

FORECASTING FOR INVENTORY CONTROL

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ABSTRACT

The company in this case is a manufacturer of spring beds. This research aims at determining the best method to forecast the company's production level, as well as finding out the economically efficient amount of raw materials for the company to order, and the best delivery routes for its products, especially spring bed type 101.

Six forecasting methods are used: Linear Regression, Moving Average, Weighted Moving Average, Exponential Smoothing, Exponential Smoothing with Trend and Naïve method. Economic Order Quantity (EOQ) is used to calculate raw materials inventory, and a Decision Tree to determine goods delivery processes. The research results suggest that the company use Linear Regression as it has the smallest MAD and MSE of the six methods. The company also has to order an economical amount of raw materials and choose shipping as a means of distributing its products to the location specified in this study.

Key words: Demand forecasting, Raw materials inventory, Goods delivery

บทคัดย่อ

บริษัทที่ทำการศึกษาคือบริษัทผู้ผลิตสปริงสำหรับเตียงนอน โดยการศึกษานี้มีวัตถุประสงค์เพื่อหาวิธีการพยากรณ์ระดับการผลิตที่เหมาะสมที่สุด และเพื่อหาปริมาณของวัตถุดิบในการสั่งซื้อที่เกิดประสิทธิภาพทางเศรษฐกิจและเส้นทาง การขนส่งที่ดีที่สุดสำหรับสินค้าของบริษัท โดยเฉพาะอย่างยิ่งสปริง ชนิด 101.

วิธีการพยากรณ์ ทั้ง 6 วิธีถูกใช้ ดังนี้ สมการถดถอยเชิงเส้นตรง (Linear Regression), วิธีการค่าเฉลี่ยเคลื่อนที่ (Moving Average), วิธีการค่าเฉลี่ยเคลื่อนที่แบบถ่วงน้ำหนัก (weighted moving average), วิธีการปรับเรียบเอ็กซ์โปเนนเชียล (Exponential Smoothing), วิธีการปรับเรียบเอ็กซ์โปเนนเชียล

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และแนวโน้ม (exponential smoothing with trend) และ วิธีไร้เดียงสา (Naïve method) ตามลำดับปริมาณ การสั่งซื้อแบบประหยัด (Economic Order Quantity) ได้ถูกคำนวณขึ้น เพื่อหาปริมาณวัตถุดิบคงคลัง และใช้ต้นไม้การตัดสินใจ (Decision Tree) เพื่อกำหนดกระบวนการขนส่งสินค้า โดยการศึกษพบว่า จากการทดลองทั้ง 6 วิธีข้างต้น การใช้สมการถดถอยเชิงเส้นตรงทำให้ ค่าคลาดเคลื่อนพยากรณ์ภาพรวม (MAD) และ ค่าเฉลี่ยความผิดพลาดกำลังสอง (MSE) น้อยที่สุด ทั้งนี้บริษัทต้องสั่งซื้อปริมาณของวัตถุดิบที่เกิดประสิทธิภาพทางเศรษฐกิจและต้องเลือกการขนส่งไปยังสถานที่ที่กำหนดขึ้นในการศึกษาครั้งนี้ คำหลัก: การพยากรณ์อุปสงค์ วัตถุดิบคงคลัง การขนส่งสินค้า

INTRODUCTION

Background

The industry has been developing and getting more advanced along with tighter competition. Every company will be striving to enhance their productivity and make all type of costs efficient in order to win superiority. The existence of a similar company or the emergence of a new competitor is one of the threatening factors which could lead to the fall, and maybe the destruction, of a company. Therefore, in order for a company to survive and stay away from destruction, various methods are needed so as not to be swayed by both its old and new competitors. One way is to forecast consumer demand. This is important because effective consumer demand forecasting would affect a company's profitability by the means of avoiding stockpiling. In some industrial manufacturing companies, including the company studied in this paper, inventory planning systems become one of the most important factors in meeting customer needs timely and in accordance with demand, as consumer demand does not always cover a company's level of inventory capacity and as a result, the company's profit declines or it may not even make any profit at all.

In order for the production activities to run properly, there is a need for communication between the production department and the inventory department. The latter manages raw materials inventory, half-finished goods inventory, finished goods inventory and other kinds of inventory. Therefore the inventory department must possess the ability to calculate or forecast inventory levels to prevent stock-out in times of need or avoid stock excess before customers place orders. To overcome this problem, a company must know which inventory management techniques suit it best.

CV. Aditama is engaged in the manufacture of spring beds under the brand name Airland. It has a plant which is located in Tangerang. All this time it has been using a simple distribution system and often there is excess inventory or inventory shortage, which brings unfavorable impacts to the company. This study recommends using a system of demand capacity forecasting or planning for the next period so that the company is able to meet customer demand. In

terms of outside-the-island distribution, the company must also be able to choose or make a decision about which delivery route should be taken to distribute its products while ensuring that the costs incurred are minimized and the goods are accepted by consumers in a timely manner.

Problem Identification

The issues identified in this research are:

- (1) How do we determine the appropriate forecasting method among Moving Average, Weighted Moving Average, Exponential Smoothing, Exponential Smoothing with Trend, Naive Method, and Linear Regression, in accordance with consumer demand?
- (2) How do we know if the company has had an optimal level of raw materials inventory to meet the amount of consumer demand?
- (3) How do we choose or decide the best alternative delivery route for the company to distribute its products?

THEORETICAL BASIS

Forecasting

According to Heizer and Render (2001), forecasting is defined as the art or science of predicting future events.

- ***Calculating Forecast Errors***

There are several commonly used methods to calculate forecast errors (Heizer and Render, 2001). These methods can be used to compare different forecasting models, as well as to oversee the forecasting process itself to ensure that it goes well. Three of the most famous methods are Mean Absolute Deviation (MAD), Mean Squared Error (MSE) and Mean Absolute Percent Error (MAPE).

- *Mean Absolute Deviation (MAD)*

MAD is the first measure of the entire forecast errors of a model. This value is calculated by dividing the sum of the absolute value of forecast errors with the number of periods (n).

- *Mean Squared Error (MSE)*

MSE is the second method used in measuring entire forecast errors. MSE is the average squared differences between the observed and predicted values. The drawback of using the MSE is that it tends to accentuate large deviations due to the squared term.

- *Mean Absolute Percentage Error (MAPE)*

A problem with both MAD and MSE is that their values depend on the magnitude of the item being forecast. If the forecast item is measured in thousands, its MAD and MSE values can be very large. To avoid this problem, we can use MAPE, which is the average of the absolute difference between the observed and predicted values, ex-

pressed as a percentage of the actual values.

Raw Materials Definition

According to Assauri (2008, p.240-241), raw materials are the tangible goods used in a production process. The goods can be acquired from natural resources or purchased from suppliers or any companies producing the raw materials used by certain factories. Those factories would process the materials which, after undergoing a couple of processes, are expected to turn into finished goods. According to Narañin (2007, p.202), raw materials are direct materials, which are defined as the materials that form a separate entity from finished goods. Raw materials are the main materials acting as the primary component of a product.

Based on these definitions, we can conclude that raw materials are the materials acquired from natural resources or bought from suppliers to produce goods and services in a production process.

- ***Economic Order Quantity and Safety Stock***

According to Heizer and Render (2001), Economic Order Quantity (EOQ) is the most economical amount of materials to order for every purchase made. For instance, a company's basic needs during a year amount to 12,000 tons in total. Issues regarding inventory in fact consist of two questions – how many items to order and how much time should be taken between orders – which play a part in minimizing costs. To calculate EOQ, we use this formula:

$$EOQ = \frac{\sqrt{2(D)(S)}}{H}$$

Where:

- EOQ** = Economic order quantity
- D** = Required raw material quantity per period
- S** = Raw material order cost
- H** = Raw material order cost per period

Even with the identification of EOQ, there is still a chance that raw materials will be out of stock during the production process. This possibility may come true if:

1. The quantities of raw materials used in the production process are greater than the quantities previously predicted. This may lead to an inventory shortage before the new purchase/order arrives. It means that there is uncertainty in material usage.
2. The raw materials purchase or order does not arrive on time (delayed), meaning that the expected lead time cannot be fulfilled.

Decision Tree Definition

- According to Heizer and Reinder (2001), a decision tree is a graphical display of the decision process that indicates decision alternatives, states of nature and their respective

- probabilities, and payoffs for each combination of decision alternative and state of nature.
- According to Nahmias (2001), a decision tree is a visual model created to simplify a rational decision-making process. Therefore, a decision chart consists of decision nodes and branch nodes.
- According to Narafin (2008), a decision tree is a structural tree, every node in which represents an attribute which has been tested, and each branch is derived from the division of the entire test results. The leaf nodes represent certain class groups. The top-level node of a decision tree is the root node which is usually an attribute that has the greatest influence on a particular class. In general, a decision tree uses top-down search strategy to find a solution. In the process of classifying unknown data, the attribute values will be tested by tracing the tree from the root nodes all the way to the end nodes (the leaf nodes) and then the new particular datum will be classified as a belonging to a certain class.

Thus, we may conclude that a decision tree is a tool being used in a decision making process, despite various alternatives readily available, done in a structured, gradual and rational manner.

Decision Tree Analysis

Regardless of the complexity of a decision or how advanced the techniques used in analyzing that decision are, every decision maker is faced with various alternatives and “state of nature”. When we create a decision tree, make sure that every alternative and state of nature are in the right and logical place and be sure to include all possible alternatives and state of nature. The notations used are:

- Glossary:
 - a. Alternatives - an action or strategy that can be chosen by a decision maker.
 - b. State of nature - an event or situation in which a decision maker has little or no control.
- Symbols used in a decision tree:
 - : A decision point where there is one or more alternative available to be chosen.
 - : A state of nature point where a state of nature could possibly happen.
- Analyzing problem using a decision tree consists of five steps:
 1. Define the problem.
 2. Draw the decision tree.
 3. Determine the probabilities for the states of nature.
 4. Estimate the payoffs for each possible combination of decision alternative and state of nature.
 5. Solve the problem by calculating the EMV of each state of nature. This is done backwards – starting from the right side of the tree all the way to the left side where the decision nodes are.

PROBLEM SOLVING STEPS

Defining Optimization Criteria

Optimization criteria used in analyzing the production needs associated with the demand level of spring beds type 101 are:

- Forecasting Analysis
Optimization criterion:
The main variable in this study is to forecast customer demand for spring bed type 101. This demand acts as one of the variables used in analyzing product demand forecast. In this case, the variables are data on product demand from January 2009 to September 2010 which then are used to forecast demand for the month of October 2010.
- Inventory Control
Optimization criterion:
Ordering - this variable is used to find out the number of products ordered by associating it with the number of primary raw materials needed (steel wires) to produce spring beds type 101. This is done in order to meet customer demand and manufacturing process stability.
- Making decision on delivery route (Decision Tree)
Optimization Criterion:
This variable acts a support variable used in deciding which delivery route is appropriate to distribute spring beds type 101. There are two available alternative routes, namely land routes and sea routes. In addition, costs are the determining factors in choosing the shipping company responsible for delivering goods.

Alternative Solutions Development

Production quality standards are determined by:

1. Forecasting is analyzed by using the help of QM for Windows software, particularly with Linear Regression, Exponential Smoothing with Trend, Exponential Smoothing, Weighted Moving Average, Moving Average and Naive Method methods. Forecasting is based on the historical data on the demand level of spring beds type 101, using the data to estimate demand for the month of October 2010 and to suggest the methods the company should use.
2. Inventory is analyzed by using the help of QM for Windows software. This analysis uses the forecast level of demand for spring bed type 101 for the month of October 2010 to calculate EOQ, Average Inventory, Orders per Period (year), Annual Setup Cost, Annual Holding Cost and Total Cost. Those are later used to determine the inventory level of steel wires, which are the raw materials needed for spring beds manufacturing.
3. Deciding the best delivery route can be done by using the Decision Tree method. It indicates which route and shipping company are best for sending goods to customers.

Optimization Model Development

- **Research Type and Method**

The research type used is problem solving research: deep research into a particular object within a certain range of time while thoroughly seeing the big picture of its production environment and past condition. The research method used is descriptive research. Once collected, the data relevant to the problems studied would be processed, interpreted and analyzed to identify existing problems and give a rough idea of how to solve those problems. The data type can be both quantitative and qualitative.

Implications of the Selected Solution

The implications of the selected solution expected to be realized from this study are:

- To overcome the problem of projecting demand for spring beds type 101, we use forecasting analysis to find out the demand condition for the next period or month.
- To overcome the company's inventory problem, we use EOQ analysis, which will display the new condition of the company's raw materials inventory and reserve, to tackle excessive lead times and soaring customer demand.
- To determine the best delivery routes between two existing alternatives (land route and sea route) offered by various shipping companies, we use Decision Tree to help the company make the best cost-minimization decision.

RESULTS AND DISCUSSION

Data Analysis

The following are data on spring beds type 101 sales from 2009 until September 2010:

Tabel 1: Type 101 Sales Data - Year 2009

Month	Number of Units
January	1200
February	1000
March	1000
April	950
May	1150
June	1000
July	800
August	1100
September	900
October	1000
November	1250
December	1170

Source: Data process result (2010)

Tabel 2: Type 101 Sales Data - January 2010 to September 2010

Month	Number of Units
January	1150
February	900
March	850
April	920
May	1000
June	1150
July	980
August	1250
September	1175

Source: Data process result (2010)

Computing Forecast

Forecasting demand for spring bed type 101 can be done by using QM (Quantity Management) for Windows software. Several methods used, among others, are Linear Regression (LR), Moving Average (MA), Weighted Moving Average (WMA), Exponential Smoothing (ES), Exponential Smoothing with Trend (ESWT) and Naive Method (NM).

Tabel 3: Calculation Results using Six Methods

METHOD	MAD	MSE	Forecast (October 2010)
LR	112.633	16,635.143	1,074.191
ES 0,3	132.89	23,037.36	1,112.21
WMA	128	23,561.111	1,158.5
MA	131.9444	24,611.2654	1,135
NM	143.25	28,026.25	1,175
ESWT	139.247	25,637.455	1,135.946

Source: Data process result (2010)

The results obtained from processing the data show that Linear Regression has the smallest MAD and MSE values. We suggest that the company use the Linear Regression method to estimate its future demand level of spring beds type 101 using manual and QM for Windows calculations.

Steel Wires Inventory

The second thing to do after forecasting product demand level is to calculate inventory level. This is very important for the company to keep its production going and meet customer demand.

Table 4: Steel Wires Inventory Data

Demand	322,500 kg
Wire Price per kg	9,800 IDR
Shipping Cost (Co)	12,000,000 IDR
Lead Time	12 days
Inventory Carrying Cost (Ch)	1,000 IDR
Number of Working Days	300 days
Safety Stock	50000 kg

Source: Data process result (2010)

- $$EQQ = \frac{\sqrt{2(D)(S)}}{H}$$

$$= \frac{\sqrt{2(322,500)(12,000,000)}}{1,000}$$

$$= \sqrt{2.3870000000}$$

$$= \mathbf{87,977.3 \text{ kg} \approx 87.98 \text{ tons}}$$
- Average Inventory = $\frac{87,977.3 \text{ kg}}{2}$

$$= \mathbf{43,988.65 \text{ kg} \approx 43.98 \text{ tons}}$$
- Order Frequency = $\frac{322,500}{87,977.3}$

$$= \mathbf{3.66 \text{ times}}$$
- Annual Setup Cost = $\frac{(322,500)(12,000,000)}{87,977.3}$

$$= \mathbf{43,988,619.791 \text{ IDR}}$$
- Annual Holding Cost = $\frac{(87,977.3)(1,000)}{2}$

$$= \mathbf{43,988,650 \text{ IDR}}$$
- Total Unit Cost = (Unit Cost)(D)
$$= (9,800 \text{ IDR})(322,500 \text{ kg})$$

$$= 3,160,500,000$$
- Total Cost = (Total Unit Cost) + (Setup Cost) + (Holding Cost)
$$= (3,160,500,000 \text{ IDR}) + (43,988,619.791 \text{ IDR}) + (43,988,650 \text{ IDR})$$

$$= \mathbf{3,248,477,269.791 \text{ IDR}}$$
- Daily Demand = $\mathbf{1,075 \text{ kg} \approx 1,075 \text{ tons}}$
- Reorder Point = SS {(LT)(DD)}
$$= 50 \text{ tons} \{(12)(1.075)\}$$

$$= \mathbf{645 \text{ tons}}$$

We can conclude from both calculations above that in order for the amount of steel wires used in manufacturing spring beds type 101 to be economical, an order of 87.977, 3 kg or 87.98 tons should be placed. That amount should be divided into 3.66 orders in a year to meet the need for steel wires. A reorder is made when the quantity of the steel wires falls below 645 tons (Reorder Point). The company needs as many as 1,075 kg or 1.075 tons of steel wires for the spring beds type 101's daily production needs. Each time an order is placed, the company has to pay order costs of 43,998,619.791 IDR and holding costs of 43,988,650 IDR. Total costs incurred to meet steel wires needs for the manufactures of spring bed type 101 are 3,248,477,269.791 IDR, while the costs of the steel wires alone are 3,248,477,269.791 IDR.

Decision Tree

The company also has to send its products, spring beds type 101, to Sulawesi. In its distribution process, two alternative routes are used, namely land route and sea route. Three shipping companies are considered for delivering them, all of which provide land and sea routes. The issue that matters here is to find the lowest spring bed delivery costs to the cities in Sulawesi. Each shipping company charges different fees for different routes.

Table 5: Shipping Rates to Sulawesi

Shipping Company	Land Route (IDR)	Sea Route (IDR)
NRD CARGO*	13,129,000	20,011,200
PT Indonesia Layarindo*	12,325,000	10,296,000
PT ABC Transportindo Cargo*	13,777,500	9,624,000

Source: Data process result (2010)

(*Shipping company name is changed)

Note: Prices are provided by the respective companies and valid for a spring beds type 101 delivery quantity of less than 100 units.

The manual calculations assume a 10% increase in the prices of each shipping company. Therefore, we need to consider both the good and bad economic values which arise from the assumption. The result of the calculations can be seen in the table below.

Table 6: Manual Decision Tree Calculation

NO	Explanation	Probability of state of nature		Decision Result Value (IDR)	
		Good Economy	Bad Economy	Good Economy	Bad Economy
Land Delivery Route					
1	NRD CARGO	0.7	0.3	19,000,000	(1,900,000)
2	PT Indonesia Layarindo	0.75	0.25	17,000,000	(1,700,000)
3	PT ABC Transportindo Cargo	0.85	0.15	16,500,000	(1,650,000)
Sea Delivery Route					
1	NRD CARGO	0.78	0.22	26,400,000	(2,640,000)
2	PT Indonesia Layarindo	0.8	0.2	13,200,000	(1,320,000)
3	PT ABC Transportindo Cargo	0.82	0.18	12,000,000	(1,200,000)

Source: Data process result (2010)

Note: Bad economic values result from the assumption of 10% increase in the good economic values.

Decision Tree Manually Calculated Results

The calculation results are as follows:

- **For Land Delivery Route**

- **NRD CARGO**

- = $(0.7)(19,000,000 \text{ IDR}) + (0.3)(-1,900,000 \text{ IDR})$

- = **13,300,000 IDR - 171,000 IDR**

- = **13,129,000 IDR**

- **PT Indonesia Layarindo**

- = $(0.75)(17,000,000 \text{ IDR}) + (0.25)(-1,700,000 \text{ IDR})$

- = 12,750,000 IDR - 425,000 IDR

- = **12,325,000 IDR**

- **PT ABC Transportindo Cargo**

- = $(0.85)(16,500,000 \text{ IDR}) + (0.15)(-1,650,000 \text{ IDR})$

- = 14,025,000 IDR - 247,500 IDR

- = **13,777,500 IDR**

- **For Sea Delivery Route**

- **NRD CARGO**

- = $(0.78)(26,400,000 \text{ IDR}) + (0.22)(-2,640,000 \text{ IDR})$

- = 20,592,000 IDR - 580,800 IDR

- = **20,011,200 IDR**

- **PT Indonesia Layarindo**

- = $(0.8)(13,200,000 \text{ IDR}) + (0.2)(-1,320,000 \text{ IDR})$

= 10,560,000 IDR - 264,000 IDR

= **10,296,000 IDR**

PT ABC Transportindo Cargo

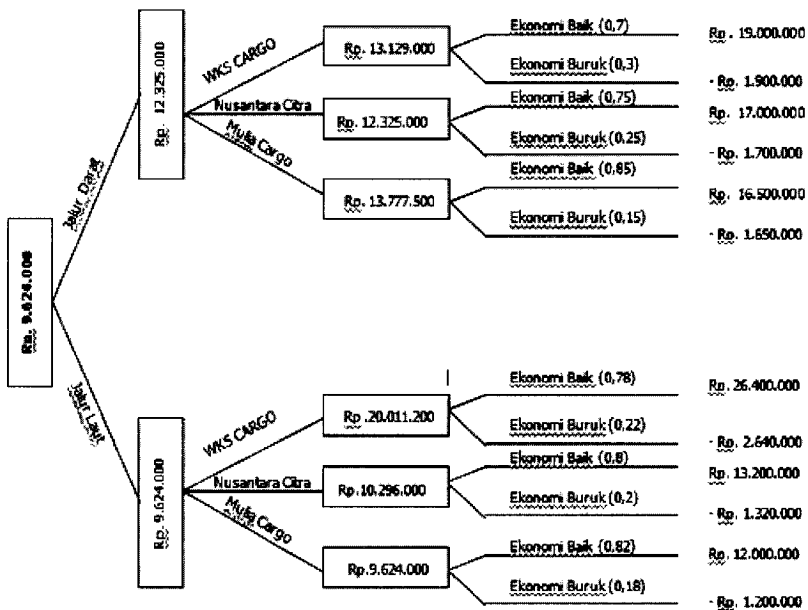
= (0.82)(12,000,000 IDR) + (0.18)(- 1,200,000 IDR)

= 9,840,000 IDR - 216,000 IDR

= **9,624,000 IDR**

Decision Tree manually calculated results suggest that the company use the sea route to deliver its spring bed type 101 to Sulawesi by using the shipment services provided by PT ABC Transportindo Cargo. These manual calculations, which are done by the author, show the same results as those which resulted from using QM for Windows software.

Diagram 1: Decision Tree of Delivery Routes



Source: Data process result, (2010)

Implications of the Research

Based on the calculations intended to generate possible solutions to the existing problems, we can see that the company had better use linear regression method to forecast the demand level of spring beds type 101. Projected demand for the month of October 2010, as shown by the linear regression method, is 1,074.191 units. This method is chosen as it has the smallest rate of MAD and MSE (112.633 and 16,635.143 respectively) among all the six methods computed.

After forecasting the demand level for the month of October 2010, which is 1,074.91 units in total, the company also has to calculate the amount of raw materials needed in the manufacturing process. In this research, some calculations are made to find the amount of the steel wires needed when manufacturing spring bed type 101. The results indicate that the company has to order an economical steel wires amount of 87,977.3 kg or 87.98 tons.

After producing the products, the company has to send them to Sulawesi. To select the best delivery route (between land and sea routes) and the best shipping company (among the existing three), the company uses the decision tree method. The results show that the company had better use the sea route to deliver its products to Manado and choose the shipping services provided by PT ABC Transportindo Cargo as it charges the smallest fee among the three shipping companies.

CONCLUSION AND SUGGESTION

The analysis results obtained above lead us to the following conclusions:

- Based on the forecast of the demand level for the month of October 2010 calculated manually and by QM using six forecasting methods, it is apparent that the best method to determine the demand level of spring beds type 101 is linear regression method as it has the smallest MAD and MSE values.
- After obtaining the forecast result of the demand level for the month of October 2010, we proceeded with the computation of the economical amount of raw materials for the company to buy. The primary raw materials, steel wires, should be purchased in the right amount so as to keep the production process going well. The calculation is done manually and uses the help of QM for Windows software. The calculation indicates that the company has to buy 16,970.627 kg or 169.705 tons of steel wires in order to meet consumer demand.
- This research also includes computing the delivery costs to Sulawesi to help the company determine the right delivery route and shopping company by using the decision tree method. Both manual and QM calculations yield the same results, which are to use the sea route for delivering products to Sulawesi and choose PT ABC Transportindo Cargo as it imposes the lowest fees among the three shipping companies observed and between the two alternative routes available.

Based on the conclusions above, and in an attempt to reduce the level of losses caused by raw materials procurement mistakes, we would like to propose some suggestions which, hopefully, the company can put into practice:

- In terms of manufacturing process, the company had better forecast the demand level of spring bed type 101, which is then followed by purchasing an economical amount of raw materials based on that forecast. This would prevent the company from making procure-

- ment mistakes that can lead to losses.
- In terms of demand forecasting, the company had better use linear regression methods as this research has shown and since it has the smallest gap value. By using the amount computed in the forecast, the company would be able to meet consumer demand and can avoid the huge inventory costs as all products will be delivered to consumers within a short time.
 - In terms of raw materials procurement, the company had better align it with time and production needs. Thus, inventory costs can be avoided. By doing so, the company can save more money and increase profits as there are few or no inventory costs. Besides, the money which used to be spent on raw materials inventory can be allocated to other costs.

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