Forecasting the Usage of Substances in Pharmaceutical Production of Millimed BFS Co., Ltd.

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Abstract

This study aimed to develop and compare forecasting models for the usage of Glucosamine Sulfate, the principal raw material utilized in pharmaceutical manufacturing at Millimed BFS Co., Ltd., with the objective of identifying the model that yields the highest predictive accuracy. The analysis was conducted using monthly usage data spanning from January 2020 to June 2025, comprising a total of 66 observations. The dataset was partitioned into a training dataset of 60 observations and a test dataset of 6 observations.Three forecasting approaches were employed: Linear Regression, Double Exponential Smoothing (DES), and the Box-Jenkins (ARIMA) methodology. The empirical results indicated that the data exhibited an increasing trend over time, with no evidence of seasonal effects, and demonstrated non-stationary characteristics. Model performance was evaluated using Root Mean Squared Error (RMSE) and Mean Absolute Percentage Error (MAPE).The findings revealed that the Linear Regression model achieved the lowest forecasting errors and demonstrated superior predictive accuracy. Consequently, this model was deemed the most appropriate for forecasting future Glucosamine Sulfate usage.

Introduction

Millimed BFS Co., Ltd. is a leading pharmaceutical manufacturer and distributor in Thailand, operating a fully integrated process from raw material procurement and quality control to distribution.This study focuses on **Glucosamine Sulfate**, a high-cost primary raw material used continuously across various medical products within the company.

Without effective forecasting planning, two main issues arise:

- Material Shortages → Production delays
- Excess Inventory → High storage costs

Since the material usage data is sequential, Time Series Analysis is applied to accurately forecast future demand.To serve as a practical guideline for procurement and production planning, reducing uncertainty and improving production cost control.

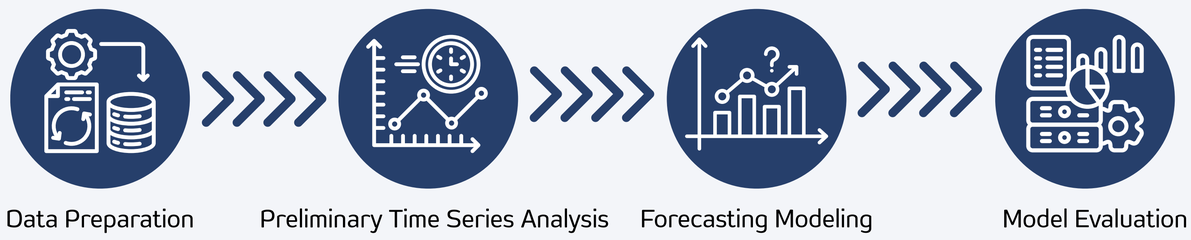
Objectives

- To develop time series forecasting models for the usage of Glucosamine Sulfate in pharmaceutical production.
- To evaluate and compare the performance of the proposed forecasting models.

Methodology

Data Overview: Monthly usage data for 66 months (Jan 2020 – Jun 2025)

Training Set (60 months) Jan 2020 – Dec 2024 | **Testing Set (6 months)** Jan 2025 – Jun 2025



Data Preparation → Preliminary Time Series Analysis → Forecasting Modeling → Model Evaluation

Model

Linear Model

$$\hat{Y}_t = a + bt$$

Double Exponential Smoothing Method

$$\hat{Y}_{t+h} = L_t + hT_t$$

Box-Jenkins (ARIMA) Method

$$\Phi_p(B)(1-B)^d Y_t = \delta + \theta_q(B)\varepsilon_t$$

Result

Table : Results of Time Series Assumption Testing

Time Series Assumption Testing	p-value
KPSS Test	0.01
Runs Test	<0.0001
Kruskal-Wallis Test	0.2747

Analysis of time series characteristics revealed that the p-values for both the stationarity and trend influence tests were significantly below 0.05. This indicates that the data is non-stationary and exhibits a prominent trend. In contrast, the seasonality test yielded a p-value greater than 0.05, suggesting no significant seasonal influence.

Table : Estimated Parameters for the Forecasting Models

Model	a	b
Linear	1399.4	50.943

Model	α	β
DES	0.39	0.41

Model	p	d	q
Box-Jenkins (ARIMA)	0	1	1

Linear Model: Yielded a Y-intercept of 1,399.4 and a slope coefficient of 50.943. Double Exponential Smoothing (DES): The optimal parameters were identified as 0.39 for the level smoothing and 0.41 for the trend smoothing. Box-Jenkins Method: The analysis identified the most suitable model as ARIMA(0, 1, 1), with the following parameters: Autoregressive = 0, Differencing = 1 and Moving Average = 1.

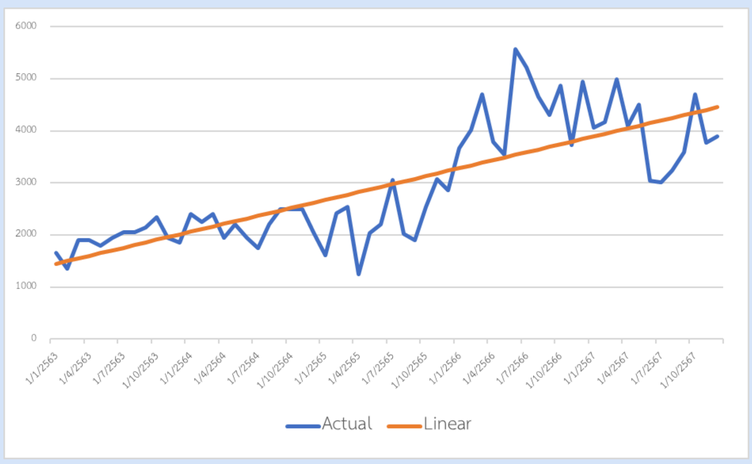
Table : Forecasting Performance Metrics

Model	RMSE	MAPE
Linear	292.0565	5.2376
DES	390.2654	7.0392
Box-Jenkins (ARIMA)	822.7231	15.4087

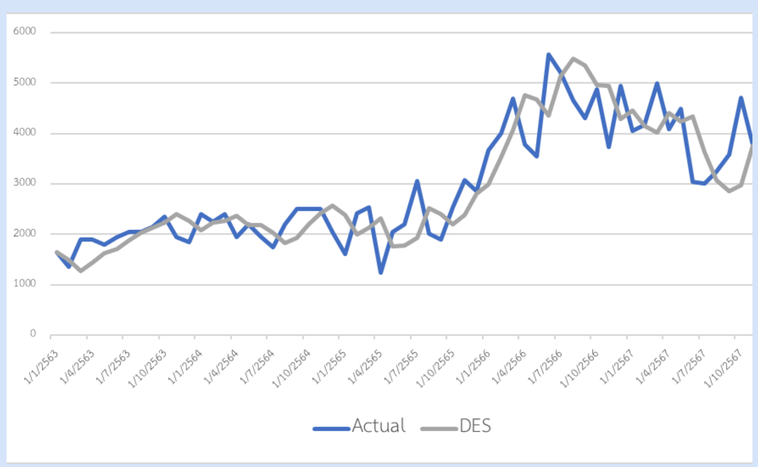
The Root Mean Squared Error and Mean Absolute Percentage Error of the three forecasting techniques were compared to identify the most suitable model. The analysis revealed that the Linear Model achieved the lowest values for both RMSE and MAPE among all tested candidates.

The Fitted Forecasting Equation:

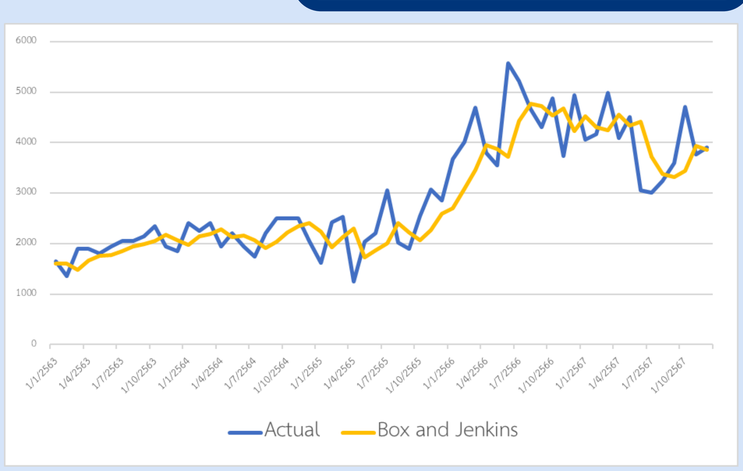
$$\hat{Y}_t = 1399.4 + 50.943t$$



Actual vs. Linear Model Forecast



Actual vs. DES Forecast



Actual vs. Box-Jenkins Forecast

Conclusion & Discussion

The study to develop a forecasting model for Glucosamine Sulfate usage at Millimed BFS Co., Ltd. utilized 66 months of monthly data from January 2020 to June 2025. The data set was divided into 60 months for training and 6 months for testing. Analysis revealed that the time series exhibited a distinct trend without clear seasonal patterns and was non-stationary. Three forecasting techniques–the Linear Model, Double Exponential Smoothing, and the Box-Jenkins (ARIMA) Method were compared systematically. By evaluating accuracy through RMSE and MAPE metrics using Microsoft Excel and R-Studio, the results demonstrated that the Linear Model is the most efficient and suitable model as it produced the lowest error values. This finding provides a reliable guideline for the company's procurement planning and raw material management.

References

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[2] Charoenkha, W. (2024). Forecasting Tap Water Consumption in Nakhon Sawan Municipality Using Time Series Analysis with the Box-Jenkins Technique. Journal of Science and Technology, Nakhon Sawan Rajabhat University, 16(24), 28-40.