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Raw Material Control and Production Planning to Reduce Excess Finished Products (Case Study: UD. ABC)

Thomas Hadi*[1], Herlina [2]

[1,2] Industrial Engineering Study Program, Faculty of Engineering, University of August 17, 1945 Surabaya, Indonesia

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ABSTRACT

UD. ABC is a manufacturing company that produces multi-purpose shelves and plate racks with a make to stock system. UD ABC faces a mismatch between production volume and actual demand, leading to overproduction, excess inventory, and idle money. This study aims to identify the most accurate forecasting method, develop an optimal production plan, and determine raw material requirements with minimum inventory cost. Demand and production data from April 2025 - August 2025 were analyzed using Moving Average, Single Exponential Smoothing, and linear trend, evaluated through MAD, MSE, MAPE, and tracking signal. The selected forecast was used to construct aggregate planning, a Master Production Schedule (MPS), MRP, and safety stock. Results show that the chosen forecasting method reduces deviations between production and demand. The proposed production plan decreases production and storage costs, while MRP yields more efficient raw material requirements. Overall, the proposed planning approach minimizes overstock and improves operational effectiveness.

1. Introduction

Production planning is a crucial element in manufacturing companies because it ensures product availability according to market needs with efficient resource utilization [1]. Inaccuracies in production planning can lead to excess or insufficient inventory, resulting in high storage costs, low capital turnover, and decreased operational performance [2], [3]. In a make-to-stock system, accurate demand forecasting becomes even more crucial because production volume is highly dependent on estimates of future demand [4], [5], [6].

UD. ABC is a manufacturing company that produces multipurpose shelves and dish racks. The production process is carried out continuously based on previous demand patterns without using measurable forecasting methods. This condition causes a mismatch between production volume and demand, as indicated by high ending inventory levels in the period April - August 2025. This inventory buildup leads to overstock, tying up the company's capital (idle money), and increasing the risk of damage and storage costs [7]. On the other hand, when demand suddenly increases, the company can potentially experience stock shortages, which hinder order fulfillment [8].

These issues highlight the need for more systematic forecasting and production planning methods to generate informed production decisions. Demand forecasting is necessary to more accurately estimate demand [9], while aggregate planning and the development of a Master Production Schedule (MRP) are needed to align production capacity with demand [10], [11]. Furthermore, Material Requirement Planning (MRP) and safety stock calculations are needed to determine optimal raw material requirements and minimize the risk of inventory shortages [12].

Although various previous studies have addressed demand forecasting in the manufacturing industry, most studies have focused on selecting a forecasting model without integrating in-depth data characteristic analysis, such as stationarity testing and the need for preprocessing before model implementation. However, the accuracy of a forecasting model is highly dependent on data patterns, whether the data is stationary or exhibits trends, seasonality, or random fluctuations. Previous research has also rarely linked forecasting results directly to the integrated development of aggregate production planning, MRP, and MRP, particularly in

Email: 1412100018@surel.untag-sby.ac.id (Hadi, T)*, herlina@surel.untag-sby.ac.id (Herlina)

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* Writer correspondence

the context of small and medium-sized industries, which face limited resources and relatively fluctuating demand patterns. Furthermore, research on production planning in the SME sector tends to emphasize practical contributions in the form of cost efficiency and increased production accuracy. However, it has not yet provided a theoretical contribution regarding how demand data characteristics influence forecasting method selection and its implications for a more comprehensive production planning framework.

This research's theoretical contribution lies in the integration of stationarity analysis and preprocessing as critical steps in forecasting method selection, providing a stronger basis for determining the best model based on demand data characteristics. This research also expands the literature on the relationship between forecast accuracy and the development of integrated production plans, including Aggregate Planning, JIP, and MRP, particularly in the context of small and medium-sized industries, which tend to experience more volatile demand patterns than large-scale manufacturers. Furthermore, this research develops an analytical framework that integrates forecasting, production planning, and raw material requirements calculations, thus providing a theoretical contribution to the design of a data-driven production planning system. Practically, this research provides recommendations for the best forecasting method for UD. ABC, developing an optimal production plan, and determining raw material requirements with minimum inventory costs to reduce overstock, minimize waste, and improve the company's operational performance.

Based on these conditions, this study was conducted to determine the best forecasting method for UD. Yurike, develop an optimal production plan, and calculate raw material requirements with minimum inventory costs. The research results are expected to provide more effective production planning suggestions to reduce overstock, minimize cost waste, and improve the company's operational performance.

2. Research methods

The method used can be seen in Figure 1 of the following research flow diagram.

2.1 Field Case Study

The steps in this research were to conduct a field case study. Three approaches were used in this study:

a. Observations were conducted by the researcher, who participated in a direct survey at the research location and oversaw the research subjects' production processes for multipurpose shelves and shoe racks. This was useful for the researcher to gain a concrete understanding of the activities taking place within the company.

b. Interviews were conducted through a dialogue process with the owner, foreman, and trusted employees, focusing on frequently encountered challenges within the company.

c. Documentation was conducted through a research approach involving the collection and analysis of company documents, including data on demand, production volume, ending inventory, and other elements relevant to the context of this research..

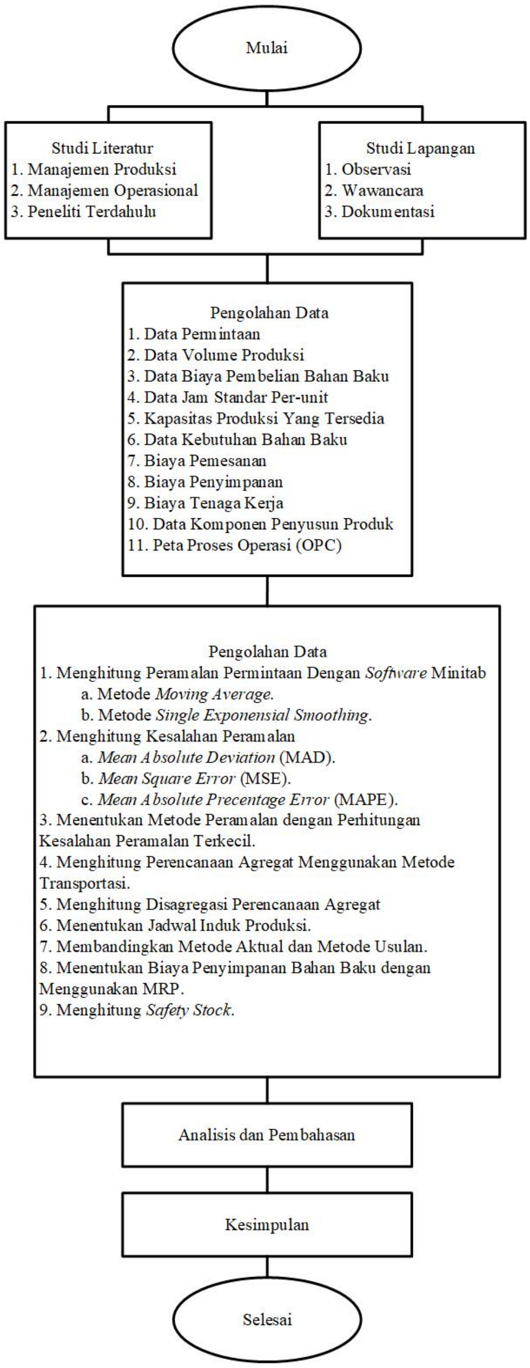


Figure 1 Research process flow

2.2 Data Collection

This stage aims to obtain quantitative and qualitative data to support the problem identification results. The data collected includes production capacity, processing time, number of workers, and the operational conditions of the equipment used. Data obtained for research purposes includes the following:

a. Demand data
b. Production data
c. Standard hours per unit data
d. Available production capacity

e. Raw material requirements data
f. Raw material ordering costs
g. Labor costs
h. Product components.

2.3 *Demand forecasting calculations*

The initial data that has been collected is processed into a form that is ready to be used in the application of the specified method. The data processing process involves several steps [1], [6], including:

2.3.1 *Demand forecasting calculations*

The collected demand data is first processed so that it is ready for use in the forecasting process. This processing stage includes selecting a forecasting method and calculating the error rate to determine the best method. Two methods were used in this study: Moving Average and Single Exponential Smoothing (SES). The Moving Average method calculates forecast values by averaging demand over several previous periods. Meanwhile, the Single Exponential Smoothing method uses a smoothing formula that considers the alpha (α) parameter, which gives greater weight to the most recent data. These two methods were chosen because the characteristics of the demand data in this study tend not to exhibit complex seasonal patterns and are more suitable for analysis with a simple time series approach.

After generating forecast values from each method, this study calculated the forecast error rate to determine the most accurate method. The indicators used were MAD, MSE, and Mean MAPE using the following formula.

a. Moving Average Method
The formula for the Moving Average method:

$$Moving\ Average = \frac{\sum(permintaan\ dalam\ n\text{–}periode\ terdahulu)}{n}$$

(1)

b. Single Exponential Smoothing Method
The formula for the Single Exponential Smoothing method

$$SES = F(t+1) = \alpha\ x\ Y(t) + (1-\alpha)\ x\ F(t)$$

(2)

2.3.2 *Calculation of forecasting errors*

a. *Mean Absolute Deviation (MAD)*
The formula used to calculate MAD:

$$MAD = \sum \frac{At - ft}{n}$$

(3)

b. *Mean Square Error (MSE)*
The formula used to calculate MSE:

$$MSE = \sum \frac{(At - ft)^2}{n}$$

(4)

c. *Mean Absolute Percentage Error (MAPE)*

$$MAPE = \sum \frac{\left(|At - ft| / At\right) 100}{n}$$

(5)

2.3.3 *Determining the smallest forecast error*

Determining the best forecasting method is done by calculating and comparing forecast error values using several error indicators, such as Mean Absolute Deviation (MAD), Mean Squared Error (MSE), and Mean Absolute Percentage Error (MAPE). These three indicators were chosen because they are able to describe the level of deviation of forecast results from actual data from an absolute, quadratic, and percentage error perspective. The evaluation process begins by applying various forecasting methods, then calculating the error value of each model based on historical demand data. The method with the lowest error value is considered to have the best level of accuracy and best fits the data pattern. This approach allows for objective and evidence-based forecasting model selection, thereby minimizing the risk of bias in determining the method to be used in production planning.

2.3.4 *Aggregate planning calculations*

Aggregate planning is designed to determine the optimal production capacity to meet forecasted demand over a specific planning horizon. The calculation procedure involves balancing labor capacity, available working hours, initial inventory levels, and related production costs such as overtime, holding costs, and shortage costs. In this study, an aggregate planning approach is used to develop efficient production scenarios by establishing monthly output levels that meet demand while minimizing total system costs. This analysis results in a more stable and structured medium-term production plan, allowing the company to avoid extreme production fluctuations and optimize the utilization of its resources.

2.3.5 *Master production schedule*

The Master Production Schedule (JIP) is prepared based on the results of aggregate planning to determine the number of final products to be produced in each period. At this stage, information related to machine capacity, production cycle time, and labor availability is integrated to ensure that the production plan can be executed according to the company's actual conditions. The JIP preparation also takes into account the level of safety stock required to anticipate demand uncertainty. The JIP serves as a link between the aggregate plan and Material Requirement Planning (MRP) so that material flow can be planned in a timely, structured manner, and aligned with final production needs.

2.3.6 *Comparison of actual and proposed*

A comparative analysis between the company's actual conditions and the proposed planning results was conducted to identify performance improvements achieved through the approach generated by this study. The comparison included aspects of ending inventory levels, holding costs, demand fulfillment rates, and production schedule stability. The evaluation results indicated that the proposed approach resulted in reduced overstock levels, increased production efficiency, and decreased inventory-related costs. Furthermore, the proposed production plan demonstrated improved material flow control, thereby reducing the risk of raw material shortages and improving capacity utilization accuracy. This evaluation confirmed the effectiveness of a more systematic, data-driven planning approach compared to the current operational pattern.

2.3.7 Material requirements planning (MRP)

Material Requirement Planning (MRP) is designed to determine raw material requirements in a structured and timely manner based on the master production schedule. MRP calculations include material requirement exploration, gross and net requirement determination, and order scheduling through lot sizing. By considering supplier lead times and initial inventory levels, MRP ensures that raw materials are available on schedule without causing excess inventory accumulation. The implementation of MRP in this study aims to optimize raw material procurement costs, improve coordination between production planning and purchasing, and prevent stockouts that can hamper the production process. The calculation results show that MRP is able to provide a more accurate and efficient material requirement planning structure compared to the company's actual practices.

2.3.8 Safety stock calculation

Safety stock calculations are performed to determine the level of safety inventory required by a company to address demand uncertainty and variability in raw material delivery times. In this study, safety stock is calculated using a demand variation approach and historical standard deviation, taking into account the company's desired service level. Quantitatively determining safety stock allows a company to minimize the risk of material shortages without causing excessive overstocking. The calculation results indicate that implementing proportional safety stock can provide effective protection against demand fluctuations and improve the overall smoothness of the production process.

$SS = Z \times \sqrt{LT}\ (\sigma d)$
Information:
SS = Safety Stock
Z = Safety Factor
LT = Lead Time
d = Average monthly demand
σd = Standard Deviation of Demand

Safety stock displays the amount of safety stock for each raw material based on the calculation formula $SS=Z\times\sqrt{LT}(\sigma d)$. Safety stock is needed to anticipate demand uncertainty and lead time variations. The data in this table ensures that production continues despite demand fluctuations or supply delays. The table values are filled in after the Z parameter, demand standard deviation, and lead time are calculated.

3. Results and Discussion

This study uses the transportation method to develop aggregate planning because it offers stronger optimization capabilities than conventional aggregate planning approaches such as level strategy, chase strategy, or mixed strategy. Unlike manual methods that only balance demand and capacity based on heuristic rules, the transportation method provides a mathematical framework that enables the search for optimal solutions by minimizing total production costs.

In the context of UD. ABC, aggregate planning is not only aimed at determining production volume per period but also requires consideration of several cost components, such as regular production costs, overtime costs, backorder costs, and storage costs. The transportation method is able to incorporate all these cost parameters simultaneously into the optimization model, thus providing a more accurate and efficient solution than other methods. Furthermore, the structure of the aggregate planning problem in this study shares characteristics with the structure of the transportation problem: the relationship between production capacity and forecasted demand, which must be balanced by considering the costs of each combination of production decisions. Therefore, the Transportation Method is the most appropriate approach because it is able to minimize total costs mathematically, not based on manual estimates or trial-and-error approaches and is suitable for multi-period conditions with quite significant variations in demand, such as what happened to the demand for multipurpose shelves and dish racks for the period April–August 2025.

3.1 Request Data

The following Table 1 shows the demand data for multi-purpose shelves and dish racks for the period April 2025 to August 2025.

Tabel 1
Tabel Data Permintaan

Month	Week	Multipurpose shelf	Dish rack
		Request(box)	Request(box)
April'25	1	525	325
	2	515	450
	3	525	450
	4	400	450
	5	380	400
Mayi'25	1	430	300
	2	400	350
	3	545	450
	4	500	425
	5	475	385
June'25	1	435	400
	2	500	445
	3	550	375
	4	495	465
July'25	1	500	450
	2	575	500
	3	400	450
	4	500	350
	5	450	350
August'25	1	350	325
	2	530	395
	3	500	500
	4	525	440
	5	450	400
Total		11455	9830

(Source: UD. ABC, 2025)

3.2 Demand Forecasting

Demand based on forecasting of multi-purpose rack and dish rack products for the period April 2025 – August 2025. The following Table 2 shows the forecasting results.

Table 2
Comparison Table of Forecasting Methods

Product name	Error	Comparison of Forecasting Methods						Selected Method
		Moving Average			*Single Exponential Smoothing*			
		MA 3	MA 4	MA 5	0,1	0,2	0,3	
Multi purpose Shelf	MAPE	12.9	14.5	14.1	11.3	11.4	11.4	SES α=0,1
	MAD	63.8	70.3	67.8	54.6	55.4	55.8	
	MSD	633	686	663	483	495	503	
Dish rack	MAPE	15.2	15.6	15.7	12.9	12.9	12.9	SES α=0,3
	MAD	65.3	65.7	65.8	58.8	55.1	55.3	
	MSD	667	678	702	472	485	492	

From the table above, the method that has the smallest results from the Moving Average and Single Exponential Smoothing methods for multipurpose rack and dish rack products is as follows:

1. Multipurpose Shelves use the Single Exponential Smoothing forecasting method with a value of α = 0,1
2. Dish Shelves use the Single Exponential Smoothing forecasting method with a value of α = 0,3

Table 3
Demand Forecast Quantity Table

Moon	week	Number of Product Requests					
		Multipurpose Shelf		Dish rack		Aggregate Quantity (Cardboard)	Aggregate Amount (Units)
		Box	Unit	Box	Unit		
September '25	1	505	3030	421	2526	926	5556
	2	505	3030	421	2526	926	5556
	3	505	3030	421	2526	926	5556
	4	505	3030	421	2526	926	5556
	5	505	3030	421	2526	926	5556
October '25	1	505	3030	421	2526	926	5556
	2	505	3030	421	2526	926	5556
	3	505	3030	421	2526	926	5556
	4	505	3030	421	2526	926	5556
	5	505	3030	421	2526	926	5556
November '25	1	505	3030	421	2526	926	5556
	2	505	3030	421	2526	926	5556
	3	505	3030	421	2526	926	5556
	4	505	3030	421	2526	926	5556
December '25	1	505	3030	421	2526	926	5556
	2	505	3030	421	2526	926	5556
	3	505	3030	421	2526	926	5556
	4	505	3030	421	2526	926	5556
	5	505	3030	421	2526	926	5556
January '26	1	505	3030	421	2526	926	5556
	2	505	3030	421	2526	926	5556
	3	505	3030	421	2526	926	5556
	4	505	3030	421	2526	926	5556
	5	505	3030	421	2526	926	5556
Total		12120	72720	10104	60624	22224	133344

In the table above, the aggregate demand is 926 boxes or the equivalent of 5556 units per week.

3.3 Aggregate Planning of Transportation Methods

After obtaining the forecast results for 24 weeks, or the equivalent of 5 months, the next stage is to create an aggregate plan for multipurpose shelves and dish racks. Aggregate planning is a production capacity calculation to determine the average number of products to be produced in a given period. The method used in this aggregate planning is the Transportation Method. Available production capacity data is explained in Table 4 below.

Table 4
Aggregate Planning Table

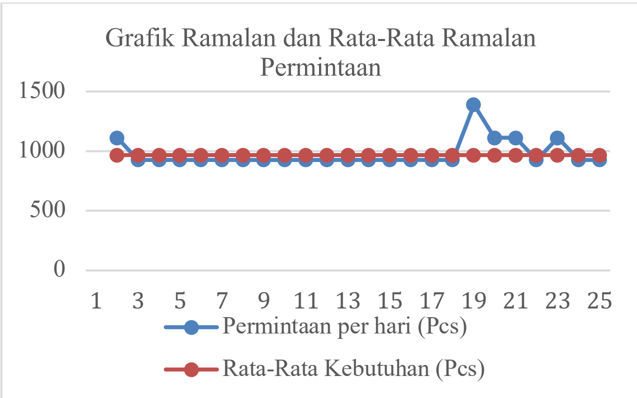
Moon	Week	Available Production Capacity				
		Aggregate Amount (Units)	Working days	Working time	Capacity (Hours)	Demand Per Day (Units)
September '25	1	5556	5	8	40	1112
	2	5556	6	8	48	926
	3	5556	6	8	48	926
	4	5556	6	8	48	926
	5	5556	6	8	48	926
October '25	1	5556	6	8	48	926
	2	5556	6	8	48	926
	3	5556	6	8	48	926
	4	5556	6	8	48	926
	5	5556	6	8	48	926
November' 25	1	5556	6	8	48	926
	2	5556	6	8	48	926
	3	5556	6	8	48	926
	4	5556	6	8	48	926
December' 25	1	5556	6	8	48	926
	2	5556	6	8	48	926
	3	5556	6	8	48	926
	4	5556	4	8	32	1389
	5	5556	5	8	40	1112
January'26	1	5556	5	8	40	1112
	2	5556	6	8	48	926
	3	5556	5	8	40	1112
	4	5556	6	8	48	926
	5	5556	6	8	48	926
Total		133344	138	192	1104	23431

To meet the average demand over the next 5-month period, the calculation is as follows:

$$\text{average demand} = \frac{Jumlah\ total\ permintaan\ (Pcs)}{Jumah\ hari\ produksi}$$

$$\frac{133344}{138} = 967 \text{ Unit/hari}$$

(6)



Gambar 2 Grafik ramalan dan rata-rata ramalan permintaan

The graph above shows that the daily demand value on the blue line fluctuates, meaning that the amount of demand is not always the same each day. Several points of increase and decrease in demand are visible in each observation period. Meanwhile, the orange line shows the average demand, which tends to be stable and constant, indicating that the average demand value is within a certain range without significant changes. Thus, it can be concluded that actual demand is unstable, while the average demand shows a constant trend. This comparison indicates the extent to which the forecast or demand planning results approximate actual conditions in the field.

3.4 Master Production Schedule

Master production schedule planning uses the transportation method. The transportation method is used to allocate production with minimal costs. The following data shows the labor time and costs required for the production process.

Number of production workers = 25 people
Normal time for multi-purpose racks = 22 minutes 20 seconds/unit
Normal time for dish racks = 24 minutes 44 seconds/unit
Regular working hours = 8 hours/day
Overtime working hours = 2 hours/day
Production cost (regular) for multi-purpose racks = Rp 101,190
Production cost (regular) for dish racks = Rp 118,056
Production cost (overtime) for multipurpose racks= Rp 125,000
Production cost (overtime) for dish racks = Rp 125,000
Storage cost = 35,000/box

Determination of production capacity for regular working hours and overtime working hours is as follows.

a. Calculating Allowance
Based on direct field observations, the allowance can be calculated as follows:
PA (Personal Allowance) = 5 minutes
FA (Fatigue Allowance) = 8 minutes
DA (Unavoidable Delay) = 10 minutes
Total time for PA, FA, and DA = 23 minutes

$$\% \, Allowance = \frac{23 \, minutes}{8 \, x \, 60 \, minutes} \, x \, 100 = 4{,}17\%$$
(7)

b. Calculating Standard Time
Standard Time Multipurpose Shelf

$$= wn \, x \, \frac{100\%}{(100\% - \%Allowance)}$$

$$= \; 22{,}3 \, menit \, x \, \frac{100\%}{(100\% - 4{,}17\%)} = 22{,}306 \, menit \; (8)$$

Standard Time for Dish Rack

$$= wn \, x \, \frac{100\%}{(100\% - \%Allowance)}$$

$$= \; 24{,}73 \, menit \, x \, \frac{100\%}{(100\% - 4{,}17\%)}$$

$$= 25{,}798 \, menit$$
(9)

c. Calculating production capacity during regular working hours

Regular hour production capacity is a company's ability to produce a product during a typical eight-hour workday. The following is the calculation of regular hour production capacity per day with one worker:

Multipurpose rack production capacity

$$= \frac{regular \, working \, hours}{standard \, time}$$

$$= \frac{8 \, x \, 60 \, minutes}{22{,}306 \, minutes}$$

$$= 21 \, unit$$
(10)

Production capacity of dish racks

$$= \frac{regular \, working \, hours}{standard \, time}$$

$$= \frac{8 \, x \, 60 \, mminutes}{25{,}798 \, minutes}$$

$$= 18 \, unit$$
(11)

So the production capacity of multi-purpose shelves is 6 days x 21 units x 25 workers = 3150 units per week. So the production capacity of dish racks is 6 days x 18 units x 25 workers = 2700 units per week.

Calculating overtime production capacity
Multipurpose rack production capacity

$$= \frac{overtime \, hours}{standard \, time}$$

$$= \frac{2 \, x \, 60 \, minutes}{22{,}306 \, minutes}$$

$$= 5 \, unit$$
(12)

Production capacity of dish racks

$$= \frac{overtime \, hours}{standard \, time}$$

$$= \frac{2 \, x \, 60 \, minutes}{25{,}798 \, minutes}$$

$$= 5 \, unit$$
(13)

So the production capacity of the multipurpose rack with overtime working hours is 6 days x 5 units x 25 workers = 750 units per week. So the production capacity of the dish rack with overtime working hours is 6 days x 5 units x 25 workers = 750 units per week. So the recapitulation of the data from the weekly production capacity calculation which includes the number of working days, regular capacity (RT), and overtime capacity (OT) is as follows:

Table 5
Production Capacity Table

Moon	Week	Working days	Multipurpose Shelf		Dish rack	
			RT	OT	RT	OT
September'25	1	5	2625	625	2250	625
	2	6	3150	750	2700	750
	3	6	3150	750	2700	750
	4	6	3150	750	2700	750
	5	6	3150	750	2700	750
October'25	1	6	3150	750	2700	750
	2	6	3150	750	2700	750
	3	6	3150	750	2700	750
	4	6	3150	750	2700	750
	5	6	3150	750	2700	750
November'25	1	6	3150	750	2700	750
	2	6	3150	750	2700	750
	3	6	3150	750	2700	750
	4	6	3150	750	2700	750
December'25	1	6	3150	750	2700	750
	2	6	3150	750	2700	750
	3	6	3150	750	2700	750
	4	4	2100	500	1800	500
	5	5	2625	625	2250	625
January'26	1	5	2625	625	2250	625
	2	6	3150	750	2700	750
	3	5	2625	625	2250	625
	4	6	3150	750	2700	750
	5	6	3150	750	2700	750

3.5 Production Plan

After determining optimal regular (RT) and overtime (OT) production capacity, the next step is to develop a demand fulfillment plan. The table below displays a master production schedule that shows the production allocation between multipurpose shelves and dish racks each week using the Lot For Lot (LFL) method. Determining production quantities using this method aims to meet net demand without leaving excess inventory. Table 6 shows the resulting master production schedule. With this schedule, the company can ensure production continuity is met efficiently.

Table 6
Master Production Schedule Table

Master Production Schedule			
Moon	Week	Multipurpose Shelf	Dish rack
September'25	1	3030	2526
	2	3030	2526
	3	3030	2526
	4	3030	2526
	5	3030	2526
October'25	1	3030	2526
	2	3030	2526
	3	3030	2526
	4	3030	2526
	5	3030	2526
November'25	1	3030	2526
	2	3030	2526
	3	3030	2526
	4	3030	2526
December'25	1	3030	2526
	2	3030	2526
	3	3460	2752
	4	2600	2300
	5	3030	2526
January'26	1	3030	2526
	2	3030	2526
	3	3030	2526
	4	3030	2526
	5	3030	2526

a. Multipurpose Shelving

This table displays the weekly production plan for multipurpose shelving, including demand, fulfillment through regular (RT) and overtime (OT) capacity, and total available production capacity. The division between RT and OT is carried out to ensure that weekly demand can be met as needed without delay. The information in this table provides a detailed overview of the involvement of production capacity in meeting demand variations, particularly in the December period, which exhibits fluctuations. Total production is calculated to ensure alignment between the master production schedule and actual production capacity.

Table 7
Multipurpose Shelf Production Plan

Moon	Week	Request (Unit)	Fulfillment	Production Plan	Production Capacity (Units)
September '25	1	3030	RT 1 = 2625 OT 1 = 405	RT 1 = 2625 OT 1 = 405	3030
	2	3030	RT 2 = 3030	RT 2 = 3030	3030
	3	3030	RT 3 = 3030	RT 3 = 3030	3030
	4	3030	RT 4 = 3030	RT 4 = 3030	3030
	5	3030	RT 5 = 3030	RT 5 = 3030	3030
October '25	1	3030	RT 1 = 3030	RT 1 = 3030	3030
	2	3030	RT 2 = 3030	RT 2 = 3030	3030
	3	3030	RT 3 = 3030	RT 3 = 3030	3030
	4	3030	RT 4 = 3030	RT 4 = 3030	3030
	5	3030	RT 5 = 3030	RT 5 = 3030	3030
November '25	1	3030	RT 1 = 3030	RT 1 = 3030	3030
	2	3030	RT 2 = 3030	RT 2 = 3030	3030
	3	3030	RT 3 = 3030	RT 3 = 3030	3030
	4	3030	RT 4 = 3030	RT 4 = 3030	3030
December '25	1	3030	RT 1 = 3030	RT 1 = 3030	3030
	2	3030	RT 2 = 3030	RT 2 = 3030	3030
	3	3030	RT 3 = 3030	RT 3 = 3150 OT 3 = 310	3460
	4	3030	RT 3 = 120 OT 3 = 310	RT 4 = 2100	2600
			RT 4 = 2100 OT 4 = 500	OT 4 = 500	
	5	3030	RT 5 = 2625 OT 5 = 405	RT 5 = 2625 OT 5 = 405	3030
January '26	1	3030	RT 1 = 2625 OT 1 = 405	RT 1 = 2625 OT 1 = 405	3030
	2	3030	RT 2 = 3030	RT 2 = 3030	3030
	3	3030	RT 3 = 2625 OT 3 = 405	RT 3 = 2625 OT 3 = 405	3030
	4	3030	RT 4 = 3030	RT 4 = 3030	3030
	5	3030	RT = 3030	RT 5 = 3030	3030
Total		72720			72720

b. Dish Racks

This table presents the weekly production plan for dish racks, including demand, fulfillment capacity through regular and overtime capacity, and total production capacity per period. Similar to the multipurpose racks, RT and OT usage are adjusted to reflect changing weekly needs in December. This table provides transparency regarding how production capacity is allocated to meet demand without creating underproduction or overproduction. Annual production totals are displayed to ensure consistency with the overall master production schedule.

3.6 Production Costs

After the master production schedule has been developed, the next step is to calculate the total production costs for the entire planning period. This calculation includes the costs for each product unit and is detailed weekly. The detailed production cost calculations for multipurpose shelving are as follows:

a. Multipurpose Shelving

Before presenting the weekly production cost breakdown, it is important to understand that production cost calculations at this stage are a crucial part of evaluating the efficiency of the production plan developed using the transportation method and the master production schedule. Cost analysis is conducted not only to determine the company's total expenditures but also to observe cost fluctuation patterns due to variations in demand, changes in production capacity, and incidental overtime use. For multipurpose shelving products, the allocation of regular and overtime production significantly impacts total costs, especially during weeks when regular capacity is insufficient to meet demand. This calculation is performed by multiplying the number of units produced through regular (RT) and overtime

(OT) capacity by the different production costs per unit for each category. Thus, the production cost table presented provides a comprehensive overview of weekly cost distribution, identifies critical weeks that incur higher costs, and facilitates accurate determination of the total production costs of multipurpose shelving throughout the entire planning horizon.

Table 14 presents a detailed weekly production cost calculation for multipurpose shelving products for the period September 2025 to January 2026. Cost calculations are based on the number of units produced through RT and OT capacity, multiplied by the production cost per unit for each category. This table helps illustrate cost variations that arise, particularly during weeks requiring additional overtime to meet demand. The total costs are then summed to determine the total production cost of multipurpose shelving during the planning period.

Table 8
Plate Rack Production Plan

Moon	Week	Request	Fulfillment	Production Plan	Production Capacity (Units)
September '25	1	2526	RT 1 = 2250	RT 1 = 2250	2526
			OT 1 = 276	OT 1 = 276	
	2	2526	RT 2 = 2526	RT 2 = 2526	2526
	3	2526	RT 3 = 2526	RT 3 = 2526	2526
	4	2526	RT 4 = 2526	RT 4 = 2526	2526
	5	2526	RT 5 = 2526	RT 5 = 2526	2526
October '25	1	2526	RT 1 = 2526	RT 1 = 2526	2526
	2	2526	RT 2 = 2526	RT 2 = 2526	2526
	3	2526	RT 3 = 2526	RT 3 = 2526	2526
	4	2526	RT 4 = 2526	RT 4 = 2526	2526
	5	2526	RT 5 = 2526	RT 5 = 2526	2526
November '25	1	2526	RT 1 = 2526	RT 1 = 2526	2526
	2	2526	RT 2 = 2526	RT 2 = 2526	2526
	3	2526	RT 3 = 2526	RT 3 = 2526	2526
	4	2526	RT 4 = 2526	RT 4 = 2526	2526
December '25	1	2526	RT 1 = 2526	RT 1 = 2526	2526
	2	2526	RT 2 = 2526	RT 2 = 2526	2526
	3	2526	RT 3 = 2526	RT 3 = 2700 OT 3 = 52	2752
	4	2526	RT 3 = 174 OT 3 = 52	RT 4 = 1800	2300
			RT 4 = 1800 OT 4 = 500	OT 4 = 500	
	5	2526	RT 5 = 2250 OT 5 = 276	RT 5 = 2250 OT 5 = 276	2526
January '26	1	2526	RT 1 = 2250 OT 1 = 276	RT 1 = 2250 OT 1 = 276	2526
	2	2526	RT 2 = 2526	RT 2 = 2526	2526
	3	2526	RT 3 = 2250 OT 3 = 276	RT 3 = 2250 OT 3 = 276	2526
	4	2526	RT 4 = 2526	RT 4 = 2526	2526
	5	2526	RT 5 = 2526	RT 5 = 2526	2526
Total		60624			60624

Table 9
Multipurpose Shelf Production Cost Table

Moon	Week	Production Cost Calculation	Total (Rp)
September '25	1	(2625*Rp 101.190)+(405*Rp 125.000)	Rp 316,248,750
	2	(3030*Rp 101.190)	Rp 306,605,700
	3	(3030*Rp 101.190)	Rp 306,605,700
	4	(3030*Rp 101.190)	Rp 306,605,700
	5	(3030*Rp 101.190)	Rp 306,605,700
October '25	1	(3030*Rp 101.190)	Rp 306,605,700
	2	(3030*Rp 101.190)	Rp 306,605,700
	3	(3030*Rp 101.190)	Rp 306,605,700
	4	(3030*Rp 101.190)	Rp 306,605,700
	5	(3030*Rp 101.190)	Rp 306,605,700
November '25	1	(3030*Rp 101.190)	Rp 306,605,700
	2	(3030*Rp 101.190)	Rp 306,605,700
	3	(3030*Rp 101.190)	Rp 306,605,700
	4	(3030*Rp 101.190)	Rp 306,605,700
December '25	1	(3030*Rp 101.190)	Rp 306,605,700
	2	(3030*Rp 101.190)	Rp 306,605,700
	3	(3030*Rp 101.190)	Rp 306,605,700
	4	(120*Rp 107.023)+(310*Rp 130.833) +(2100*Rp 101.190)+(500*Rp 125.000)	Rp 328,399,990
	5	(2625*Rp 101.190)+(405*Rp 125.000)	Rp 316,248,750
January '26	1	(2625*Rp 101.190)+(405*Rp 125.000)	Rp 316,248,750
	2	(3030*Rp 101.190)	Rp 306,605,700

3	(2625*Rp 101.190)+(405*Rp 125.000)	Rp 316,248,750
4	(3030*Rp 101.190)	Rp 306,605,700
5	(3030*Rp 101.190)	Rp 306,605,700
	Total	Rp 7,418,903,290

b. Dish Rack

This table displays detailed production cost calculations for dish racks for each week within the planning period. Costs are calculated based on regular production allocations and overtime, based on the number of units required to meet the master production schedule. Some weeks show increased costs due to overtime, particularly in December. The accumulated weekly costs are then summed to obtain the total production cost of dish racks for the entire planning period.

Table 10
Table of Production Costs for Dish Racks

Moon	Week	Cost Calculation	Total (Rp)
September '25	1	(2250*Rp118.056)+(276*Rp125.000)	Rp 300,126,000
	2	(2526*Rp 118.056)	Rp 298,209,456
	3	(2526*Rp 118.056)	Rp 298,209,456
	4	(2526*Rp 118.056)	Rp 298,209,456
	5	(2526*Rp 118.056)	Rp 298,209,456
October '25	1	(2526*Rp 118.056)	Rp 298,209,456
	2	(2526*Rp 118.056)	Rp 298,209,456
	3	(2526*Rp 118.056)	Rp 298,209,456
	4	(2526*Rp 118.056)	Rp 298,209,456
	5	(2526*Rp 118.056)	Rp 298,209,456
November '25	1	(2526*Rp 118.056)	Rp 298,209,456
	2	(2526*Rp 118.056)	Rp 298,209,456
	3	(2526*Rp 118.056)	Rp 298,209,456
	4	(2526*Rp 118.056)	Rp 298,209,456
December '25	1	(2526*Rp 118.056)	Rp 298,209,456
	2	(2526*Rp 118.056)	Rp 298,209,456
	3	(2526*Rp 118.056)	Rp 298,209,456
	4	(174*Rp123.889)+(52*Rp130.833) +(1800*Rp118.056)+(500*Rp 125.000)	Rp 303,360,802
	5	(2250*Rp 118.056)+(276*Rp 125.000)	Rp 300,126,000
January '26	1	(2250*Rp 118.056)+(276*Rp 125.000)	Rp 300,126,000
	2	(2526*Rp 118.056)	Rp 298,209,456
	3	(2250*Rp 118.056)+(276* Rp 125.000)	Rp 300,126,000
	4	(2526*Rp 118.056)	Rp 298,209,456
	5	(2526*Rp 118.056)	Rp 298,209,456
		Total	Rp 7,169,844,466

3.7 Comparison of Actual Method with Proposed Method

The results of implementing the new forecasting and planning method were then compared with the company's actual conditions before the improvements. This comparison aims to measure potential savings or efficiency improvements. A summary of the comparison between the actual and proposed methods is presented in detail in Table 11 below.

Table 11
Comparison Table of Actual and Proposed Methods

Information	Before Forecast		After Forecast	
	Multipurpose Shelf (Unit)	Dish rack (Unit)	Multipurpose Shelf (Unit)	Dish rack (Unit)
RT	67008	57965	70290	58968
OT	7950	6625	2120	1380
Storage	2077	656	430	226

Table 12
Cost Table Before Forecast

Production cost	Before Forecast	
	Reguler	*Overtime*
Multipurpose Shelf	Rp 6,780,571,429	Rp 993,750,000
Dish Rack	Rp 6,843,090,278	Rp 828,125,000
Storage	Rp 72,695,000	
Overall	Rp 15,518,231,706	

The data in the column before the forecast shows the company's actual operating conditions and costs before implementing the proposed planning system. These figures serve as an initial benchmark for comparison.

Table 13
Cost Table After Forecast

Production cost	After Forecast	
	Reguler	*Overtime*
Multipurpose Shelf	Rp 7,112,678,571	Rp 265,000,000
Dish Rack	Rp 6,961,500,000	Rp 172,500,000
Storage	Rp 22,960,000	
Overall	Rp 14,534,638,571	

The column after the forecast displays the master production schedule (JIP) calculated based on the forecast, as well as the impact of changes to the workforce requirements (RT and OT) and the company's total operational costs.

Table 14
Total Cost Savings Table

Production cost	Savings
Multipurpose Shelf	Rp396,642,857
Dish Rack	Rp537,215,278
Storage	Rp49,735,000
Overall	Rp983,593,135

The financial impact of comparing the actual method with the proposed method is shown in the production cost breakdown below. The calculation results indicate a potential total savings of Rp 983,993,135.

3.8 Raw Material Requirements

Before presenting the summary of raw material requirements, it is important to emphasize that the material requirements calculation process in this study was conducted systematically as a follow-up to the master production schedule and the results of the Material Requirement Planning (MRP) analysis. The calculation of raw material requirements was performed by multiplying the number of production units per week by the material composition contained in the Bill of Materials (BOM) for each product. This approach ensures that the calculated material quantities are accurate, consistent with the production plan, and reflect actual field needs. Furthermore, the calculations were conducted weekly to provide greater granularity, allowing the company to periodically monitor material requirements, anticipate potential material shortages, and reduce the risk of production delays due to insufficient supply. Therefore, the raw material requirements summary table serves not only as a quantitative list of materials that must be available but also as a strategic planning tool that assists the company in more efficient procurement, inventory control, and raw material ordering scheduling. Table 15 also allows the identification of critical periods with high material requirements, such as peak production weeks, allowing the company to adjust its purchasing strategy and storage capacity according to operational needs.

Table 15
Summary Table of Raw Material Requirements

Summary of Raw Material Requirements				
Moon	Week	Iron Pipe (Unit)	Wire (cm)	Rubber Pads (Pcs)
September'25	1	5556	27496008	60600
	2	5556	27496008	60600
	3	5556	27496008	60600
	4	5556	27496008	60600
	5	5556	27496008	60600
October'25	1	5556	27496008	60600
	2	5556	27496008	60600
	3	5556	27496008	60600
	4	5556	27496008	60600
	5	5556	27496008	60600
November'25	1	5556	27496008	60600
	2	5556	27496008	60600
	3	5556	27496008	60600
	4	5556	27496008	60600
Dcsember'25	1	5556	27496008	60600
	2	5556	27496008	60600
	3	6212	30893616	69200
	4	4900	24098400	52000
	5	5556	27496008	60600
January'26	1	5556	27496008	60600
	2	5556	27496008	60600
	3	5556	27496008	60600
	4	5556	27496008	60600
	5	5556	27496008	60600

3.9 Safety Stock Summary

a. Multipurpose Shelf
Given:
Confidence Level = 1.65
Lead Time (L) = 1

$$L = \sqrt{\frac{1}{129}} = 0,088$$

(14)

Calculation of standard deviation of demand

$$\sigma_d = \sqrt{\frac{n \sum x^2 - (\sum x^2)}{n(n-1)}}$$

(15)

The following is the calculation of the standard deviation of multi-purpose shelf demand.

Given:
Demand for the next 5 months = 12,120 boxes
Average demand per month (x) = 505 boxes
Period (n) = 24

$$\sigma_d = \sqrt{\frac{n \sum x^2 - (\sum x^2)}{n(n-1)}}$$

$$\sigma_d = \sqrt{\frac{(24 \, x \, 505^2 - (505^2)}{24(24-1)}}$$

σ_d = 103 boxes/ 618 units

(16)

It is known that the standard deviation based on calculations for multipurpose shelves is 103 boxes, equivalent to 618 units. Below is the safety stock calculation for multipurpose shelves.

Safety stock

= $Z \; x \; \sigma_d \; x \; L$

= 1,65 x 103 x 0,088

= 15 boxes / 90 unit

(17)

Based on the safety stock calculation, the required safety stock for each finished product is determined. This safety stock serves as a buffer against demand fluctuations during the procurement lead time. The following is a summary of the safety stock requirements for the final products, multipurpose shelves and dish racks:

Table 16
Summary Table of Product Storage Quantities

Products	**Save Amount**
Multipurpose Rack	15 boxes / 90 units
Dish Rack	13 boxes / 78 units

After calculating the safety stock for the final product, the calculation continues to determine the safety stock required for each material component. This safety stock component aims to minimize the risk of delays or shortages in material supplies that could hinder the production process. The following is a complete recap of the safety stock requirements for each material component:

Table 17
Summary Table of Raw Material Storage Quantities

Component	Save Amount
Frame (iron pipe (3/4 inch x 1.2mm x 600cm))	1135
Multipurpose shelf side hooks (wire)	180
Dish rack side hooks (wire)	150
Multipurpose shelf shelf	450
Dish rack shelf	300
Rubber pads	330

4. Conclusion

Based on the data processing results at ABC Company, this study indicates that the most accurate forecasting method for predicting demand five months into the future is the Single Exponential Smoothing method. Forecasting was conducted for the period September 2025 to January 2026 using Minitab software and twenty-four weeks of historical data. Forecast error evaluation results show that the Single Exponential Smoothing method with an α value of 0.1 provides the best accuracy for multipurpose shelves, while an α value of 0.3 provides the most accurate results for dish racks. These findings emphasize the importance of selecting appropriate smoothing parameters to produce more reliable demand estimates in a make-to-stock production system.

Furthermore, this study also analyzed raw material inventory costs using three lot sizing techniques: Lot for Lot (LFL), Fixed Period Requirement (FPR), and Fixed Order Quantity (FOQ). The calculations indicate that the LFL method produces the lowest total inventory costs compared to the other two methods. The total costs obtained using the LFL method were Rp 13,800,000 for the multipurpose rack and Rp 13,440,000 for the dish rack. These findings indicate that the LFL method is more efficient for raw material ordering needs at ABC Company because it can reduce storage costs while providing the appropriate amount of material to meet production needs for each period.

This study has several limitations that should be considered. The demand data used only covers a twenty-four-week period, so seasonal patterns or long-term demand changes cannot be fully analyzed. Furthermore, this study focuses on raw material inventory costs and does not consider other variables such as labor costs, machine capacity, productivity fluctuations, or operational disruptions that could impact production planning results.

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