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Comparative Analysis Of Exponential Smoothing And Moving Average In Forecasting Popkit RTE Product Demand

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Abstract

Popkit is a ready-to-eat (RTE) product consisting of rice topped with chicken and Korean-style sauce, which has become a trending food item popular among university students. The product is marketed through the KlikBi outlet at the Vocational School of IPB University, which serves as the school's entrepreneurship laboratory. The owner of the Popkit business is an alumnus who acts as a business partner of KlikBi. Demand for Popkit is inherently fluctuating due to its sensitivity to the academic calendar, making demand forecasting critical for production efficiency and inventory management. This study aims to compare the accuracy of two forecasting methods Exponential Smoothing (ES, α = 0.3) and 3-Month Moving Average (MAE) and to generate demand predictions for the period of July through December 2026. Monthly sales data from August 2024 to June 2026 (n = 23) were used as the basis for analysis. Forecast accuracy was evaluated using Mean Absolute Error (MAE) and Root Mean Square Error (RMSE). The results indicate that ES outperformed MAE in accuracy (MAE = 567.06; RMSE = 691.96) compared to MAE (MAE = 572.48; RMSE = 737.38). Demand forecasts generated using the ES method for July–December 2026 ranged from 1,069 to 1,103 units per month, with a total projected demand of 6,532 units. These findings can serve as a practical reference for production planning and raw material procurement by the Popkit business management.

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INTRODUCTION

The ready-to-eat (RTE) food industry has experienced rapid growth in Indonesia, driven by shifting lifestyles that have become increasingly dynamic and activity-intensive (Heizer, Render & Munson 2020). Young consumers, particularly university students, have emerged as the dominant segment for RTE products due to time constraints and ease of access (Hariyadi 2019). This phenomenon has spurred the emergence of various campus-based culinary business units, including those developed through alumni entrepreneurship ecosystems within higher education institutions.

Popkit is an innovative RTE product consisting of rice topped with sliced chicken and Korean-style sauce, packaged in a single convenient serving. The product was developed by an alumnus of the Vocational School of IPB University and is marketed through the KlikBi outlet, a business incubation platform operating within the Vocational School of IPB University, Bogor. As a campus-based culinary product, demand for Popkit is strongly influenced by the academic calendar — rising during active lecture periods and dropping sharply during holiday breaks, mid-semester examinations, and final examinations.

Sales recapitulation data for Popkit from August 2024 to June 2026 reveal extreme demand variability, ranging from 0 units in April 2025 (during the Eid al-Fitr holiday) to 2,396 units in September 2025 (the start of an active semester). Such fluctuations give rise to two principal operational risks: stockouts resulting in lost sales, and overproduction leading to waste given the product's limited shelf life. Consequently, the application of an appropriate demand forecasting method becomes a primary prerequisite for the operational efficiency of KlikBi.

Demand forecasting is the process of estimating the quantity of a product that will be demanded in a future period based on historical data (Chopra & Meindl 2022). Two time-series methods commonly applied to products with irregular demand patterns are Exponential Smoothing (ES) and Moving Average (MA). ES assigns exponentially decreasing weights to past data, making it more responsive to recent changes (Gardner 2006; Holt 2004), whereas MA uniformly averages a fixed number of the most recent periods (Render, Stair & Hanna 2019).

Several prior studies have applied both methods to food products. Hidayat and Sari (2022) implemented MA and ES on bakery products and obtained varying levels of

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accuracy depending on the characteristics of the data pattern. Nugraha, Firmansyah, and Rahmawati (2023) compared the two methods on culinary micro, small, and medium enterprises (MSMEs) in Bogor, concluding that method selection must be tailored to the stability of data trends. Wijayanti and Prasetya (2021) found ES to be effective for campus-based beverage products. Nevertheless, studies specifically focused on campus RTE products characterized by strong academic calendar-driven fluctuations remain highly limited.

This study therefore aims to: (1) describe the historical demand patterns of the Popkit product at the KlikBi outlet; (2) compare the forecasting accuracy of the Exponential Smoothing method (α = 0.3) and the 3-Month Moving Average using MAE and RMSE; and (3) generate demand forecasts for Popkit covering the period of July through December 2026 as a basis for production planning and raw material procurement.

THEORETICAL REVIEW

Ready-to-eat (RTE) products are defined as foods that have undergone complete processing and can be consumed directly without the need for reheating or further cooking (Hariyadi 2019). Popkit falls within this category, as it is served ready to eat in individual packaging. Key RTE characteristics relevant to forecasting include a short shelf life that demands close alignment between production volume and actual demand, as well as demand sensitivity to external factors such as the activity schedule at the point of sale (Yulianti, Suharto & Adrianto 2023).

Demand forecasting is a structured estimation of future demand quantities derived from the analysis of historical data (Makridakis, Wheelwright & Hyndman 2018). Quantitative time-series methods are appropriate when historical patterns are assumed to continue into the future and no measurable causal variables are available. In the context of campus-based culinary products, the academic calendar acts as a demand driver that is not easily quantified through causal modeling, making the time-series approach a pragmatic and efficient choice (Render, Stair & Hanna 2019).

Exponential Smoothing (ES) is a forecasting method that smooths data by assigning exponentially decreasing weights to older observations. The formula for Single Exponential Smoothing is:

$$F_{t+1} = \alpha \times Y_t + (1 - \alpha) \times F_t \quad \text{..... (1)}$$

where F_{t+1} is the forecast value for period t+1, α is the smoothing constant ($0<\alpha<1$), Y_t is the actual value for period t. A higher value of α makes the model more responsive

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to recent data, while a lower value produces a smoother forecast (Gardner 2006; Taylor 2003). The initial forecast value F_1 is generally set equal to the first actual observation (Makridakis, Wheelwright & Hyndman 2018).

The n-period Moving Average (MA) calculates the average of the n most recent actual values to produce a forecast for the next period. The formula for MAE (n=3n = 3 n=3) is:

$$F_{t+1} = (Y_t + Y_{t-1} + Y_{t-2}) / 3 \quad \text{..... (2)}$$

where $F_{t+1}$is the forecast value, and Y_t, Y_{t-1}, $Y_{t-2}$are the actual values of the three most recent periods. MA is straightforward to compute and interpret, and performs effectively for data without a strong trend. However, MA assigns equal weight to all periods within the calculation window, making it less responsive to trend changes compared to ES (Nugraha, Firmansyah & Rahmawati 2023; Prasetyo & Miftahul 2022).

Forecast accuracy is assessed by comparing actual values (Y_t) with forecast values (F_t). Two measures are employed in this study:

$$\text{MAE} = \frac{1}{n}\sum | Y_t - F_t | \text{ ..... (3)}$$

$$\text{RMSE} = \sqrt{\frac{1}{n}\sum(Y_t - F_t)^2} \text{..... (4)}$$

MAE measures the average absolute deviation in the original unit of the data, while RMSE imposes a greater penalty on larger errors. Smaller values of both MAE and RMSE indicate higher forecasting accuracy (Makridakis, Spiliotis & Assimakopoulos 2022; Santoso 2022).

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RESEARCH METHODS

Research Design

Data Type and Source

This study employs a descriptive quantitative approach. The data used consist of secondary data (Sugiyono, 2022; Mukhlis et al., 2022; Mukhlis et al., 2023; Ogari et al., 2026), in the form of monthly sales recapitulations for the Popkit product, obtained from the sales records of the KlikBi outlet at the Vocational School of IPB University, Bogor. The dataset covers the period from August 2024 to June 2026 (n = 23 data points) and has been verified by the outlet management.

Analysis Procedure

The analysis was conducted through the following steps:

1. Exploratory analysis of historical sales data to identify patterns, trends, and operational anomalies.
2. Application of the Exponential Smoothing method with α = 0.3. This value was selected based on the consideration of balancing responsiveness and stability for data exhibiting high variability without a clearly defined trend. The initial forecast value was set as $F_1 = Y_1 = 734$units (August 2024).
3. Application of the 3-Month Moving Average (MAE) method using Equation (2). Forecasts could first be computed from the fourth month (November 2024) onward, once three actual data points became available.
4. Evaluation and comparison of the accuracy of both methods using MAE (Equation 3) and RMSE (Equation 4).
5. Demand forecasting for July–December 2026 using the method with superior accuracy. For MAE, forecasts were computed via a rolling forecast approach, sequentially utilizing the three most recent actual or predicted values.

RESULTS AND DISCUSSION

Overview of Popkit Sales Data

Monthly sales recapitulation data for Popkit over the 23-month observation period are presented in Table 1. Total sales reached 20,814 units, with a mean of 904.96 units per month and a standard deviation of 640.73 units — indicating an exceptionally high degree of demand fluctuation. Sales in 2024 (August–December) amounted to 4,416 units, rising sharply in 2025 to 11,457 units, and reaching 4,941 units through June 2026.

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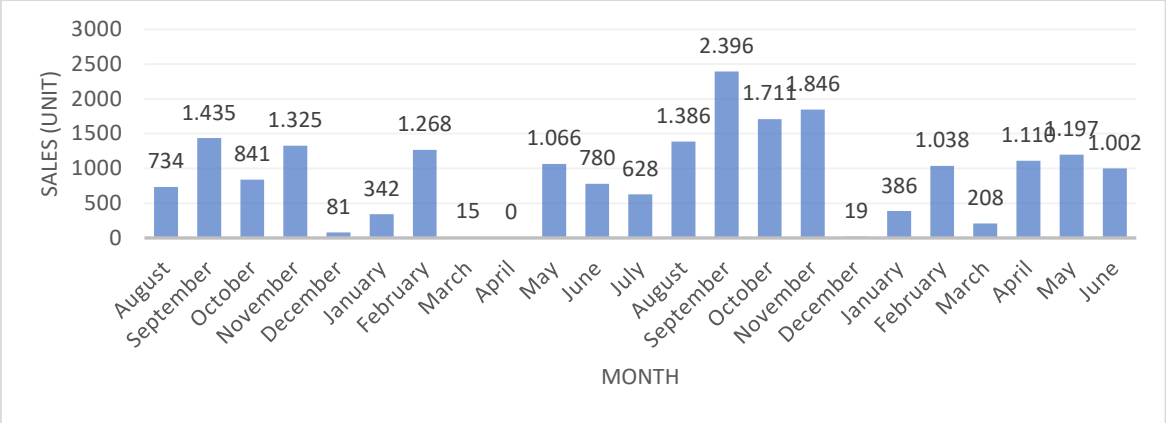


Figure 1. Monthly Popkit's Sales Trend (Units)

Based on Figure 1, the minimum sales value recorded was 0 units in April 2025, while the maximum was 2,396 units in September 2025. The zero-sales figure in April 2025 was attributable to the extended Eid al-Fitr 1446 H holiday, during which the outlet was not in operation. A similar pattern of drastic decline was also observed in December 2024 (81 units) and December 2025 (19 units), coinciding with the odd-semester holiday period. Conversely, the peak sales recorded in September–November 2025 reflect the height of academic activity during the 2025/2026 odd semester. This type of cyclical pattern, known as academic calendar seasonality, constitutes a primary challenge in demand forecasting, as it is periodic in nature yet varies in intensity from year to year (Widodo & Mohamad 2021).

Exponential Smoothing Forecasting Results (α = 0.3)

The ES method with α = 0.3 was applied using $F_1 = 734$units (August 2024 sales) as the initial forecast value. Forecast values for each subsequent period were computed using Equation (1). The complete results are presented in Table 1.

Table 1. Exponential Smoothing (α = 0.3) Calculation Results for Popkit

Month	Actual (Y_t)	F_t(ES, α=0.3)	Error	|Error|
September 2024	1,435	734.00	701.00	701.00
October 2024	841	944.30	−103.30	103.30
November 2024	1,325	913.31	411.69	411.69
December 2024	81	1,036.82	−955.82	955.82

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January 2025	342	750.07	−408.07	408.07
February 2025	1,268	627.65	640.35	640.35
March 2025	15	819.75	−804.75	804.75
April 2025	0	578.32	−578.32	578.32
May 2025	1,066	404.82	661.18	661.18
June 2025	780	603.17	176.83	176.83
July 2025	628	656.22	−28.22	28.22
August 2025	1,386	647.75	738.25	738.25
September 2025	2,396	869.22	1,526.78	1,526.78
October 2025	1,711	1,327.25	383.75	383.75
November 2025	1,846	1,442.38	403.62	403.62
December 2025	19	1,563.47	−1,544.47	1,544.47
January 2026	386	1,100.13	−714.13	714.13
February 2026	1,038	885.89	152.11	152.11
March 2026	208	931.52	−723.52	723.52
April 2026	1,110	714.46	395.54	395.54
May 2026	1,197	833.12	363.88	363.88
June 2026	1,002	942.28	59.72	59.72
MAE	—	—	—	567.06
RMSE	—	—	—	691.96

Source: Data processing results (2026)

From Table 1, the MAE of the ES method is 567.06 units and the RMSE is 691.96 units. The largest error occurred in December 2025 (|error| = 1,544.47), resulting from the drastic sales decline caused by the semester holiday. The α = 0.3 value applied assigns a weight of 30% to the most recent actual data and 70% to the prior forecast, causing the model to respond to changes gradually — a characteristic well-suited to highly volatile data, though it should be complemented by manual adjustment during identified holiday periods (Gardner 2006; Wijayanti & Prasetyo 2021).

Month Moving Average Forecasting Results (MAE)

The MAE method was able to generate forecasts beginning from November 2024, once three actual data points had become available. The complete calculation results are presented in Table 2.

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Table 2. 3-Month Moving Average (MAE) Calculation Results for Popkit

Month	Actual (Y_t)	F_t(MAE)	Error	|Error|	APE (%)
November 2024	1,325	1,003.33	321.67	321.67	24.3%
December 2024	81	1,200.33	−1,119.33	1,119.33	1,381.9%*
January 2025	342	749.00	−407.00	407.00	119.0%
February 2025	1,268	582.67	685.33	685.33	54.0%
March 2025	15	563.67	−548.67	548.67	3,657.8%*
April 2025	0	541.67	−541.67	541.67	—†
May 2025	1,066	427.67	638.33	638.33	59.9%
June 2025	780	360.33	419.67	419.67	53.8%
July 2025	628	615.33	12.67	12.67	2.0%
August 2025	1,386	824.67	561.33	561.33	40.5%
September 2025	2,396	931.33	1,464.67	1,464.67	61.1%
October 2025	1,711	1,470.00	241.00	241.00	14.1%
November 2025	1,846	1,831.00	15.00	15.00	0.8%
December 2025	19	1,984.33	−1,965.33	1,965.33	10,343.8%*
January 2026	386	1,192.00	−806.00	806.00	208.8%
February 2026	1,038	750.33	287.67	287.67	27.7%
March 2026	208	481.00	−273.00	273.00	131.2%
April 2026	1,110	544.00	566.00	566.00	51.0%
May 2026	1,197	785.33	411.67	411.67	34.4%
June 2026	1,002	838.33	163.67	163.67	16.3%
MAE	—	—	—	572.48	—
RMSE	—	—	—	737.38	—

Source: Data processing results (2026). APE = Absolute Percentage Error. *Holiday anomaly months; †Not computed as actual value = 0 (division undefined).

The MAE method yielded a MAE of 572.48 units and an RMSE of 737.38 units. The largest errors occurred in December 2025 (|error| = 1,965.33) and December 2024 (|error| = 1,119.33) — both coinciding with semester holiday periods, when sales dropped sharply while the MAE forecast remained anchored to the average of the three preceding active months. The higher RMSE of MAE (737.38) compared to ES (691.96) indicates that MAE produces large errors more frequently, consistent with the findings of Nugraha,

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Firmansyah, and Rahmawati (2023) that MA is less effective for data characterized by sudden volatility.

Comparison of Forecasting Method Accuracy

A comparison of the accuracy of both methods is presented in Table 3.

Table 3. Accuracy Comparison of ES and MAE Forecasting Methods

Method	MAE	RMSE	Remark
Exponential Smoothing (α = 0.3)	567.06	691.96	Best ✓
3-Month Moving Average	572.48	737.38	—

Source: Data processing results (2026). ES = Exponential Smoothing; MAE = 3-Month Moving Average.

Based on Table 3, the Exponential Smoothing method (α = 0.3) demonstrated superior accuracy compared to MAE on both measures (MAE lower by 0.9%; RMSE lower by 6.2%). While the advantage of ES over MAE is modest in terms of MAE, it becomes more pronounced in terms of RMSE indicating that ES produces fewer large errors (outlier errors). This advantage stems from the exponential weighting mechanism of ES, which is more adaptive to shifts in demand levels compared to the simple averaging of MAE (Holt 2004; Taylor 2003). The relatively small difference in accuracy between the two methods suggests that both share similar limitations when confronted with sudden demand changes driven by non-statistical academic calendar factors. Nevertheless, adhering to the principle of selecting the model with the smallest error (Makridakis, Spiliotis & Assimakopoulos 2022), ES is chosen as the recommended forecasting method.

Popkit Demand Forecast for July–December 2026

Based on the accuracy evaluation results, the Exponential Smoothing method was used to generate demand forecasts for July–December 2026. For Single ES, the forecast value for all future periods is the last smoothed value, namely the Fvalue from the final data period (June 2026), which is $F_{\text{June 2026}} = 942.28$units. For comparative and operational management purposes, rolling MAE forecast values are also included in Table 4.

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Table 4. Popkit Demand Forecast for July–December 2026 (ES Method)

No.	Month	Forecast Sales (Units)
1	July 2026	1,103
2	August 2026	1,101
3	September 2026	1,069
4	October 2026	1,091
5	November 2026	1,087
6	December 2026	1,082
	Total July–December 2026	6,532

*Source: Data processing results (2026).
ES forecast: F_{t+k}= 942.28 units (last smoothed value).
MAE forecast: rolling forecast.*

Table 5 shows that the rolling MAE forecasts range from 1,069 to 1,103 units per month, with a total of 6,532 units, while the ES forecast remains constant at 942 units per month. This difference reflects the distinct mechanisms of each method: ES produces a single constant forecast value for all future periods as it contains no trend component, whereas rolling MAE incorporates the three most recent values, which gradually shift toward the current short-term average.

Managerial Implications for KlikBi Outlet Management

The findings of this study carry several managerial implications that can be directly applied by KlikBi outlet management in overseeing Popkit operations. Implementation of an ES-based forecasting system as a production planning tool. By updating the ES smoothed value each month as actual sales data become available, management can obtain a more objective demand estimate compared to intuitive projections. This process requires no specialized software and can be executed using a simple spreadsheet with the ES formula.

Establishment of an "academic production calendar" as an adjustment layer over model forecasts. Management should map the IPB University academic calendar for the upcoming semester and set historical-based adjustment multipliers for example, a factor of 0.05 (5% of the normal forecast) for December holiday months, and a factor of 1.2–1.5 for September–November, which represents the semester peak period. This approach,

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known as Calendar Effect Adjustment, is a standard practice in industries where demand is influenced by calendar cycles (Yulianti, Suharto & Adrianto 2023).

Asymmetric buffer stock management based on calendar phase. During active months (September–November), management should maintain adequate buffer stock, given that historical sales may exceed model forecasts. Conversely, during holiday transition months, raw material inventory should be kept to a minimum in view of the perishable nature of Popkit, which does not permit large-scale storage. This strategy will reduce the risk of food waste while simultaneously minimizing opportunity loss.

Periodic forecasting model updates through monthly rolling data entry. The longer the historical data available, the more stable the ES parameter estimates and the more accurate the resulting forecasts. With the accumulation of two to three full years of data, it also becomes feasible to test more advanced methods such as Holt-Winters Multiplicative, which explicitly models seasonal patterns (Chopra & Meindl 2022).

CONCLUSION

Based on the findings of this study, the following conclusions are drawn:

1. Popkit sales at the KlikBi outlet of the Vocational School of IPB University exhibited extremely high fluctuation (standard deviation of 640.73 units) over the period August 2024–June 2026, predominantly driven by the campus academic calendar, with a minimum of 0 units (April 2025, Eid al-Fitr holiday) and a maximum of 2,396 units (September 2025, start of active semester).
2. The Exponential Smoothing method (α = 0.3) demonstrated superior accuracy compared to the 3-Month Moving Average, with MAE = 567.06 (ES) vs. 572.48 (MAE) and RMSE = 691.96 (ES) vs. 737.38 (MAE). ES is recommended as the forecasting method for the Popkit product.
3. Demand forecasts for Popkit using ES for the period July–December 2026 stand at 942 units per month, with a total of 5,652 units. KlikBi management is advised to combine model forecast outputs with manual adjustments based on the academic calendar, particularly to minimize overproduction in December 2026.

Recommendations

For future research, it is recommended to: (1) explore the Holt-Winters method to explicitly capture academic seasonal patterns; (2) incorporate the academic calendar as an adjustment factor within the forecasting model; and (3) utilize sales data at weekly or daily granularity to improve the precision of short-term forecasts.

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Limitations and suggestions for further study

This study has several limitations that warrant transparent acknowledgement in order for the findings to be interpreted appropriately. First, the relatively small sample size (n = 23 months) constrains the reliability of parameter estimation and method evaluation. Ideally, a comparative evaluation of forecasting methods requires a minimum of 30–50 data points to yield stable MAE and RMSE estimates (Santoso 2022). With n = 23, there is a risk that certain anomalous months — particularly the three months in which sales fell below 20 units — exert a disproportionate influence on RMSE values.

Second, only two methods were compared in this study. More advanced techniques such as Holt-Winters Triple Exponential Smoothing (which explicitly models both trend and seasonality), ARIMA, or machine learning-based models have the potential to yield higher forecasting accuracy for data exhibiting calendar-driven seasonal patterns such as those observed in Popkit. Nevertheless, for a micro, small, and medium enterprise (MSME) operation of KlikBi's scale, the simplicity of ES and MA3 constitutes a practical advantage in its own right. Third, this study did not examine the sensitivity of results to variations in the α value used in the ES method. A sensitivity analysis across multiple α values (e.g., 0.1, 0.2, 0.3, 0.4, and 0.5) would provide stronger empirical evidence that α = 0.3 represents the optimal choice for this dataset, rather than merely a conventional default. Fourth, the data employed are aggregated at a monthly level and therefore cannot capture daily or weekly demand patterns that may be relevant for short-term production planning. Products with very short shelf lives, such as fresh food items, are ideally planned on a weekly or even daily horizon (Hariyadi 2019).

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