Telkom University

Fakultas Rekayasa Industri
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TEKMI LABORATORY

MODULE 0
DEMAND FORECASTING

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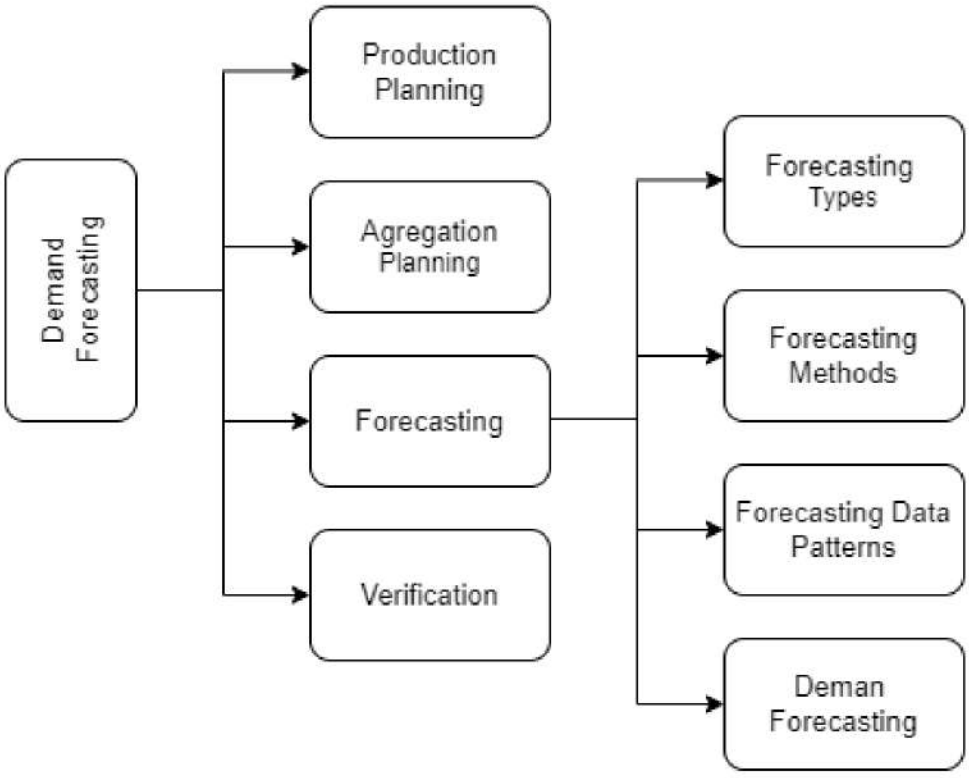
LABWORK OBJECTIVES

1. Students understand the relationship between time series patterns and forecasting methods.
2. Students are able to calculate the error rate using MSE to get the optimal method.
3. Students understand the stages of forecasting verification using Moving Range Charts.
4. Students are able to know and understand the actions that can be taken when out of control conditions occur.

PRACTICUM OUTLINE



THEORETICAL EXPLANATION

1.1. Production Planning

1.1.1. Definition of Production Planning

Production planning incorporates various elements of production, from: the day-to-day activities of staff to the ability to achieve accurate delivery times for customers. With effective production planning operations at its core, any form: manufacturing process has the ability to harness its full potential.

According to Henri Fayol, production planning is the prior determination of the line of action by which certain results will be obtained. Meanwhile, according to Urwich production planning is a continuous process of making entrepreneurial decisions systematically and with the best knowledge of the future by systematically organizing the effort required to carry out these decisions and measuring the results of these decisions against expectations through organized and systematic feedback.

1.1.2. Production Planning Objectives

The objectives of production planning according to Ginting (2007) are:

1. Production planning will be the first step to determine the production activity which becomes an item in the master production schedule.
2. Production Planning will be the input of resource plans, and so the resource planning could be developed to support the production planning.
3. Stabilized the production and workforce against the demand fluctuations.

1.2. Aggregate Planning

1.2.1. Definition of Aggregate Planning

Aggregate Planning is concerned with determining the quantity and scheduling of production for the medium term in the future. Time on the aggregate plan runs normally from 3 to 18 months. Therefore, the plan is a by-product of the long-term strategy of the plan. This is an important differentiation because the planning horizon may have a direct impact on business volume requirements. In conclusion, Aggregate Planning is a

fundamental method for further determining what will be needed to complete this transformation process. This includes the capacity to include facilities and labor, raw materials either directly consumed in the manufacture of the product or consumed as part of the process and finally the inventory level is regulated to maintain delivery dates and at the same time minimize costs.

Meanwhile, according to Heizer and Render (2010) aggregate planning is an approach to determine the quantity and time of production in the medium term (usually 3 to 18 months in the future). Meanwhile, according to Herjanto (2008) aggregate planning is the heart of intermediate planning which aims to develop an overall production plan that is feasible and optimal. From the two definitions above, the conclusion is that aggregate planning is a plan made by forecasting future sales, to increase capacity and meet customer demand while minimizing the company's production costs.

1.2.2. Aggregate Planning Objectives

Aggregate planning objectives according to Baroto (2002), are:

1. Production strategy planning,
2. For medium-term production,
3. Minimizing details in production planning,
4. Determining resource requirements (labor, materials, facilities, equipment, costs, etc.),
5. As the initial step in the production activities used for the preparation of the Master Production Schedule (JIP).

1.3. Forecasting

1.3.1. Definition of Forecasting

According to Render and Heizer (2007) forecasting is the art and science of predicting future events. According to Handoko (1999) forecasting is an attempt to predict future conditions through testing of past situations. But Russell and Taylor (2001: 497), the amount of inventory needed, the number of products that must be made and the number of

materials that must be purchased by suppliers will be determined by predicting product demand, which aims to achieve the predicted customer needs.

1.3.2. Purpose of Forecasting

The purpose of forecasting in production activities is to reduce uncertainty, so that an estimate is close to the actual situation (Ginting, 2007). The following is an explanation of forecasting covered by Taylor (2004) forecasting can be classified into three categories based on the future time horizon:

1. **Short-Term Forecasting**

   Short-term forecasting is generally carried out for forecasting one to five weeks. These forecasts are usually used to make decisions in terms of whether or not to work overtime, work scheduling and other long-term control decisions.

2. **Medium-Term Forecasting**

   Medium-Term forecasting or intermediate forecasting is done to predict a person twenty-four months. Forecasting is usually used to determine cash flow, production planning and budgeting.

3. **Long-Term Forecasting**

   Long-term forecasting is generally for planning a period of two to ten years. This forecast is used for product planning and resource planning

1.4. Types of Forecast

According to Heizer and Render (2004), organizations generally use three types of forecasts:

1. **Economic Forecast**

   It describes the business cycle by predicting inflation rates, money availability, funds needed to build housing and other planning indicators.

2. **Technology Forecast (Technological Forecast)**

   It pays attention to the level of technological progress that can be launched attracting new products, which require new plant and equipment

3. **Demand Forecast (Demand Forecast)**

   It predicts the demand for the company's products or services. Forecasts are usually classified according to the future time horizon they cover.

1.5. Forecasting Methods

1. **Quantitative Methods**

   Quantitative methods are forecasting methods based on past quantitative data. Forecasting results are highly dependent on the method used in forecasting. Quantitative methods can be used if three conditions exist: (Makridakis, 2008):

   a. There is information or data about the past
   b. This information or data can be measured by numerical data
   c. It can be assumed that some aspects of the past pattern will continue.

2. **Causal Method**

   Method is a quantitative method to analyze the influence and also the relationship between the independent variable and the dependent variable. According to Ginting (2007), the causal method is a method used to analyze the pattern of relationships between variables to be estimated with other variables that influence it.

3. **Time Series Method**

   Time series method is a method that deals with the values of a variable that is set periodically over time in which the demand forecast is projected to determine the variation of certain indicators of a particular product over time. It is used to analyze a data series based on a function of time.

   3.1 Regression

   Forecasting calculation methods are based on trend lines, so that things can be projected that will be studied in the future (Sofyan, 2013).

   a. Constant

      The formula:

$$d't = \frac{\sum d_t}{n}$$

Note :

d't : Forecasting value in period t

dt = Demand in period t

N = Number of period

b. Linear

The formula:

$$d't = a + bt$$

$$a = \frac{\sum t^2 . d(t) - \sum t \sum t . d(t)}{n\sum t^2 - (\sum t)^2}$$

$$b = \frac{n\sum t . d(t) - \sum t \sum t . d(t)}{n\sum t^2 - (\sum t)^2}$$

Note :

d't = Forecasting value in period t

dt = Demand in period t

n = Number of periods

a = intercept

b = Slope

c. Smoothing

1. Moving Average

1. Single Moving Average

A simple moving average (SMA) is an arithmetic moving average calculated by adding the last closing price and then dividing by the number of time periods in the average calculation.

The formula:

$$d't = \frac{d_{t-1} + d_{t-2} + d_{t-3} + \cdots + d_{t-n}}{n}$$

Note :

dt-1 = Demand Period-t-1

N = Number of time series used

d't = Estimated value in period t

2. Multiple Moving Average (mxn)

Apply the moving average technique twice, once to the original data and then to the resulting single moving average data.

$$S'_t = \frac{d_{t-1} + d_{t-2} + d_{t-3} + \ldots + d_{t-n+1}}{n}$$

$$S''_t = \frac{S'_{t-1} + S'_{t-2} + \ldots + S'_{t-m+1}}{m}$$

$$a_t = S'_t + (S'_t - S''_t) = 2S'_t - S''_t$$

$$b_t = \frac{2}{N-1}(S'_t - S''_t)$$

$$d'_t = a_{t-1} + b_{t-1}M$$

Note :

dt-1 = Demand Period-t-1

dt = Estimated value in period t

S't = Single Moving Average

St = Multiple Moving Average

n = Total Single Moving Average Period

m = Total Period Average Multiple Moving Average

M = Deviation between forecast period and current period

N = Total forecast period

3. Weight Moving Average

Average Weighted Moving Average gives more weight to recent data and less weight to past data.

The formula:

$$d'_t = \frac{W_1 d_1 + W_2 d_2 + W_3 d_3}{W_1 + W_2 + W_3}$$

Note :

W1 = Weight in period t-1

W2 = Weight in period t-2

Wn = Weight in period tn

n = Number of periods

d't = Forecasting value in period t

2. Exponential Smoothing

a) Single Exponential Smoothing

This forecasting method is the most widely used of all forecasting techniques.

This method is used when the data pattern is more or less horizontal.

The formula:

$$d'_t = d'_{t-1} + \alpha(d_{t-1} - d'_{t-1})$$

Note:

d't-1 = Estimated data in period t-1

dt-1 = Demand data in period t-1

α = Constant

t = Estimated at t period

b) Double Exponential Smoothing

The formula:

$$S'_t = s'_{t-1} + \alpha(d_t - s'_{t-1})$$

$$S''_t = s''_{t-1} + \alpha(s'_t - s''_{t-1})$$

$$a_t = S'_t + (S'_t - S''_t) = 2S'_t - S''_t$$

$$b_t = \frac{\alpha}{1-\alpha}(S'_t - S''_t)$$

$$D'_t = a_{t-1} + b_{t-1}m$$

Note :

dt = demand in period t

α = Constant

S' = Single Exponential Smoothing

S" = Multiple Exponential Smoothing

4. Qualitative Methods

A qualitative approach (or assessment) can be useful in formulating short-term forecasts and can also complement projections based on the use of quantitative methods.

a. Delphi

This is a group technique in which a panel of experts invited individuals about their perceptions of future events. Experts do not meet as a group, to reduce the possibility of reaching consensus due to dominant personality factors. Instead, the forecasts and accompanying arguments are summarized by outsiders and returned to the expert along with further questions. This continues until a consensus is reached.

The Delphi method according to Keeney S. et al (2006) has evolved since it was first reported in the 1960s. However, many of the fundamental characteristics of the approach still remain from Dalkey and Helmer's original outline. First, the overarching approach is based on a series of 'rounds', where a set of experts are asked their opinions on a particular issue. The questions for each round are based in part on the findings of the previous one, allowing the study to evolve over time in response to earlier findings. Second, participants are able to see the results of previous rounds—including their own responses—allowing them to reflect on the views of others and reposition their own opinions accordingly.

b. Top Down

This is a commonly used method for industrial applications. First, management makes an estimate of potential sales before developing a sales guata. The last stage is the construction of the sales forecast. However, when the assumptions underlying

the past cannot be applied, problems arise with this method. Over time, the correlation between quantity demanded and economic variables may become weak or change.

The most common approaches in hierarchical forecasting are the top-down method and also the bottom-up methodology Top-down method involves forecasting the aggregated series, and then disaggregating the forecasts based on the historical or forecast proportions (Gross and Sohl, 1990).

c. Bottom Up

Bottom Up is a technique used by analysts in which the market is broken down into segments and the demand for each segment is calculated separately. Industry surveys, intention to purchase surveys, and sales force composites were used by analysts to collect data. Segment aggregates are used to prepare total sales forecasts.

The bottom-up method involves forecasting each of the disaggregated series at the lowest level of the hierarchy, and then using aggregation to obtain forecasts at higher levels of the hierarchy, (Kahn, 1998).

d. Jury Executive Opinion

A forecasting method that uses combined forecasts prepared by numbers from individual experts. Experts form their own opinions initially from the data provided and revise their choices according to the opinions of others. Finally, individual final opinions are combined.

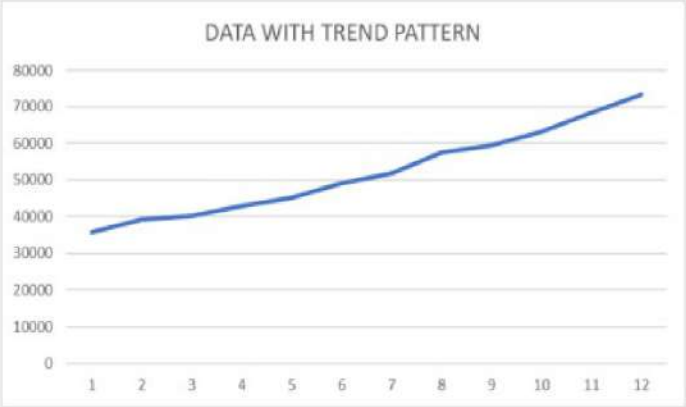
The jury of executive opinion is a marketing research technique used to identify if an idea or concept is germane to a research study. The basic model seeks the opinions of a small group of high-level experienced managers within a specific field. It is a qualitative (opinion-based) tool that incorporates judgmental and subjective factors into an assessment (Green and Tull, 1978).

1.6. Data Patterns Forecasting

With time series analysis, it can be shown how the demand for a particular product varies with time. The nature of changes in demand from year to year is formulated to forecast sales in the future. There are four main patterns that affect this analysis (Ginting, 2007)

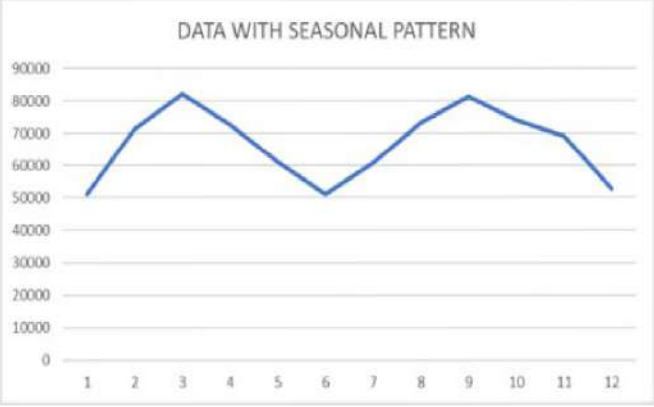
1. **Trends Patterns**

   This data pattern occurs when the data has a tendency to rise or fall continuously in the long term. From fluctuating data, a line can be drawn so that data patterns can be seen. Forecasting methods that are in accordance with the trend of the data pattern are linear regression, exponential smoothing and double exponential smoothing method.



2. **Seasonal Patterns**

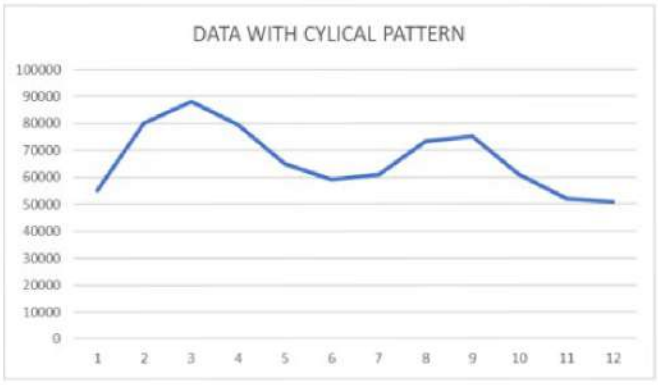
   Seasonal data patterns can be described as sales patterns that repeat in each period and demand is influenced by seasons. Forecasting methods that are suitable for seasonal data patterns are moving averages and weight moving averages.



3. **Cycle Pattern**

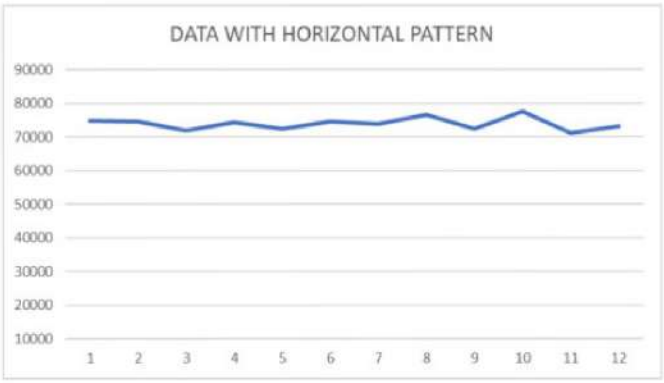
   This data pattern is usually influenced by economic fluctuations and the pattern data is repeated periodically with an indefinite time frame. Forecasting methods that are suitable for

cyclical data patterns are moving averages, heavy moving averages and exponential smoothing methods.



4. Horizontal Pattern

Data patterns that occur because data values fluctuate around a constant average value. A product whose sales have not increased or decreased over time is also included in this type of data pattern. The method that fits the horizontal data pattern is constant. The following is a picture of a horizontal data pattern.



1.7. Forecasting Performance Criteria

1. Mean Absolute Deviation (MAD)

Mean Absolute Deviation is the average absolute error over a certain period regardless of whether the forecasting result is greater or less (Ginting, 2007). The formula for Mean Absolute Deviation (MAD):

$$MAD = \frac{1}{n}\sum_{i=1}^{n}|e_i|$$

Note :

n = Number of periods n

ei = The difference between the estimated value and the actual data

2. Mean Squared Error (MSE)

Mean Sguared Error is the accuracy calculated by adding up the squares of all errors in each period and dividing by number of predictions (Ginting, 2007). The formula for the Guaranteed Mean Error (MSE):

$$MSE = \frac{1}{n}\sum_{i=1}^{n}{e_i}^2$$

Note :

n = Number of periods n

ei = The difference between the estimated value and the actual data

3. Mean Absolute Percentage Error (MAPE)

Mean Absolute Percentage Error (MAPE) is a statistical measure of how accurate the forecasting system is. The formula for the Average Absolute Percentage of Error (MAPE):

$$MAPE = \left[\frac{1}{n}\sum_{i=1}^{n}|(e_i \,/\, D_i)|\right] x\ 100\%$$

Note :

n = Number of periods n

ei = The difference between the estimated value and the actual data

Di = The estimated value in period t

4. Estimation Standard Error (SEE)

The standard error of the estimate is a measure of the accuracy of the prediction. Formula for Standard Error of Estimation (SEE):

$$SEE = \sqrt{\frac{\Sigma(Y - Y')^2}{n - f}}$$

Note :

Y = Actual Demand

Y' = Forecast Value

n = Number of periods

f = Degrees of freedom

5. Verification

Verification is a process used to determine whether the forecasting method is representative of the data. Checks can be done using the Moving Range Chart (MRC). The graph shows whether the distribution is still under control or not. When the distribution is not controlled, the prediction function or method does not match and the predictive pattern in the data becomes unrepresentative. (Ginting, 2007).

Out of control conditions can be checked using the following rules:

1. One Point Rule

   If there is one distribution (Y"-Y) outside UCL and LCL.

2. Three-Point Rule

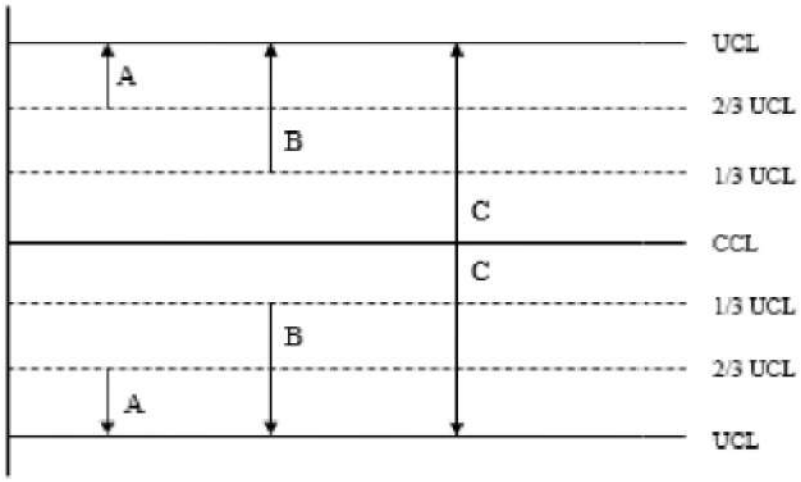
   If there are two or more than three points on a line that fall successively into area A on the same side of the centerline.

3. Five-Point Rule

   If there are four or more than five succession points, they fall into area B on the same side of the centerline.

4. Eight-Point Rule

   If there are eight or more consecutive points in area C on the same side of the center line.


UCL
A
2/3 UCL
B
1/3 UCL
C
CCL
C
1/3 UCL
B
2/3 UCL
A
UCL

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