there are 4 main components that comprise this method, namely [12]:

a. Trend
   Trend is a long-term component that indicates the increase or decrease in time series data over a specific period. Simply put, a trend can be described as a curve that shows a general tendency of a time series data

b. Cycle
   A cycle is an irregular series of fluctuating waves or cycles with long durations. Cycles are typically associated with the business cycle, where a movement is considered cyclic if it reoccurs after a period longer than one year.

c. Seasonability
   Seasonality is a pattern of demand fluctuations above or below the trend line that occurs annually. Seasonal fluctuations can be classified quarterly, monthly, weekly, or daily, leading to regular pattern changes over time

d. Irregular
   An irregular is a sporadic or fluctuating movement caused by unpredictable events or non-periodic occurrences.

Time Series analysis is conducted by grouping data on chicken egg demand and production. Subsequently, the data is sorted historically based on the time series.

Least Squares Method Process

The Least Square Method is a technique used to determine the trend equation of data, which includes Time Series analysis, with two cases of even and odd data [13]. The Least Square Method is one of the methods involving periodic series data, which requires future data to determine the outcome [14]. Therefore, the Least Square Method is needed as one of the techniques for forecasting future periods.

In the process of the Least Square Method, if more data is collected, the estimation or forecast obtained will be more accurate. Conversely, if there is little data collected, the estimation or forecast results will be poorer [15]. Hence, the amount of data significantly affects the outcome of the Least Square Method. The forecasting process using the Least Square Method can be explained as follows [16]:

a. Initializing input data.
b. Determining the data period/time variable.
c. Calculating the sum of data (Y).
d. Determining parameter X. In determining parameter X, if the data count is even, then the values of X used are -5, -3, -1, 1, 3, 5, and so on depending on the data count. For odd data counts, the values of X used are -3, -2, -1, 0, 1, 2, 3, and so on [12].
e. Determining the values of X2 and X.Y.
f. Finding the coefficient a using the following formula:

$$a = \frac{\sum y}{n}$$

g. Calculating the coefficient b with respect to x (time) using the formula:

$$b = \frac{\sum X + Y}{n}$$

Determining the equation of the trend variable value using the formula:

$$Y' = a + bx$$

From the process above, the Least Squares method optimizes the data values using a mathematical equation formed by the least squares. The Least Squares method process is carried out to obtain predicted values. The Least Squares Method process is conducted according to the framework depicted in Figure 1.

Predicted Outcome

After the Least Square method process is performed, the predicted results for a specific period as desired are obtained. The obtained prediction results cannot be confirmed as accurate yet, as they require observing the actual facts in the field [17]. Therefore, it is necessary to determine the error from the prediction results by comparing them with the actual values.

Determining Error Values

The error value is obtained from the percentage comparison between predicted results and actual data or facts. The smaller the percentage of the error value obtained, the closer the prediction will be to the factual data. To determine this error value, Mean Absolute Percentage Error (MAPE) is used. MAPE is the average of the squared errors between the actual values and the forecasted values; if the result obtained is zero, then the prediction is perfect [18].

Prediction Evaluation

After obtaining the error value, the predicted value can be determined. From the obtained predicted values, an evaluation needs to be conducted to achieve good results. To improve the evaluation results of the Mean Absolute Percentage Error (MAPE), it is necessary to add more historical data to obtain appropriate prediction results [19].

III. RESULTS AND DISCUSSION

From the discussed research methodology, the results and discussion of the chicken egg demand and production forecasting process using Time Series analysis with the Least Squares technique can be explained further.

Y.D.S et al. (2022) examined egg price forecasting in both traditional and modern markets in Jambi using statistical models, highlighting the importance of accurate price prediction to stabilize supply chains and market equilibrium. Additionally, Yogi S. (2020) analyzed production and consumption forecasting of broiler meat to maintain self-sufficiency in Indonesia, emphasizing the role of demand analysis in agricultural planning. Building on these studies, the present research applies the Least Square Method to forecast egg production and demand, providing a structured approach to anticipate market trends. By leveraging historical data and trend analysis, this study enhances forecasting accuracy, supporting policymakers and industry stakeholders in making informed decisions to balance production and market needs.

The process can be described as follows:

Demand Forecasting Process

Demand Time Series Analysis

To conduct Time Series analysis on demand data, it is necessary to arrange historical data. The Time Series analysis on chicken egg demand data can be seen in the following Table 2:

TABLE II. TIME SERIES DEMAND ANALYSIS

No	Period	Demand / Grain (Y)
1	July 2022	1120 grain
2	August 2022	1200 grain
3	September 2022	1230 grain
4	October 2022	970 grain
5	November 2022	1100 grain
6	December 2022	1150 grain
7	January 2023	1280 grain
8	February 2023	1235 grain
9	March 2023	1150 grain
10	April 2023	950 grain
11	May 2023	1290 grain
12	June 2023	1400 grain
13	July 2023	1400 grain
14	August 2023	1395 grain
15	September 2023	1360 grain
16	October 2023	1325 grain
17	November 2023	1350 grain

From the above data, further processing using the Least Square method will be conducted to forecast demand for the December 2023 period.

Least Squares Demand Process

After conducting Time Series analysis on chicken egg demand data, the next step involved applying the Least Squares Method to obtain forecasting results. The first step is to determine the parameter X. Subsequently, from the obtained parameter X, we can determine the values of X^2 and X.Y. The values of parameter X, X^2, and X.Y. from the acquired demand data can be seen in the following Table 3.

TABLE III. VALUES OF PARAMETER X AND VALUES X^2 AND X.Y DEMAND

No	Period	Y	X	X^2	X.Y
1	July 2022	1120	-8	64	-8960
2	August 2022	1200	-7	49	-8400
3	September 2022	1230	-6	36	-7380
4	October 2022	970	-5	25	-4850
5	November 2022	1100	-4	16	-4400
6	December 2022	1150	-3	9	-3450
7	January 2023	1280	-2	4	-2560
8	February 2023	1235	-1	1	-1235
9	March 2023	1150	0	0	0
10	April 2023	950	1	1	950
11	May 2023	1290	2	2	2580
12	June 2023	1400	3	9	4200
13	July 2023	1400	4	16	5600
14	August 2023	1395	5	25	6975
15	September 2023	1360	6	36	8160
16	October 2023	1325	7	49	9275
17	November 2023	1350	8	64	10800

Total n = 17	**20905**	**0**	**406**	**7305**

After obtaining the parameter value of X, X^2, and X.Y data demand, next we can determine the coefficients a and b of the trend equation. To obtain these trend values, you can use the formula:

$$a = \frac{\sum Y}{n} = \frac{20905}{17} = 1229{,}706$$

$$b = \frac{\sum X*Y}{n} = \frac{7305}{406} = 17{,}993$$

Therefore, from the obtained coefficient values, the value of the trend Y' or demand prediction for the December 2023 period can be generated using the formula:

Y' = a + bx
= 1229,706 + (17,993 * 9)
= 1391,639

The value of x(9) is obtained from the sequence for the December 2023 period. Based on the trend result Y', it is predicted that the demand for the December 2023 period will be 1391 eggs.

Production Forecasting Process

Production Time Series Analysis

In accordance with the previous process, the Time Series analysis of chicken egg production data can be seen in the following Table 4.

TABLE IV. TIME SERIES PRODUCTION ANALYSIS

No	Period	Demand / Grain (Y)
1	July 2022	1234 grain
2	August 2022	1194 grain
3	September 2022	1423 grain
4	October 2022	1367 grain
5	November 2022	1285 grain
6	December 2022	1293 grain
7	January 2023	1357 grain
8	February 2023	1245 grain
9	March 2023	1113 grain
10	April 2023	1267 grain
11	May 2023	1376 grain
12	June 2023	1351 grain
13	July 2023	1398 grain
14	August 2023	1421 grain
15	September 2023	1352 grain
16	October 2023	1250 grain
17	November 2023	1353 grain

From the above data, the next step is to conduct the Least Square method to forecast production for the December 2023 period.

Least Squares Production Process

After conducting Time Series analysis on chicken egg production data, the next step involved using the Least Squares Method to obtain forecasting results. Similar to the previous process, the parameter values X, X^2, and X.Y were determined. The parameter values X, X^2, and X.Y for the production data obtained can be seen in the following Table 5.

TABLE V. VALUES OF PARAMETER X AND VALUES X^2 AND X.Y PRODUCTION

No	Period	Y	X	X^2	X.Y
1	July 2022	1234	-8	64	-9872
2	August 2022	1194	-7	49	-8358
3	September 2022	1423	-6	36	-8538
4	October 2022	1367	-5	25	-6835
5	November 2022	1285	-4	16	-5140
6	December 2022	1293	-3	9	-3879
7	January 2023	1357	-2	4	-2714
8	February 2023	1245	-1	1	-1245
9	March 2023	1113	0	0	0
10	April 2023	1267	1	1	1267
11	May 2023	1376	2	2	2752
12	June 2023	1351	3	9	4053
13	July 2023	1398	4	16	5592
14	August 2023	1421	5	25	7105
15	September 2023	1352	6	36	8112
16	October 2023	1250	7	49	8750
17	November 2023	1353	8	64	10824
Total n = 17		**22279**	**0**	**406**	**1874**

After obtaining the parameter value of X, X2, and X.Y production data, the trend equation coefficients a and b can then be determined. To obtain these trend values, you can use the formula:

$$a = \frac{\sum Y}{n} = \frac{22279}{17} = 1310{,}529$$

$$b = \frac{\sum X*Y}{n} = \frac{1874}{406} = 4{,}616$$

Thus, from the coefficients obtained, the value of the trend Y' or production prediction for the December 2023 period can be generated using the formula:

Y' = a + bx
= 1310,529 + (4,616 * 9)
= 1352,071

The value of x (9) is obtained from the sequence for the December 2023 period. Based on the trend result Y', it is predicted that the chicken egg production for the December 2023 period will be 1352 eggs.

Error Assesment

After obtaining the predicted values for production and demand, the next step is to determine the error value for the production and demand predictions. The error value is obtained from the percentage difference between the actual data and the predicted data. To determine this error value, Mean Absolute Percentage Error (MAPE) is used. The formula to calculate the error using MAPE is as follows: [20].

$$MAPE = \frac{1}{n} + \sum_{i=1}^{n} \frac{Yx - Y'x}{Yx} * 100\%$$

Where:
n : Number of Data
Y'x : Predicted Value at period i
Yx : Actual Data at period i

From this formula, the error value of the predicted production and demand for chicken eggs in December 2023 can be determined. It is known that in December 2023, actual data for production was obtained at 1367 eggs and demand at 1355 eggs. Therefore, the error value can be calculated as follows:

a. Data demand error value

$$MAPE = \frac{1}{17} + \frac{1355 - 1391}{1355} * 100\%$$

$$= 3{,}2\%$$

b. Data production error value

$$MAPE = \frac{1}{17} + \frac{1367 - 1352}{1367} * 100\%$$

$$= 6{,}9\%$$

From the MAPE calculations above, the error values obtained for demand prediction in December 2023 are 3.2% from the actual data, while for production prediction in December 2023, the error value is 6.9% from the actual data. With these small error percentages, the prediction data can be used to make decisions in forecasting future chicken egg demand and production.

From the results of the forecasting analysis obtained using Time Series analysis with the Least Square Method, it was then implemented into an information system. The result of the implementation into the system can be seen in the forecast analysis form for demand data as shown in Figure 2 below:

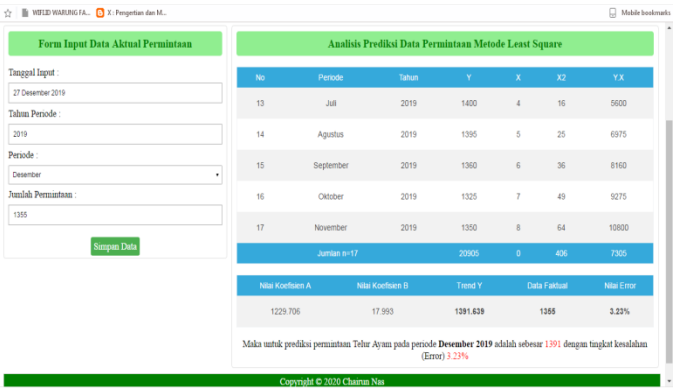

Figure 2. Forecasting Analysis Results for Demand

Meanwhile, the forecast analysis form for production data can be seen in Figure 3 below:

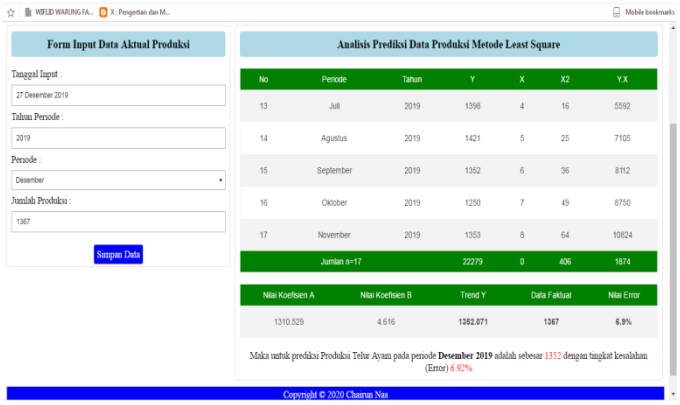

Figure 3. Forecasting Analysis Results for Production

From implementation into the system, the manual analysis process yields the same results as those obtained by the system. Therefore, for forecasting analysis, this forecasting system can be used to predict chicken egg production and demand.

IV. CONCLUSIONS

Based on the research conducted, it can be concluded that Time Series analysis using the Least Squares method has been able to forecast chicken egg production and demand. From the analysis of historical data that has been conducted, the forecast results for production in December 2023 were 1352 eggs, with an error of 6.9% from the actual data of 1367 eggs. Meanwhile, for egg demand data, the forecast result was 1391 eggs with an error of 3.2% from the actual data of 1355 eggs. With error values of less than 10%, the forecast results closely approximate the actual outcomes. The results of the production and demand forecasts for chicken eggs can then be used by the company to make decisions regarding future production and demand challenges.

Suggestions for Future Research:

· Exploring Alternative Forecasting Methods – Future studies could compare the Least Square Method with other forecasting techniques, such as Artificial Neural Networks (ANN), ARIMA, or Machine Learning models, to evaluate accuracy and efficiency.

· Incorporating External Factors – Further research could integrate external variables such as weather conditions, feed quality, and market trends to improve the accuracy of egg production and demand forecasting.

· Real-Time Data Analysis – Future work could develop a real-time forecasting system using IoT and cloud computing to enhance decision-making for poultry farmers.

· Long-Term Forecasting Studies – Expanding the study to cover longer periods and different regions could provide more

comprehensive insights into egg production and market demand patterns.

· Economic and Policy Implications – Investigating the economic impact of egg production forecasting on supply chain management and government policies could add value to the field.

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