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Forecasting Food Industry Enterprises in Ciamis Using Holt Winter Linear Trend Method

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ABSTRACT

The food industry sector in Ciamis Regency plays an important role in driving regional economic growth and employment. Understanding its future trend is essential for supporting policy formulation and industrial development strategies. To predict the number of food sector businesses in Ciamis Regency, this study uses the Holt-Winters Linear Trend method. The number of food industry enterprises has shown fluctuating and declining patterns in recent years, raising the question of how accurately the Holt-Winters Linear Trend method can predict future non-seasonal trends. This study provides a new application of the Holt-Winters Linear Trend method for forecasting non-seasonal industrial data at a regional level, an area rarely explored in previous research on small-scale industries. The method was implemented in Python, and performance was evaluated using MAE, MSE, RMSE, MAPE, and R^2. The forecast shows that the number of food industry enterprises will reach 92 units in 2026, 77 in 2027, 89 in 2028, 75 in 2029, and 86 in 2030, with an accuracy of 93.40%. For future studies, ensemble forecasting is recommended, with related variables such as labor numbers and production value added to enhance method performance.
Keywords: Accuracy, Economy, Evaluation, Fluctuation, Trend.

ABSTRAK

Industri usaha makanan di Kabupaten Ciamis berperan penting dalam mendorong pertumbuhan ekonomi daerah dan penyerapan tenaga kerja. Data jumlah industri usaha makanan di Kabupaten Ciamis menunjukkan adanya fluktuasi dengan kecenderungan menurun, sehingga diperlukan peramalan untuk memperoleh gambaran tren ke depan serta mendukung strategi perencanaan pengembangan industri makanan. Metode *Holt Winters Linear Trend* dipilih karena mampu meramalkan data tahunan dengan pola tren naik maupun turun tanpa pengaruh musiman, sesuai dengan karakteristik data industri usaha makanan di Kabupaten Ciamis. Hasil peramalan menunjukkan bahwa jumlah industri usaha makanan di Kabupaten Ciamis diprediksi mencapai 92 unit pada tahun 2026, 77 unit pada tahun 2027, 89 unit pada tahun 2028, 75 unit pada tahun 2029, dan 86 unit pada tahun 2030. Evaluasi model memberikan hasil dengan nilai MAE sebesar 5,36, MSE sebesar 58,04, RMSE sebesar 7,62, MAPE sebesar 6,60%, dan R^2 sebesar 0,5046, yang menunjukkan tingkat akurasi peramalan mencapai 93,40%. Untuk pengembangan selanjutnya, sebaiknya dilakukan *ensemble forecasting* dengan menambahkan data peramalan dengan variabel terkait seperti jumlah tenaga kerja serta nilai produksi industri pengolahan makanan.
Kata Kunci: Akurasi, Ekonomi, Evaluasi, Fluktuasi, Tren

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1. INTRODUCTION

The industrial business sector plays a vital role in driving regional economic growth (1,2). Micro, Small, and Medium-Sized Enterprises (MSMEs) employ over 97% of Indonesia's workforce and provide over 61% of the country's Gross Domestic Product (GDP), making them one of the main pillars sustaining the national economy (3). Ciamis Regency, as one of the developing regions in West Java, has various types of enterprises ranging from small to medium scale, with the food industry being one of the most prominent sectors (4). The presence of food industry enterprises significantly contributes to regional economic growth and employment absorption (5).

The number of food industry enterprises in Ciamis Regency has shown fluctuating and declining trends in recent years. This situation indicates the need for a reliable forecasting method to provide future insights that can support strategic planning and decision-making in the development of the local food industry. The available data remain historical and do not adequately represent future dynamics, which limits policymakers' ability to anticipate industrial trends effectively.

Previous studies have applied various time series forecasting methods across different fields. The Double Exponential Smoothing Brown model achieved an MAPE of 0.889% for forecasting Indonesia's total birth rate but relied on a single variable (6). The Holt-Winters Exponential Smoothing method reached an MAPE of 4.42% in predicting Indonesia's Gross Domestic Product, yet parameter optimisation was not performed (7). The Fuzzy Time Series Chen model showed a MAPE of 13.49% in forecasting foreign tourist arrivals in Bali, while the Average-Based variant recorded 44.57% for rainfall prediction in Melawi, both facing accuracy limitations (7,8). The Holt Winters method was successful in capturing seasonal and trend patterns in the U.S. furniture industry, despite its tendency to yield somewhat conservative projections (9).

Most previous research focused on macroeconomic, tourism, and meteorological data. Applications at the regional industrial level, particularly for forecasting the number of food industry enterprises using annual data, remain limited. The Holt-Winters Linear Trend method can forecast time series data with upward or downward trends without seasonal effects, making it suitable for annual data such as the number of food industry enterprises in Ciamis Regency (10). Forecasting enables a more systematic analysis of changes in industrial growth patterns, providing clearer insights into the future development trajectory of the regional food industry.

The purpose of this study is to predict the number of food sector businesses in Ciamis Regency by using and assessing the Holt-Winters Linear Trend method. The results are expected to serve as a foundation for strategic policy formulation and to provide recommendations for sustainable industrial development at the regional level.

2. MATERIAL AND METHODS

2.1. Food Industry Enterprises in Ciamis Regency

The food industry sector in Ciamis Regency plays a significant role in assisting regional economic growth. Based on industrial data, this sector has shown continuous growth over the years, as reflected by the increasing number of small, medium, and household-scale enterprises engaged in food processing (4). More broadly, the contribution of Micro, Small, and Medium Enterprises (MSMEs), including the food industry, is also substantial to the national economy. MSMEs employ over 97% of Indonesia's labor force and account for

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about 61% of the country's GDP, making them a key driver of economic activity (3). The existence of the food industry not only serves as a source of livelihood for local communities but also strengthens regional identity through distinctive local products that are competitive in both regional and national markets (4).

A study on the household banana chips industry in Selamanik Village, Cipaku District, shows that this business is financially feasible, with an R/C ratio of 1.11. This indicates that every IDR 1,000 of production cost yields a return of IDR 1,110, demonstrating its profitability and contribution to regional economic development (4). Given the continuous growth of the food industry, it is necessary to conduct analysis and forecasting using statistical methods, such as the Holt-Winters Linear Trend method, to estimate the number of food industries in the future. This can support the formulation of more targeted and effective regional economic development strategies aligned with local needs.

2.2. Forecasting

Forecasting is an analytical technique used to predict future values by identifying patterns in sequentially organised historical data (6). In the context of the food industry in Ciamis Regency, forecasting is conducted to understand the potential development of the number of food industry enterprises in the upcoming periods. The information generated from forecasting is highly important, as it serves as a foundation for policy formulation, strategic planning, and the development of the food industry sector by both government authorities and business actors. The forecasting results are crucial as a basis for designing policies, strategic planning, and industrial sector development initiatives (11).

Time series forecasting methods in the food processing industry help the government and business owners project how the number of business units may change in the future, allowing for more targeted investment planning and development. Recent studies show that forecasting is crucial for contemporary production systems because it directly contributes to the efficiency of industrial operations, including resource allocation and supply chain management (12,13).

2.3. Forecasting Flowchart

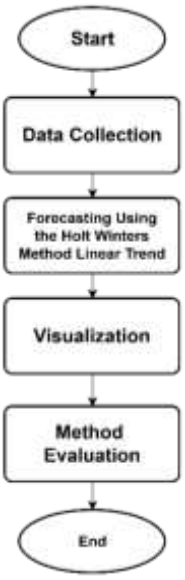

Figure 1. Forecasting Flowchart

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Figure 1 shows the process of forecasting the number of food industry companies in Ciamis Regency using the Holt-Winters Linear Trend method, which consists of several stages. The process begins with data collection, obtained by scraping results from Google Maps and OpenStreetMap using the Instant Data Scraper tool. The next step is forecasting using the Holt-Winters Linear Trend method, followed by visualizing the forecasting results thru graphical representation. The final stage involves an evaluation matrix, which is created by calculating several evaluation metrics, namely Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Percentage Error (MAPE), Coefficient of Determination (R^2), and Accuracy.

2.4. Data Collection

The data used in this study were obtained through a scraping process carried out on Google Maps and OpenStreetMap. The objective was to identify and collect information related to food industry enterprises operating in Ciamis Regency. To support this process, the Instant Data Scraper extension from webrobots.io was employed, which automates the extraction of relevant information from HTML pages (14). The scraping was conducted by examining each district in Ciamis Regency and recording the food-related industrial activities found within the area. The results were then organised into an Excel file, which included the year of observation and the number of food industry enterprises for each corresponding year.

The results of data collection on the number of food industry enterprises in Ciamis Regency include the years and the corresponding number of enterprises from 2015 to 2025, as presented in Table 1.

Table 1. Food Industry Enterprises Data

Year	Number of Food Industry Enterprises
2015	105
2016	73
2017	97
2018	81
2019	93
2020	83
2021	84
2022	82
2023	82
2024	95
2025	65

Table 1 shows that the scraped data indicate there were 105 units of food industry enterprises in 2015, 73 units in 2016, 97 units in 2017, 81 units in 2018, 93 units in 2019, 83 units in 2020, 84 units in 2021, 82 units in 2022, 82 units in 2023, 95 units in 2024, and 65 units in 2025.

2.5. Holt Winters Linear Trend

The Holt-Winters Linear Trend method is an extension of the Exponential Smoothing technique used for forecasting time series data that exhibit a trend pattern. This method incorporates both level and trend components into the forecasting process, enabling it to

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capture upward or downward tendencies in data over time (15). One of the main advantages of this method is its computational simplicity, while still providing sufficiently accurate forecasting results for dynamic data (16).

In its application, the Holt-Winters method updates prediction values through a weighted combination of actual data and previous period estimates (17). The three main parameters, level smoothing, trend smoothing, and seasonal smoothing, are optimised to minimise forecasting errors (18). Due to its flexibility in adapting to changes in data patterns, this method performs better than a simple linear trend method, which only captures trends without accounting for seasonal variations (9).

The stages of the Holt-Winters Linear Trend method begin by determining the initial values of the level and trend, followed by a recursive smoothing process for each new period, updating both components continuously (17). The resulting forecasts are then compared with the actual data to assess accuracy using indicators such as the Mean Absolute Percentage Error (MAPE).

In the context of this study, the Holt-Winters Linear Trend method is applied to forecast the number of food industry enterprises in Ciamis Regency. Through this approach, the pattern of changes in the number of industries over the years can be analysed more systematically, and the results are expected to provide a more accurate depiction of future developments in the regional food industry sector. The Holt-Winters Linear Trend approach incorporates two key elements: the level and the trend (19,20). Both components are continuously updated from one period to the next using exponential weighting. The mathematical expressions used to estimate the level and trend are provided in equations (1), (2).

$$\text{Level} = L_t = \alpha Y_t + (1-\alpha)(L_t - 1 + T_t - 1) \quad (1)$$

$$\text{Trend} = Tt = \beta(L_t - L_t - 1) + (1-\beta)T_t - 1 \quad (2)$$

Equation (1) provides an updated value of the level at time. This value is obtained by combining the actual observation with the previous level adjusted by the prior period's trend. The smoothing parameter controls how much emphasis is placed on the most recent observation, so a larger value makes the level more responsive to recent changes (20,21). Equation (2) refines the trend component by smoothing the difference between consecutive levels; the parameter determines how quickly the trend adapts to new information, while the term preserves some influence of the previous trend to avoid abrupt shifts (19,22). Recent reviews and applied studies also highlight practical issues such as parameter optimization and model selection when using Holt–Winters for economic, meteorological, and epidemiological time series (20,23).

2.6. Visualization

Once the forecasting process was completed, the results were visualised to make the outcomes easier to interpret and to present the overall pattern more clearly. Both the historical data and the forecasted values were displayed in a graphical format that illustrates the year-to-year changes in the number of food industry enterprises. This visualisation allows for direct comparison between the observed figures and the projected trends, making it easier to identify general patterns such as growth, decline, or fluctuations. The graph also highlights the transition point between the actual data and the forecasted period, providing a more intuitive understanding of how the Holt-Winters Linear Trend method captures and extends the underlying patterns present in the dataset.

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2.7. Method Evaluation

The final stage following the forecasting process is the evaluation of the method, which is carried out by calculating several performance metrics, namely the Mean Absolute Error (MAE), Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Coefficient of Determination (R^2), Mean Absolute Percentage Error (MAPE), and overall accuracy (24).

The formula used to calculate the Mean Absolute Error (MAE) is presented in equation (3).

$$\text{MAE} = \frac{1}{n}\sum_{i=1}^{n} |y_{i-} \hat{y} \quad (3)$$

MAE reflects the average magnitude of absolute deviations between the actual values and the forecasted results, offering a straightforward indication of how far the predictions diverge from the observed data without considering the direction of the error (25). MAE provides an intuitive and interpretable measure of performance because each error contributes proportionally to the final score (26).

The formula used to calculate the Mean Squared Error (MSE) is presented in equation (4).

$$\text{MSE} = \frac{1}{n}\sum_{i=1}^{n}(P_{i-}P_o)^2 \quad (4)$$

MSE represents the average of the squared differences between actual and predicted values by assigning greater weight to larger errors; it becomes particularly useful for identifying methods that may produce unstable or inconsistent predictions (25).

The formula used to calculate the Root Mean Squared Error (RMSE) is presented in equation (5).

$$\text{RMSE} = [\frac{1}{n}\sum_{i=1}^{n}(P_{i-}P_o)^2]^{\frac{1}{2}} \quad (5)$$

RMSE, as the square root of MSE, expresses the error in the same unit as the original data, making its interpretation more intuitive in practical contexts (25). RMSE is particularly helpful when stakeholders require a precise, usable sense of forecasting accuracy, such as in manufacturing units, sales volume, or the number of businesses. Furthermore, because RMSE penalizes bigger mistakes more severely, it can show whether the forecasting model occasionally produces considerable deviations, which is a crucial measure of the model's stability and dependability over time (27,28).

The formula used to calculate the R^2 Score is presented in equation (6)

$$R^2 \text{ Score} = 1 - \frac{\sum(yi-\hat{y}i)2}{\sum(yi0y-i)2} \quad (6)$$

R^2 Score indicates the extent to which the method can explain variations in the historical dataset values. Closer to 1 signifies a stronger explanatory power (29) .

The formula used to calculate the Mean Absolute Percentage Error (MAPE) is presented in equation (7)

$$\text{MAPE} = \frac{100\%}{n}\sum_{i=1}^{n} |\frac{y_{i-}\hat{y}_i}{yi}| \quad (7)$$

MAPE measures the average percentage deviation between the actual and predicted values, providing a clear perspective on the forecasting accuracy in percentage terms (30).

The formula used to calculate Accuracy is presented in equation (8)

$$\text{Accuracy} = \frac{1}{n}\sum_{i=1}^{n} 1(|y_i - \hat{y}_i \leq r) \text{ x } 100\% \quad (8)$$

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Accuracy in forecasting serves to evaluate the proportion of predicted values that fall within an acceptable margin of error. The accuracy value is derived from the percentage of predictions whose absolute differences from the actual data remain within a defined tolerance limit. A higher accuracy score indicates superior model performance in generating estimates that closely represent real conditions, making this metric essential for ensuring the quality and reliability of forecasting methods in practical applications (31).

3. RESULTS AND DISCUSSION

3.1. Data Collection

The dataset gathered for this study represents the number of food industry enterprises in Ciamis Regency from 2015 to 2025. It contains two main fields: the year and the corresponding count of food-related enterprises recorded in that period. This information later served as the foundation for generating forecasts using the Holt-Winters Linear Trend method, allowing the historical figures to guide the projection of future developments.

3.2. Forecasting Using the Holt Winters Linear Trend

The forecasting process using the Holt-Winters Linear Trend method begins by identifying the year and the number of food industry enterprise columns, then converting them into an annual time series format to align with the historical data pattern of the food industry in Ciamis Regency. The forecasting is conducted to predict the number of food industry enterprises for the next five years.

Table 2. Forecasting Results

Year	Number of Food Industry Enterprises
2026	92
2027	77
2028	89
2029	75
2030	85

Table 2 displays the forecasting results for the next five years, from 2026 to 2030. Businesses in the food sector are expected to number 92 in 2026, 77 in 2027, 89 in 2028, 75 in 2029, and 86 in 2030. These fluctuations demonstrate the nonlinear expansion of food-related enterprises in Ciamis Regency, reflecting the dynamic nature of the sector. The forecast rises in other years might point to new business opportunities or improved economic conditions, while the expected declines might point to issues like market saturation, rising operational costs, or limited access to resources. Overall, the outlook indicates that although the industry is expected to continue operating, it may experience periodic contractions and expansions, highlighting the need for strategic intervention and policy assistance to ensure long-term growth.

3.2. Visualization

The number of food industries in Ciamis Regency is represented graphically in Figure 2, which is based on predicted results and historical data. An orange dashed line displays the projected values, while a blue line with dots and numerical labels for each year represents the historical data. To distinguish between the predicted and historical data, a vertical line is applied. According to the forecasted data, there will be 92 food industries in 2025; 77 in 2026; 89 in 2027; 75 in 2029; and 86 in 2030.

The pattern of oscillations throughout time is easier to see thanks to this graphical form,

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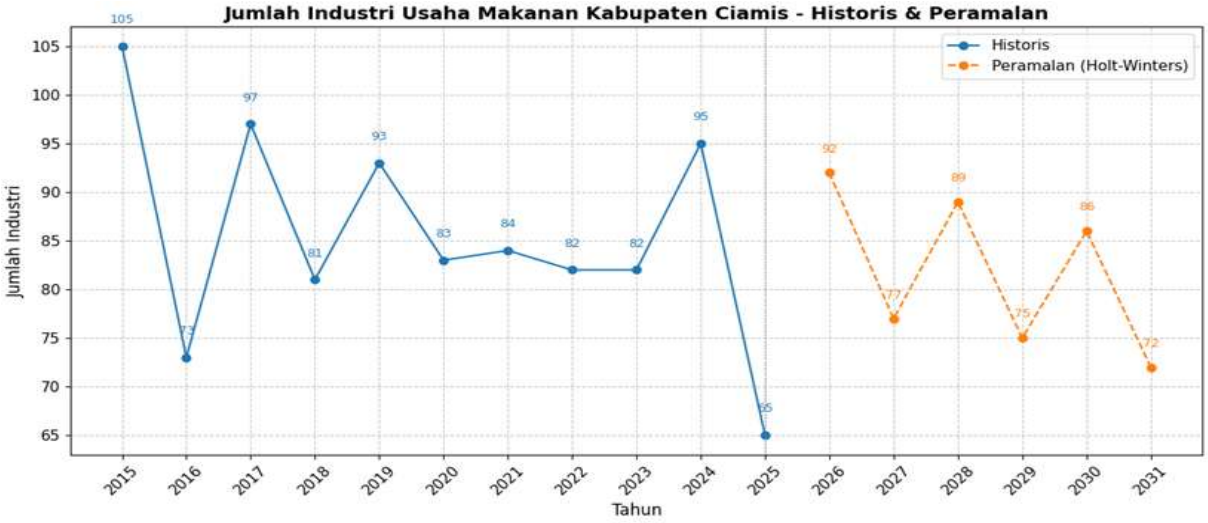
which offers a clearer visual comparison between historical trends and future projections. The food industry sector in Ciamis Regency may be impacted by external variables such as market demand, company competition, raw material availability, and changes in government laws, according to the alternating upward and downward movements. These fluctuations demonstrate the industry's dynamic character and emphasize the significance of ongoing observation and strategic planning to promote long-term prosperity.

Figure 2. Historical Data and Forecasting Chart



3.3. Method Evaluation

The evaluation of the Holt-Winters Linear Trend method used for forecasting the number of food industries in Ciamis Regency produced an MAE value of 5.36, an MSE value of 58.04, an RMSE value of 7.62, a MAPE value of 6.60%, and an R^2 value of 0.5046. This indicates that the method is capable of explaining 50.46% of the data variation, with a forecasting accuracy of 93.40%. A previous study titled "A Comparison Study on Fuzzy Time Series and Holt-Winter Model in Forecasting Tourist Arrival in Langkawi, Kedah" reported an accuracy value of 89.93% and a MAPE value of 10.06% [16]. Based on these results, the forecasting of the number of food industry enterprises in Ciamis Regency using the Holt-Winters Linear Trend method shows an improvement in accuracy by 3.47%, reaching 93.40%.

3.4. Advantages of the Holt Winters Linear Trend Method

The evaluation and forecasting results show that the Holt-Winters Linear Trend approach has a number of noteworthy advantages. It can capture both upward and negative trends indicated in the historical records, and it works well with annual datasets that don't show seasonal variations. With a MAPE of 6.60%, an accuracy rate of 93.40%, and an R2 score of 0.5046, the approach yielded performance measures that show a reasonably dependable level of accuracy when predicting the number of food sector businesses in Ciamis Regency. These results indicate that the Holt–Winters Linear Trend approach is a reasonably good technique for this kind of study, accounting for about 50.46% of the variation in the data.

3.5. Limitations of the Holt Winters Linear Trend Method

Based on the forecasting results and the subsequent evaluation, the Holt-Winters Linear Trend method also presents several limitations. The approach is not suitable for datasets that contain seasonal patterns, as it is designed to method trend components only. Its performance is highly dependent on the quality and stability of the historical data; longer and more

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consistent time series generally produce more reliable forecasts. In addition, the method is sensitive to extreme fluctuations, meaning that abrupt spikes or irregular variations in the data can reduce the robustness of the method and affect the overall accuracy of the forecasts.

4. CONCLUSION

The forecasting results indicate that the number of food industry enterprises in Ciamis Regency for the next five years is projected to reach 92 units in 2026, 77 units in 2027, 89 units in 2028, 75 units in 2029, and 86 units in 2030. The evaluation of the Holt-Winters Linear Trend method produced an MAE value of 5.36, an MSE value of 58.04, an RMSE value of 7.62, a MAPE value of 6.60%, and an R^2 value of 0.5046, indicating that the method explains approximately 50.46% of the data variation. The forecasting accuracy achieved 93.40%.

Based on the forecasting and evaluation results, it is suggested that future research expand the dataset to include not only the year and the number of food industries but also other relevant variables, such as the number of workers in the food industry and the production value of food and beverage processing industries. Additionally, to reduce forecasting errors and improve stability, ensemble forecasting approaches combining multiple methods or algorithms can be applied.

AUTHOR CONTRIBUTIONS

Irfan Permana: The author contributed to the conceptualisation, methodology, data collection, data curation, writing the original draft, and visualisation of this study.
Alam Rahmatulloh: The author contributed solely to the review of this article.

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CONFLICT OF INTEREST

All the authors declare that there are no conflicts of interest.

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