

# Pengantar Teknik Industri

TIN 4103

# Lecture 13 & 14

- **Outline:**

- Perencanaan dan Pengendalian Produksi

- **References:**

- Smith, Spencer B., *Computer-Based Production and Inventory Control*, Prentice-Hall, 1989.
- Tersine, Richard J., *Principles of Inventory and Materials Management*, Prentice-Hall, 1994.
- Yuniar, Rahmi. PPT: PTI – Perencanaan dan Pengendalian Produksi. PSTI-UB. 2011.

# FORECASTING

# Manajemen Permintaan

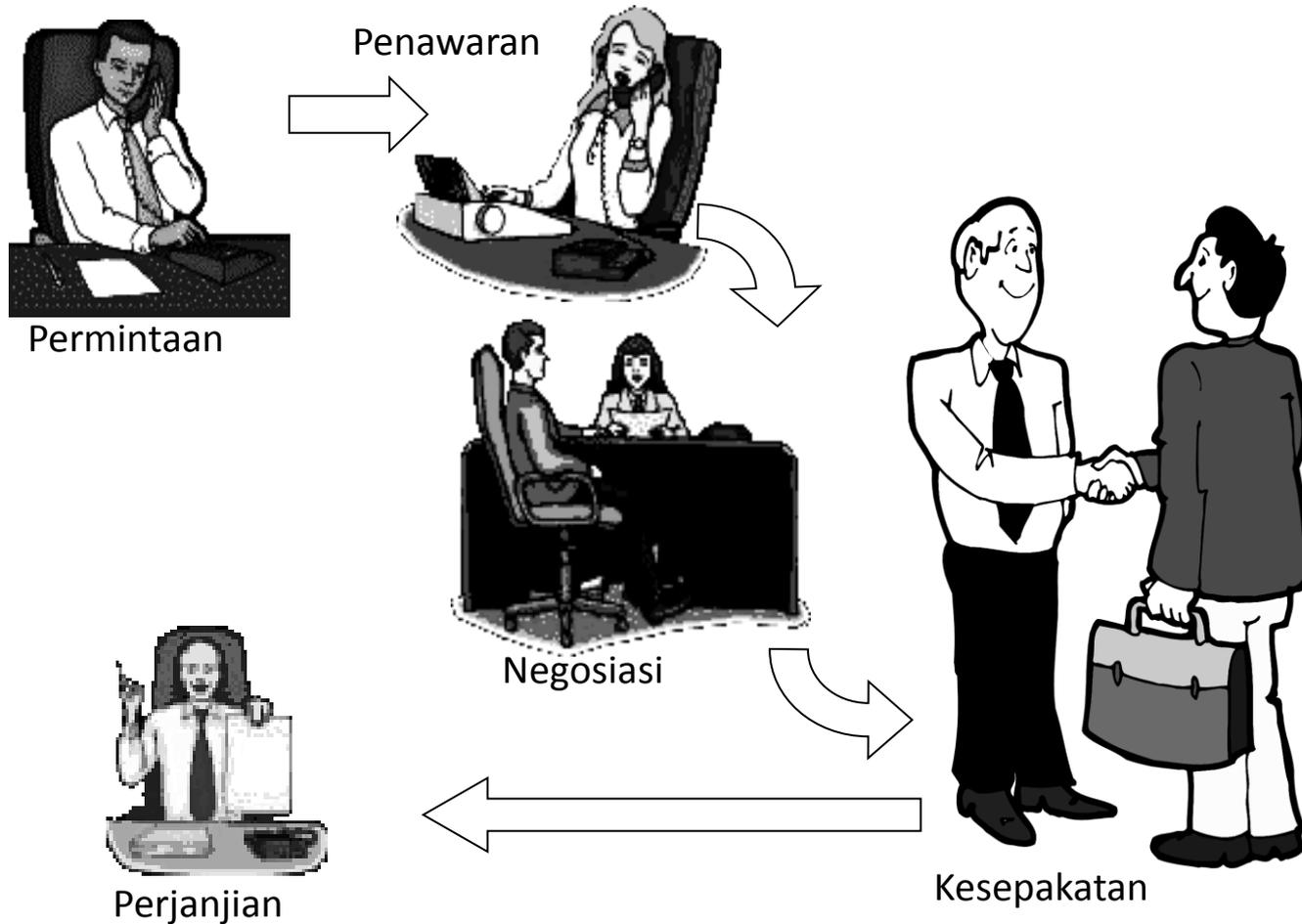
Order Pesanan



Ramalan  
Permintaan



# Pengelolaan Order Pesanan



# What is Forecasting?



## **FORECAST:**

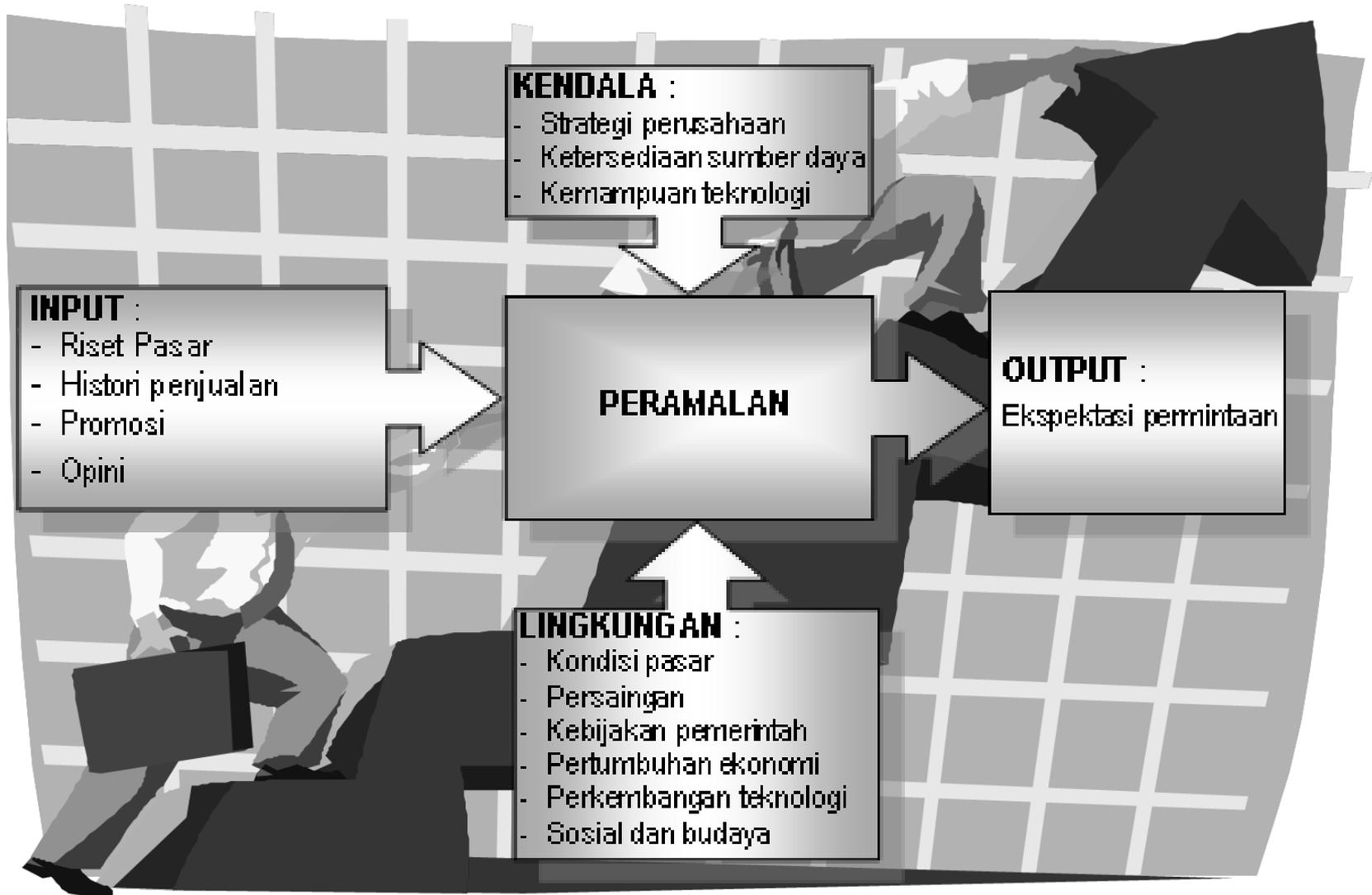
- A statement about the future value of a variable of interest such as demand.
- Forecasts affect decisions and activities throughout an organization
  - Accounting, finance
  - Human resources
  - Marketing
  - MIS
  - Operations
  - Product / service design

# Uses of Forecasts



Accounting	Cost/profit estimates
Finance	Cash flow and funding
Human Resources	Hiring/recruiting/training
Marketing	Pricing, promotion, strategy
MIS	IT/IS systems, services
Operations	Schedules, MRP, workloads
Product/service design	New products and services

# Peramalan Permintaan



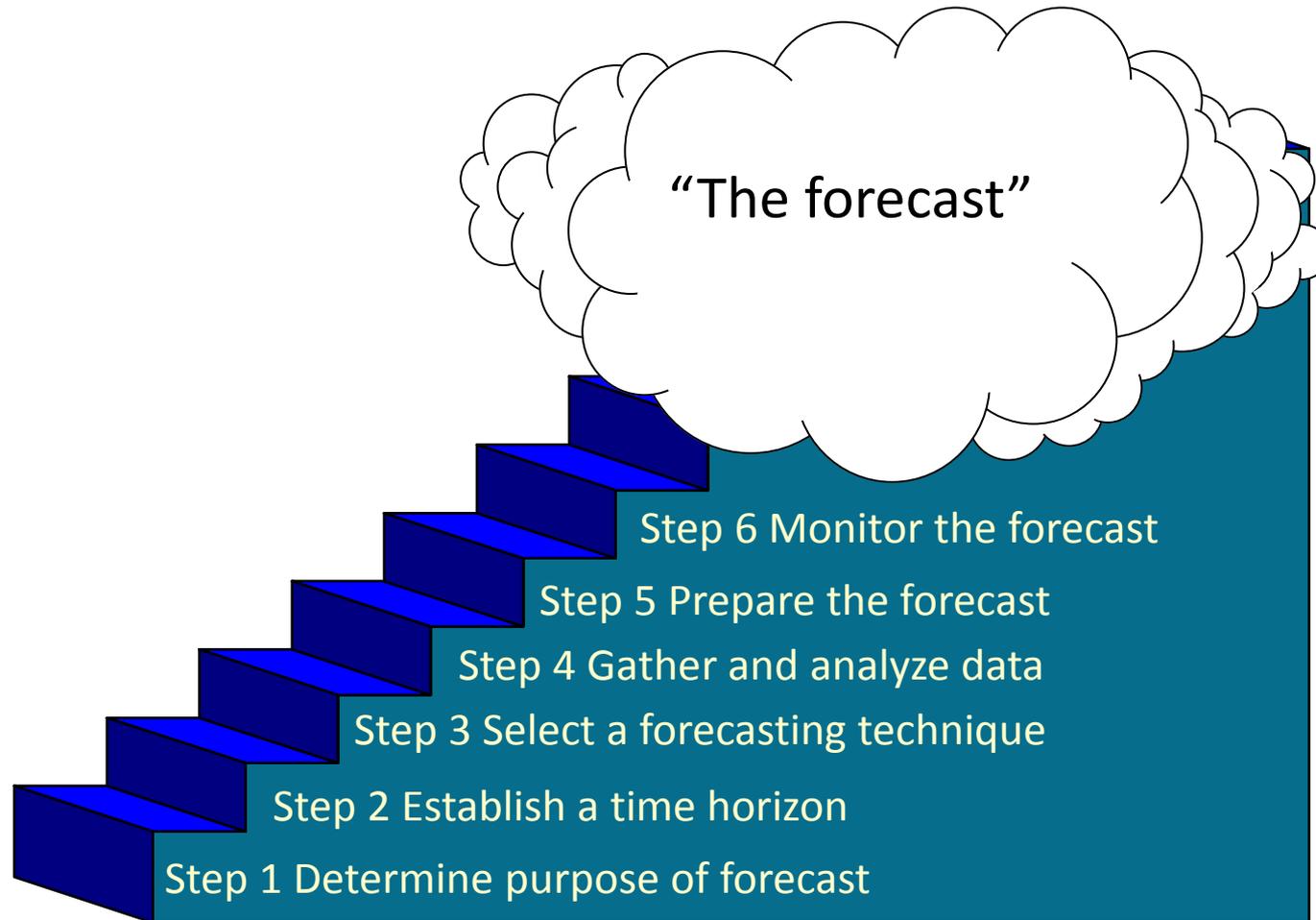
# Common in all forecasts



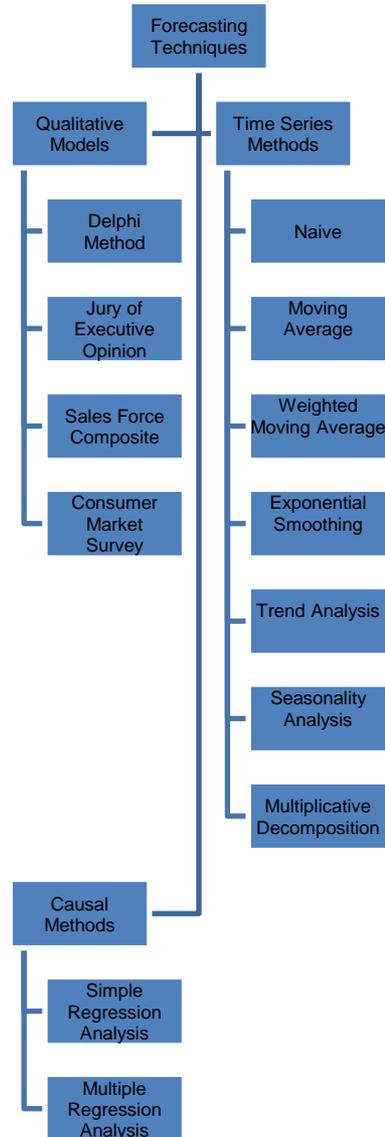
- Assumes causal system  
past ==> future
- Forecasts rarely perfect because of randomness
- Forecasts more accurate for groups vs. individuals
- Forecast accuracy decreases as time horizon increases



# Steps in the Forecasting Process



# Forecasting Models



# Model Differences

- Qualitative – incorporates judgmental & subjective factors into forecast.
- Time-Series – attempts to predict the future by using historical data.
- Causal – incorporates factors that may influence the quantity being forecasted into the model

# Qualitative Forecasting Models

- Delphi method
  - Iterative group process allows experts to make forecasts
  - Participants:
    - decision makers: 5 -10 experts who make the forecast
    - staff personnel: assist by preparing, distributing, collecting, and summarizing a series of questionnaires and survey results
    - respondents: group with valued judgement provide input to decision makers



# Qualitative Forecasting Models (cont)



- Jury of executive opinion
  - Opinions of a small group of high level managers, often in combination with statistical models.
  - Result is a group estimate.
- Sales force composite
  - Each salesperson estimates sales in his region.
  - Forecasts are reviewed to ensure realistic.
  - Combined at higher levels to reach an overall forecast.
- Consumer market survey.
  - Solicits input from customers and potential customers regarding future purchases.
  - Used for forecasts and product design & planning



# Time Series Forecasts



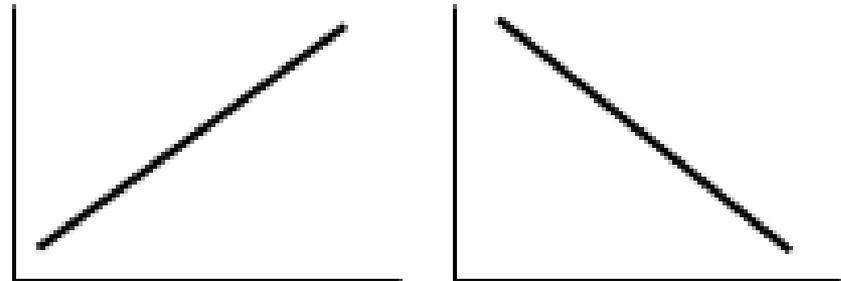
- Trend - long-term movement in data
- Seasonality - short-term regular variations in data
- Cycle – wavelike variations of more than one year’s duration
- Random variations - caused by chance

# Pola Kecenderungan Data Historis Penjualan

Faktor  
Keacakan



Faktor  
Tren



Faktor  
Siklik



Faktor  
Musiman



# Forecast Error



- Bias - The arithmetic sum of the errors

$$\text{Forecast Error} = A_t - F_t$$

- Mean Square Error - Similar to simple sample variance

$$\begin{aligned} \text{MSE} &= \sum_{t=1}^T |\text{forecast error}|^2 / T \\ &= \sum_{t=1}^T (A_t - F_t)^2 / T \end{aligned}$$

- MAD - Mean Absolute Deviation

$$\text{MAD} = \sum_{t=1}^T |\text{forecast error}| / T = \sum_{t=1}^T |A_t - F_t| / T$$

- MAPE – Mean Absolute Percentage Error

$$\text{MAPE} = 100 \sum_{t=1}^T [|A_t - F_t| / A_t] / T$$

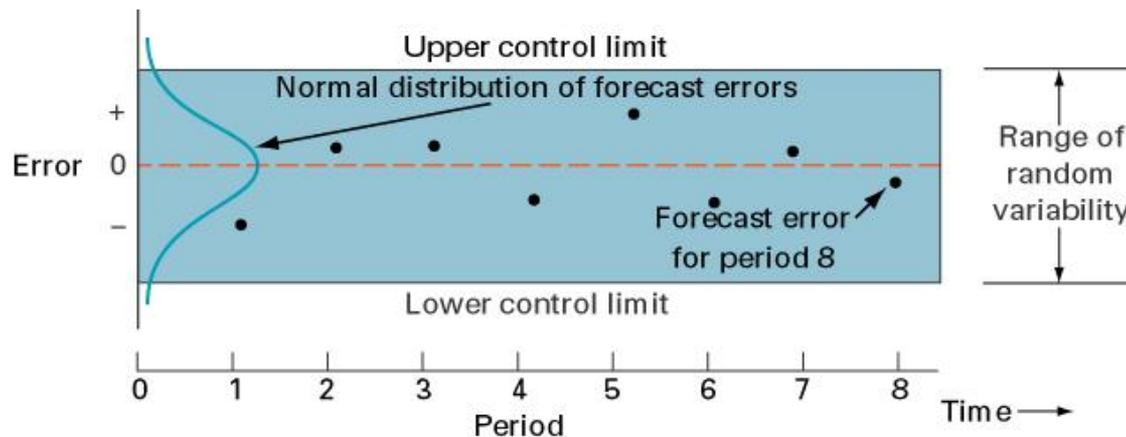
# Example



Period	Actual	Forecast	(A-F)	A-F	(A-F)^2	( A-F /Actual)*100
1	217	215	2	2	4	0,92
2	213	216	-3	3	9	1,41
3	216	215	1	1	1	0,46
4	210	214	-4	4	16	1,90
5	213	211	2	2	4	0,94
6	219	214	5	5	25	2,28
7	216	217	-1	1	1	0,46
8	212	216	-4	4	16	1,89
			-2	22	76	10,26
<b>MAD=</b>	2,75					
<b>MSE=</b>	9,50					
<b>MAPE=</b>	1,28					

# Controlling the Forecast

- Control chart
  - A visual tool for monitoring forecast errors
  - Used to detect non-randomness in errors



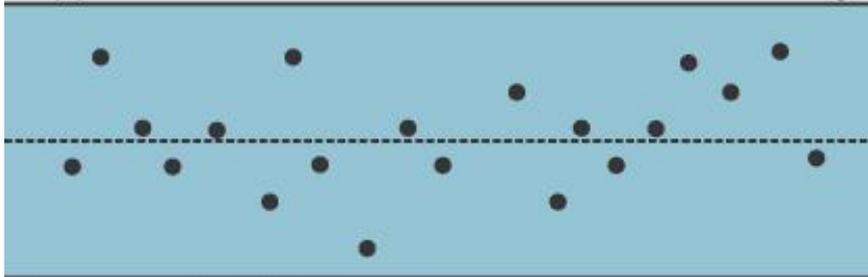
- Forecasting errors are in control if
  - All errors are within the control limits
  - No patterns, such as trends or cycles, are present

# Controlling the forecast

**Point beyond a control limit**

Error above the upper control limit

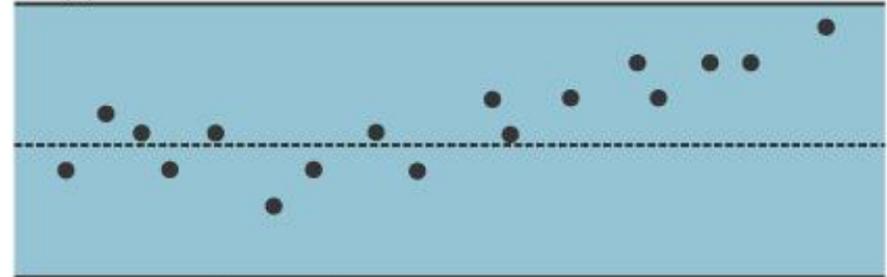
Upper control limit



Lower control limit

**Trend**

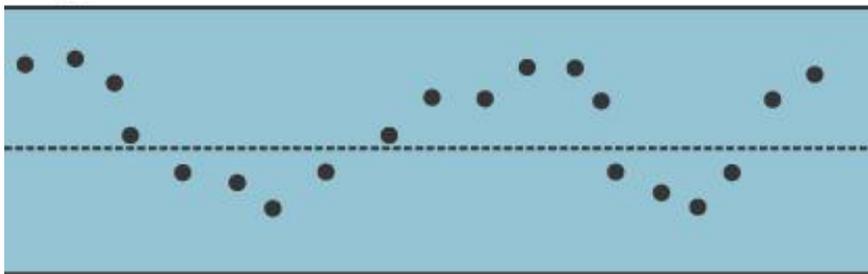
Upper control limit



Lower control limit

**Cycling**

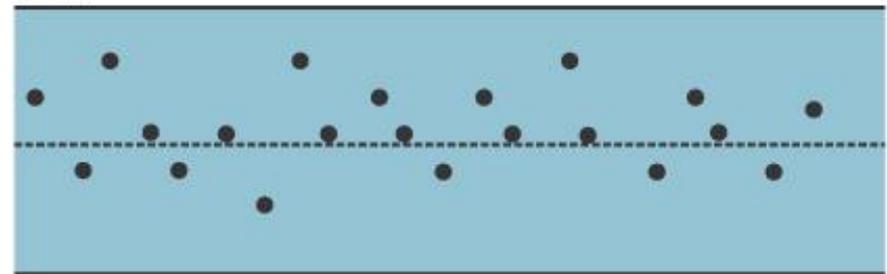
Upper control limit



Lower control limit

**Bias (too many points on one side of the centerline)**

Upper control limit



Lower control limit

# Quantitative Forecasting Models



- Time Series Method
  - Naïve
    - Whatever happened recently will happen again this time (same time period)
    - The model is simple and flexible
    - Provides a baseline to measure other models
    - Attempts to capture seasonal factors at the expense of ignoring trend

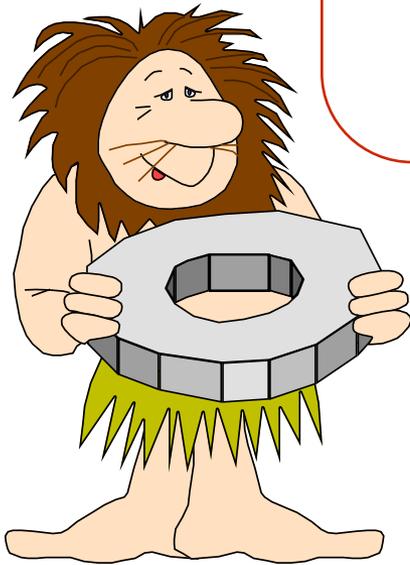
$$F_t = Y_{t-1}$$

$$F_t = Y_{t-4} : \text{Quarterly data}$$

$$F_t = Y_{t-12} : \text{Monthly data}$$

# Naive Forecasts

Uh, give me a minute....  
We sold 250 wheels last  
week.... Now, next week  
we should sell....



The forecast for any period equals  
the previous period's actual value.

# Naïve Forecast

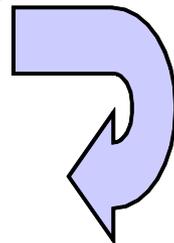
**Wallace Garden Supply**  
Forecasting

**Storage Shed Sales**

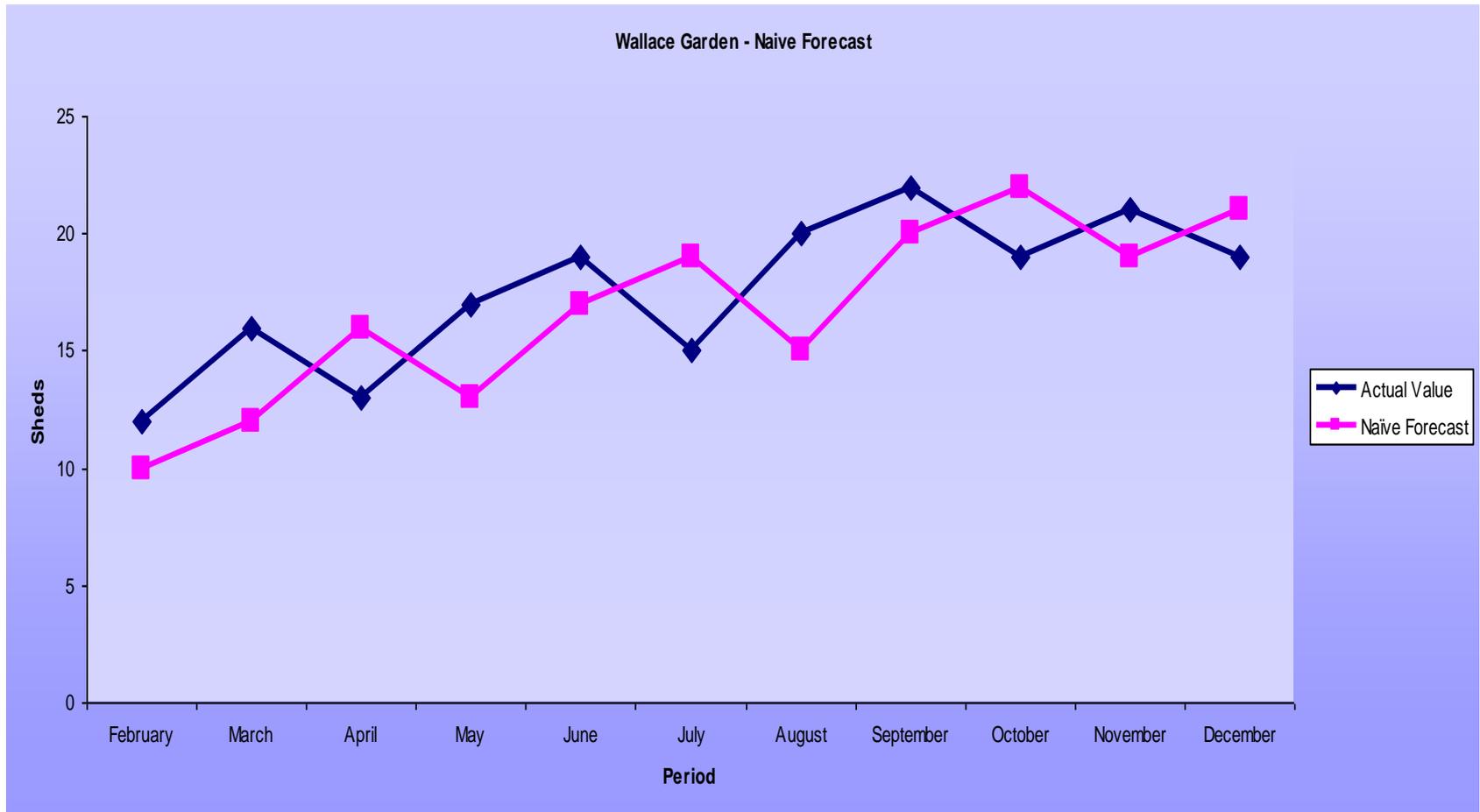
Period	Actual Value	Naïve Forecast	Error	Absolute Error	Percent Error	Squared Error
January	10	N/A				
February	12	10	2	2	16,67%	4,0
March	16	12	4	4	25,00%	16,0
April	13	16	-3	3	23,08%	9,0
May	17	13	4	4	23,53%	16,0
June	19	17	2	2	10,53%	4,0
July	15	19	-4	4	26,67%	16,0
August	20	15	5	5	25,00%	25,0
September	22	20	2	2	9,09%	4,0
October	19	22	-3	3	15,79%	9,0
November	21	19	2	2	9,52%	4,0
December	19	21	-2	2	10,53%	4,0

0,818	3	17,76%	10,091
<b>BIAS</b>	<b>MAD</b>	<b>MAPE</b>	<b>MSE</b>

**Standard Error (Square Root of MSE) = 3,176619**



# Naïve Forecast Graph



# Naive Forecasts



- Simple to use
- Virtually no cost
- Quick and easy to prepare
- Easily understandable
- Can be a standard for accuracy
- **Cannot provide high accuracy**

# Techniques for Averaging



- Moving average
- Weighted moving average

# Metode Peramalan Deret Waktu

- Teknik peramalan yang menggunakan data-data historis penjualan beberapa waktu terakhir dan mengekstrapolasinya untuk meramalkan penjualan di masa depan
- Peramalan deret waktu mengasumsikan pola kecenderungan pemasaran akan berlanjut di masa depan.
- Sebenarnya pendekatan ini cukup naif, karena mengabaikan gejolak kondisi pasar dan persaingan

# Langkah-langkah Peramalan Deret Waktu

- Kumpulkan data historis penjualan
- Petakan dalam diagram pencar (scatter diagram)
- Periksa pola perubahan permintaan
- Identifikasi faktor pola perubahan permintaan
- Pilih metode peramalan yang sesuai
- Hitung ukuran kesalahan peramalan
- Lakukan peramalan untuk satu atau beberapa periode mendatang

# Moving Averages



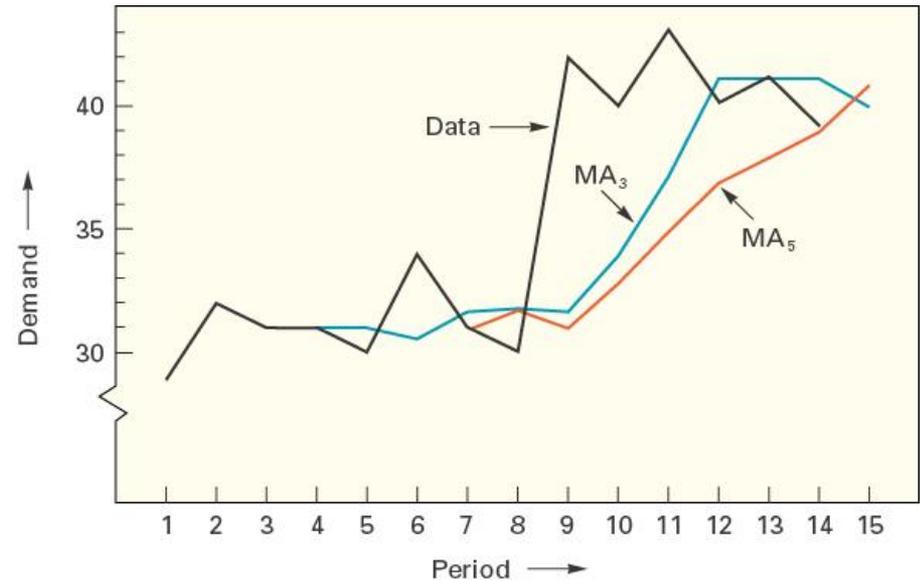
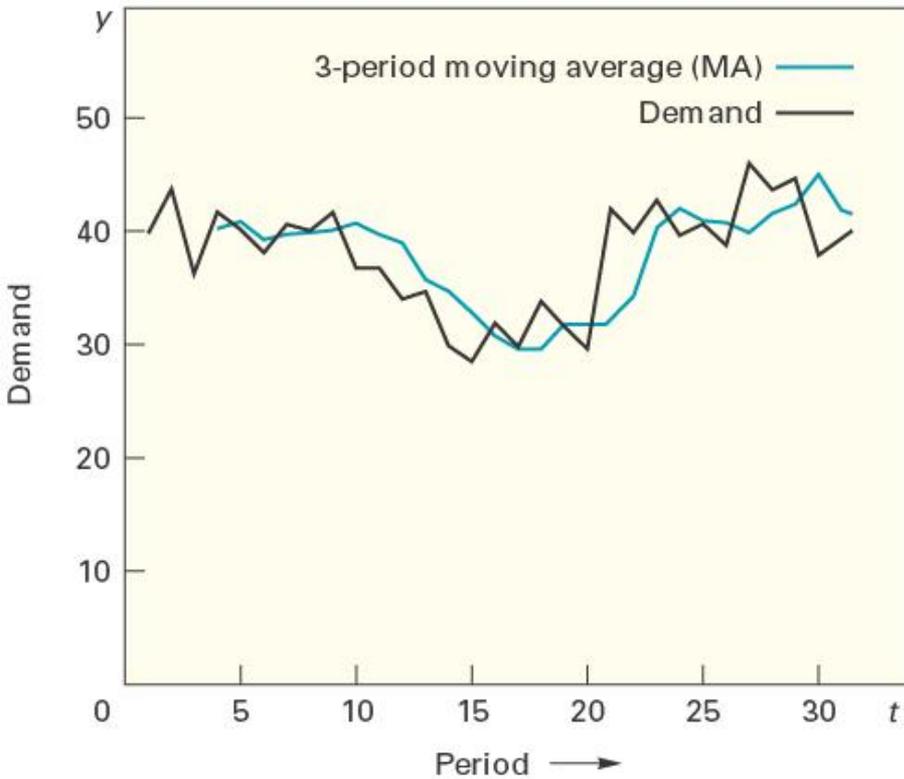
- Moving average – A technique that averages a number of recent actual values, updated as new values become available.

$$MA_n = \frac{\sum_{i=1}^n A_i}{n}$$

- The demand for tires in a tire store in the past 5 weeks were as follows. Compute a three-period moving average forecast for demand in week 6.

83 80 85 90 94

# Moving average & Actual demand



# Moving Averages

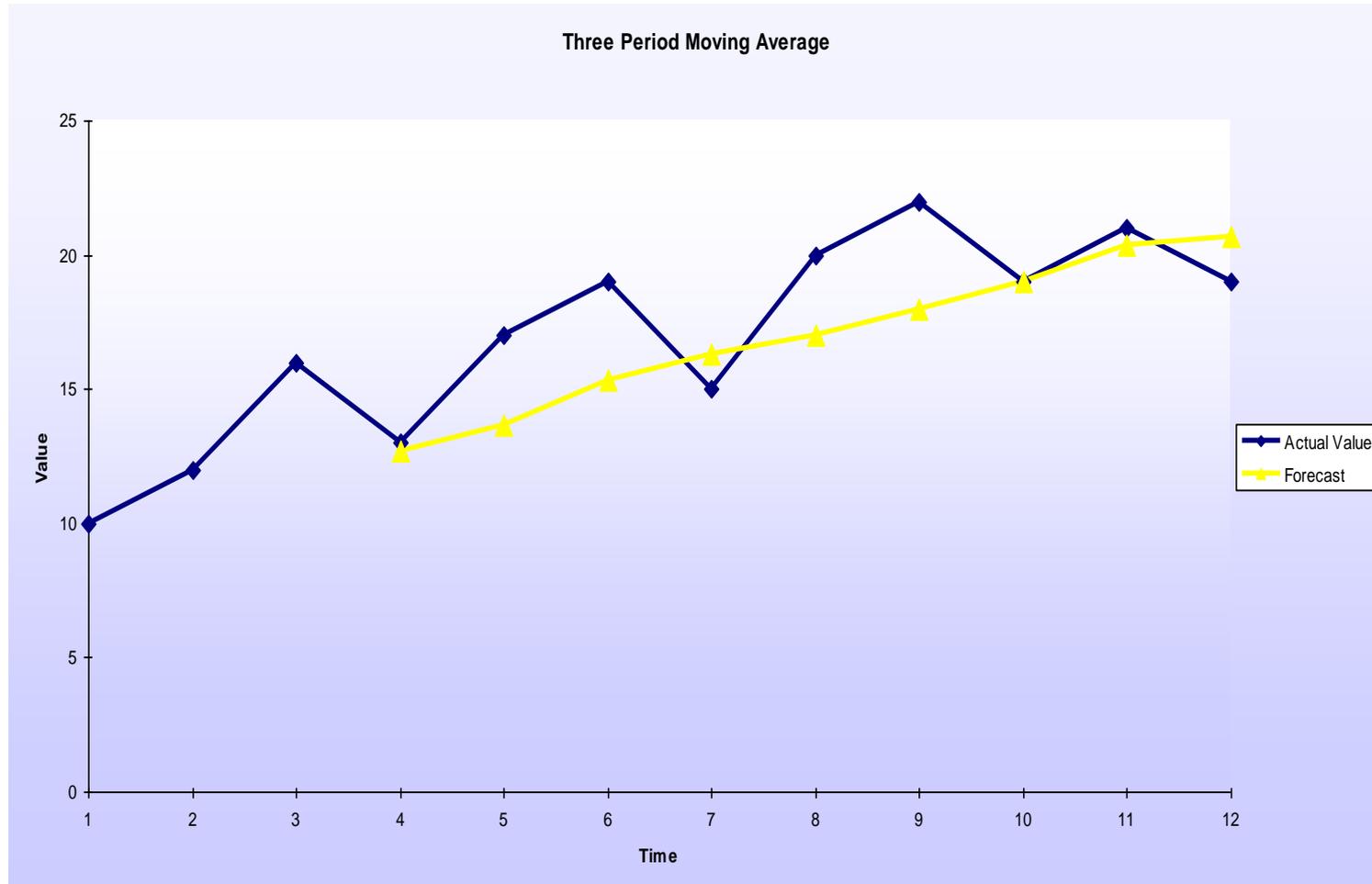
## Wallace Garden Supply Forecasting

Storage Shed Sales

Period	Actual Value	Three-Month Moving Averages					
January	10						
February	12						
March	16						
April	13	10	+	12	+	16	/ 3 = 12.67
May	17	12	+	16	+	13	/ 3 = 13.67
June	19	16	+	13	+	17	/ 3 = 15.33
July	15	13	+	17	+	19	/ 3 = 16.33
August	20	17	+	19	+	15	/ 3 = 17.00
September	22	19	+	15	+	20	/ 3 = 18.00
October	19	15	+	20	+	22	/ 3 = 19.00
November	21	20	+	22	+	19	/ 3 = 20.33
December	19	22	+	19	+	21	/ 3 = 20.67



# Moving Averages Graph



# Moving Averages



- Weighted moving average – More recent values in a series are given more weight in computing the forecast.
  - Assumes data from some periods are more important than data from other periods (e.g. earlier periods).
  - Use weights to place more emphasis on some periods and less on others.

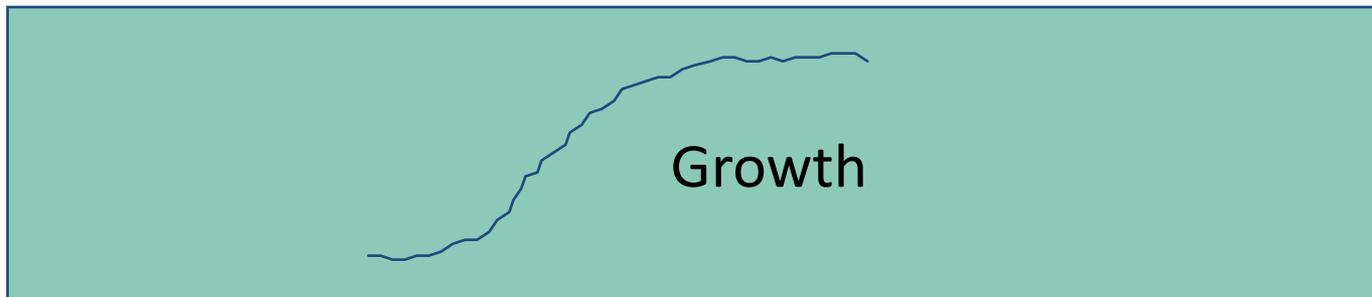
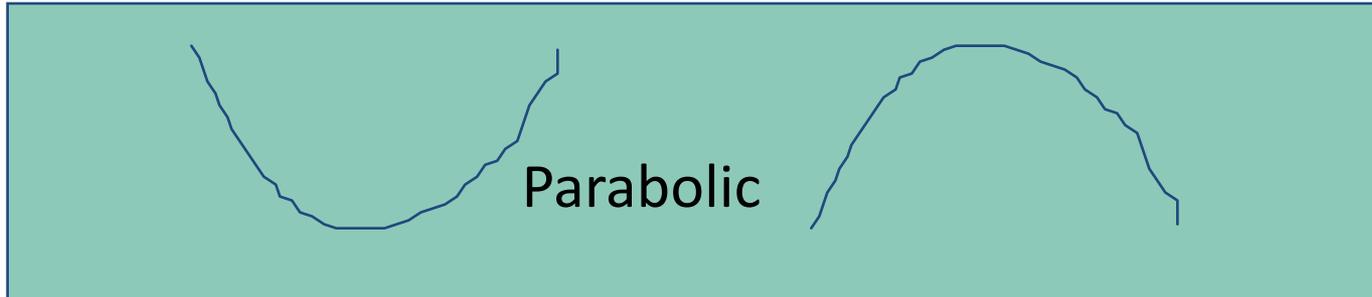
## Example:

- For the previous demand data, compute a weighted average forecast using a weight of .40 for the most recent period, .30 for the next most recent, .20 for the next and .10 for the next.
- If the actual demand for week 6 is 91, forecast demand for week 7 using the same weights.

# Techniques for Trend

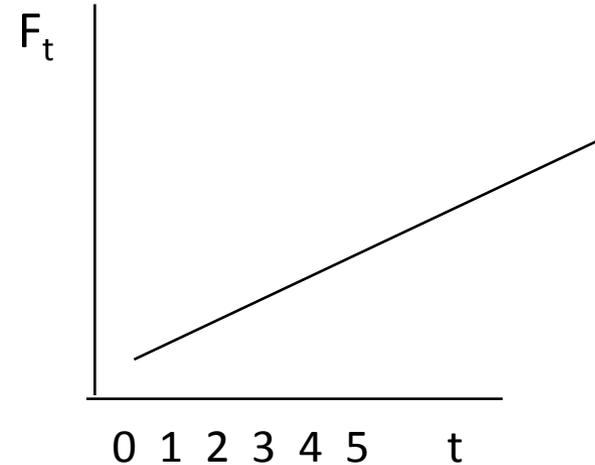
- Develop an equation that will suitably describe trend, when trend is present.
- The trend component may be linear or nonlinear
- We focus on linear trends

# Common Nonlinear Trends



# Linear Trend Equation

$$F_t = a + bt$$



- $F_t$  = Forecast for period  $t$
- $t$  = Specified number of time periods
- $a$  = Value of  $F_t$  at  $t = 0$
- $b$  = Slope of the line

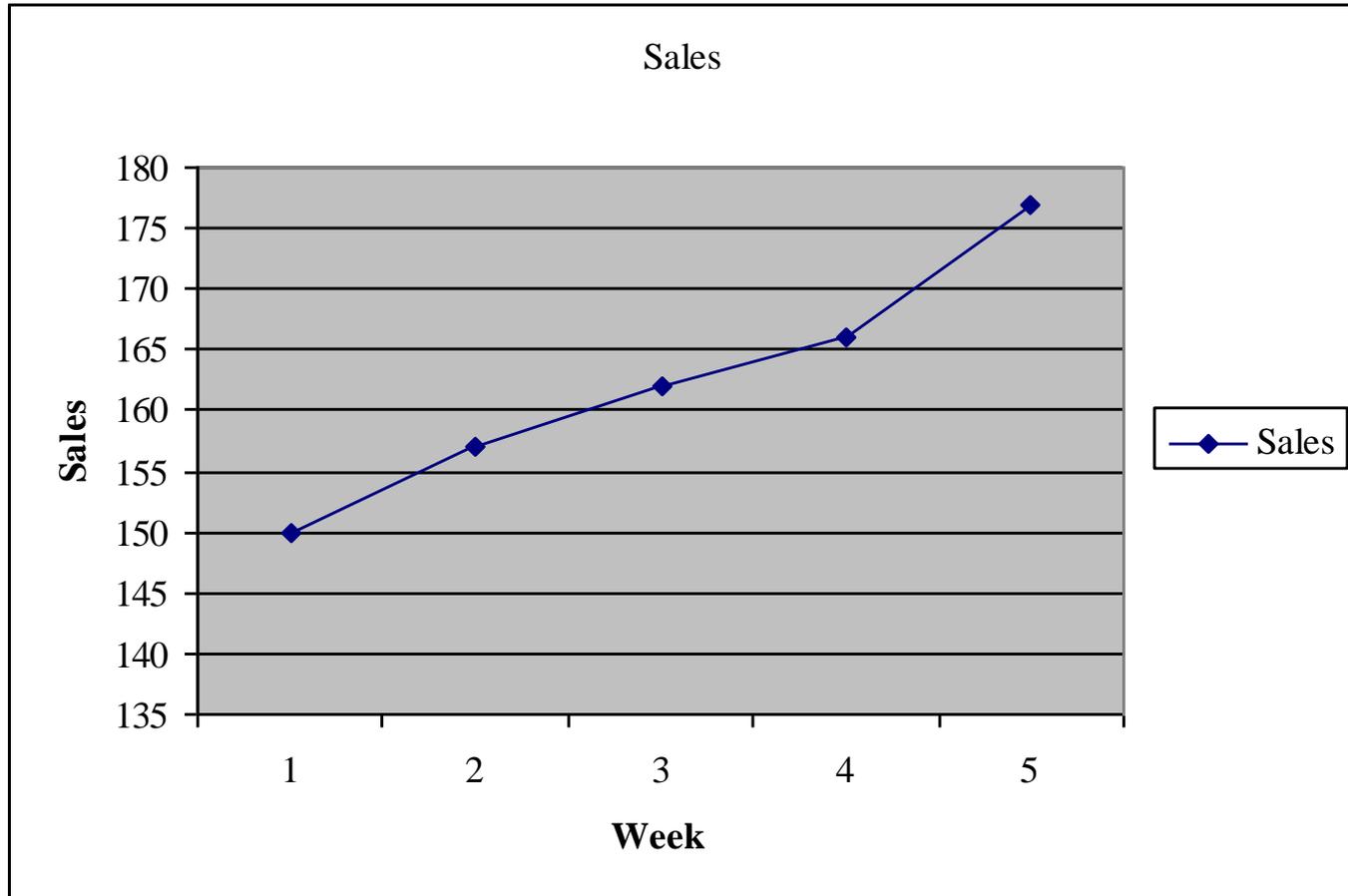
# Example

- Sales for over the last 5 weeks are shown below:

Week:	1	2	3	4	5
Sales:	150	157	162	166	177

- Plot the data and visually check to see if a linear trend line is appropriate.
- Determine the equation of the trend line
- Predict sales for weeks 6 and 7.

# Line chart



# Calculating a and b



$$b = \frac{n \sum (ty) - \sum t \sum y}{n \sum t^2 - (\sum t)^2}$$

$$a = \frac{\sum y - b \sum t}{n}$$

# Linear Trend Equation Example



t Week	$t^2$	y Sales	ty
1	1	150	150
2	4	157	314
3	9	162	486
4	16	166	664
5	25	177	885
$\Sigma t = 15$ $(\Sigma t)^2 = 225$	$\Sigma t^2 = 55$	$\Sigma y = 812$	$\Sigma ty = 2499$

# Linear Trend Calculation

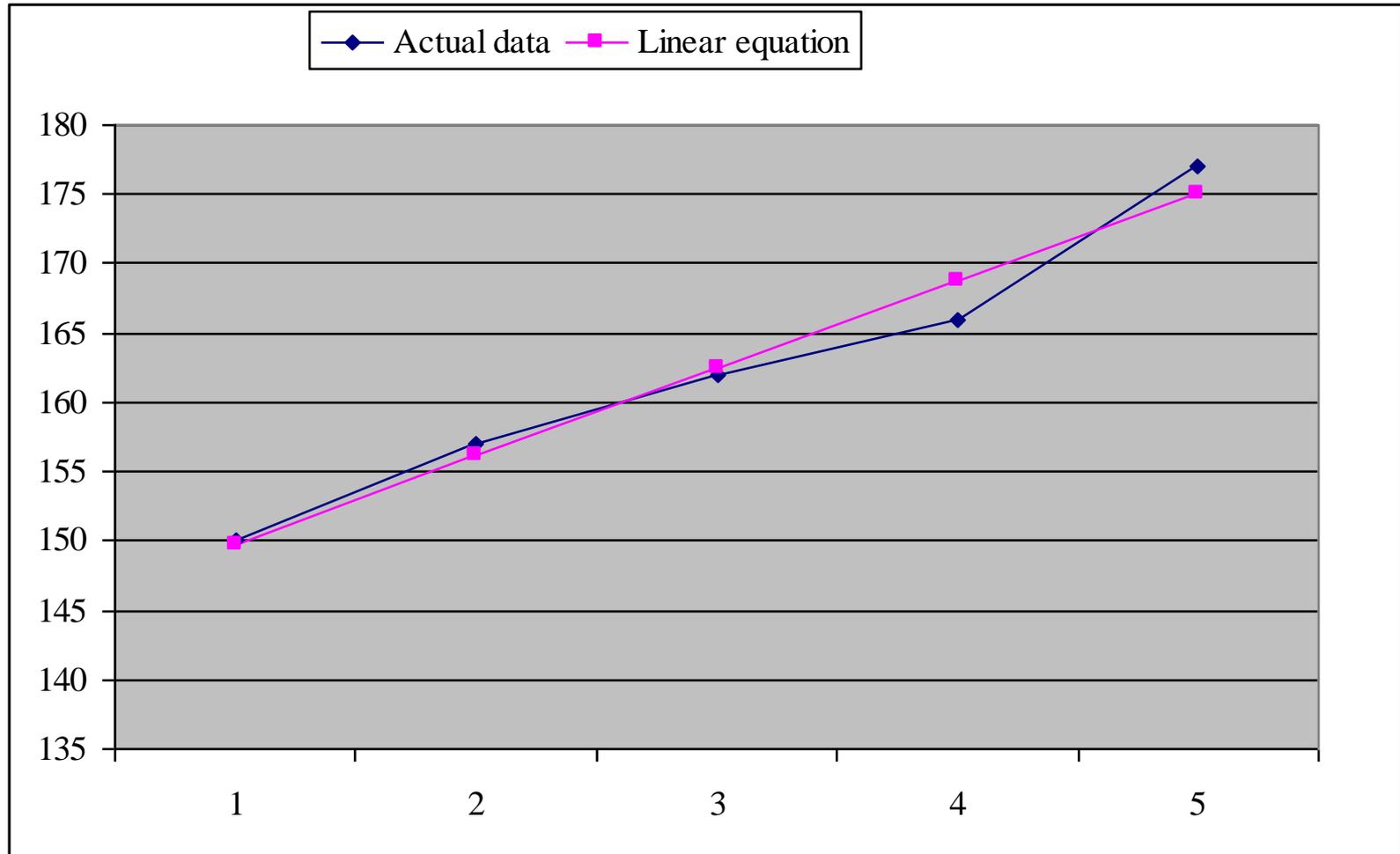


$$b = \frac{5(2499) - 15(812)}{5(55) - 225} = \frac{12495 - 12180}{275 - 225} = 6.3$$

$$a = \frac{812 - 6.3(15)}{5} = 143.5$$

$$y = 143.5 + 6.3t$$

# Linear Trend plot



# Problem 1



- National Mixer Inc. sells can openers. Monthly sales for a seven-month period were as follows:
  - Forecast September sales volume using each of the following:
    - A five-month moving average
    - The naive approach
    - A weighted average using .60 for August, .30 for July, and .10 for June.

<b>Month</b>	<b>Sales (1000)</b>
Feb	19
Mar	18
Apr	15
May	20
Jun	18
Jul	22
Aug	20

# Recall: Problem 1



- National Mixer Inc. sells can openers. Monthly sales for a seven-month period were as follows:
  - Plot the monthly data
  - Forecast September sales volume using a line trend equation
  - Compute MAD, MSE, and MAPE each method of forecast.
  - Which method of forecast seems least appropriate?

<b>Month</b>	<b>Sales (1000)</b>
Feb	19
Mar	18
Apr	15
May	20
Jun	18
Jul	22
Aug	20

# **MODEL PENGENDALIAN PERSEDIAAN (*INVENTORY MODELS*)**

# KLASIFIKASI *DEMAND*

- *Independent Demand* → kebutuhan akan suatu item barang tidak tergantung item yang lain.
  - Misalnya kebutuhan barang untuk memenuhi permintaan pembeli di sebuah toko, kebutuhan bahan baku utama dari produk yang kebutuhannya ditentukan berdasarkan *demand forecasting*.
- *Dependent Demand* → kebutuhan akan item tertentu tergantung/terkait pada kebutuhan terhadap item yang lain. Ketergantungan antar item bisa berbentuk :
  - ketergantungan vertikal : mis. kebutuhan dari komponen penyusun subrakitan/ produk jadi.
  - ketergantungan horizontal : mis. kebutuhan dr komponen pelengkap (bahan pembantu) yang menyertai produk.

# FUNGSI PERSEDIAAN :

- Mengurangi ketergantungan antar tahap dalam mata rantai sistem produksi – distribusi.
- Mempertahankan stabilitas penggunaan tenaga kerja karena fluktuasi *demand*.
- Mengantisipasi kemungkinan terjadinya gangguan yang berupa keterlambatan pasokan atau berhentinya aktivitas dalam sistem produksi.
- Mengambil keuntungan dng memanfaatkan potongan harga untuk pembelian dlm jumlah besar.
- Mengantisipasi terjadinya kenaikan harga barang karena inflasi.
- Mengantisipasi terjadinya *stock out* karena permintaan melebihi perkiraan.

# KLASIFIKASI PERSEDIAAN (*INVENTORY*)

## 1. Berdasarkan Fungsi :

- *Decoupling Inventory*
- Seasonal Inventory (*Anticipation Stock*)
- *Transit Inventory* (Movement/Pipeline Inventory)
- *Safety/Buffer Inventory* (*Stok Penyangga/Pengaman*)

## 2. Berdasarkan Karakteristik *Demand* :

- Distribution inventory
- Manufacturing inventory

# KLASIFIKASI PERSEDIAAN (*INVENTORY*)

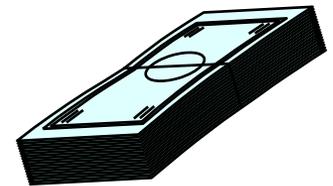
## 3. Berdasarkan Status Material :

- *Raw Material*
- *Finished Part*
- *Component Part*
- *Subassembly Material*
- *Work In-Process (WIP)*
- *Finished Goods*

# Introduction to Basic Inventory Models



- The purpose of inventory theory is to determine rules that management can use to minimize the costs associated with maintaining inventory and meeting customer demand.
- Inventory models answer the following questions
  1. When should an order be placed for a product?
  2. How large should each order be?



# Costs Involved in Inventory Models

- The inventory models that we will discuss involve some or all of the following costs:
  - **Ordering and Setup Cost**
    - These costs do not depend on the size of the order. They typically include things like paperwork, billing or machine setup time if the product is made internally.
  - **Unit Purchasing Cost**
    - This cost is simply the variable cost associated with purchasing a single unit. Typically, the unit purchasing cost includes the variable labor cost, variable overhead cost, and raw material cost.

## – Holding or Carrying Cost

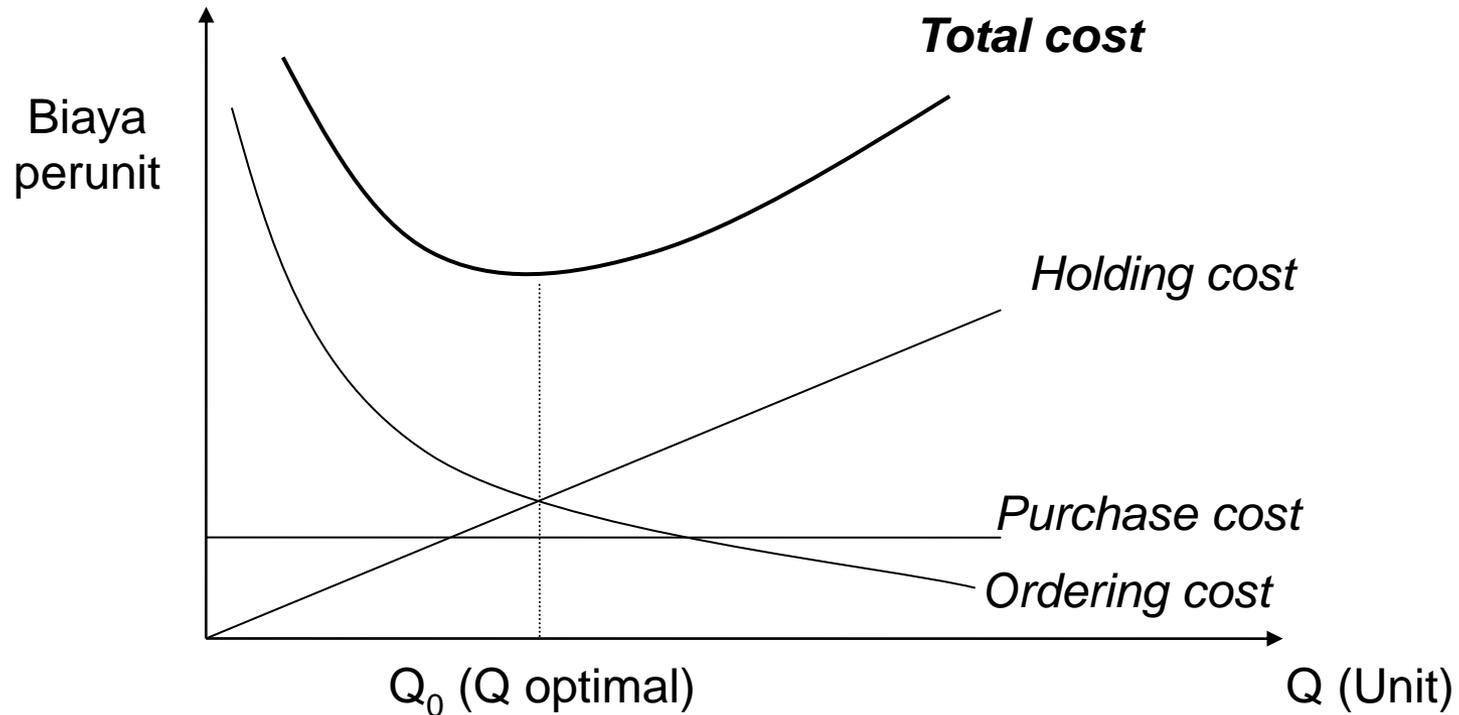
- This is the cost of carrying one unit of inventory for one time period. The holding costs usually includes storage cost, insurance cost, taxes on inventory and others.

## – Stockout or Shortage Cost

- When a customer demands a product and the demand is not met on time, a stockout, or shortage, is said to occur. If they will accept delivery at a later date, we say the demands are **back-ordered**. This case is often referred to as the **backlogged demand** case. If they will not accept late delivery, we are in the **lost sales** case. These costs are often harder to measure than other costs.

# BIAYA TOTAL *INVENTORY*

- Biaya total *inventory* = *Ordering cost* + *Purchase cost* + *Holding cost* + *Stockout cost* .



# MODEL *INVENTORY CONTROL* YANG DETERMINISTIK



## **MODEL *PURCHASE ORDER QUANTITY* ATAU *ECONOMIC ORDER QUANTITY (EOQ)***

EOQ, or **Economic Order Quantity**, is defined as the optimal quantity of orders that minimizes total variable costs required to order and hold inventory.

# How to use EOQ in your organization



How much inventory should we order each month?



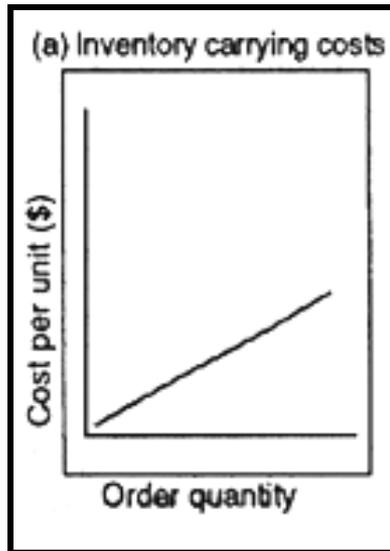
The EOQ tool can be used to model the amount of inventory that we should order each month.

## *ECONOMIC ORDER QUANTITY (EOQ)*

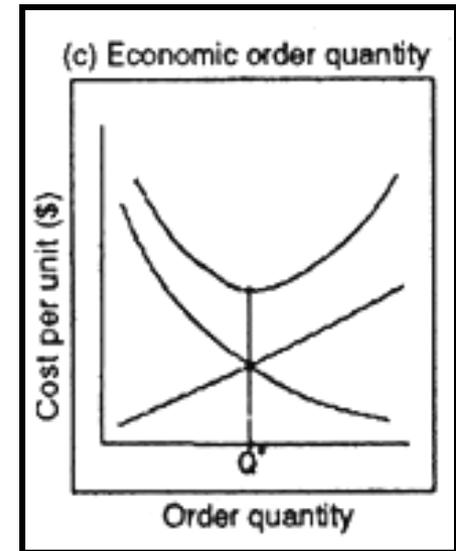
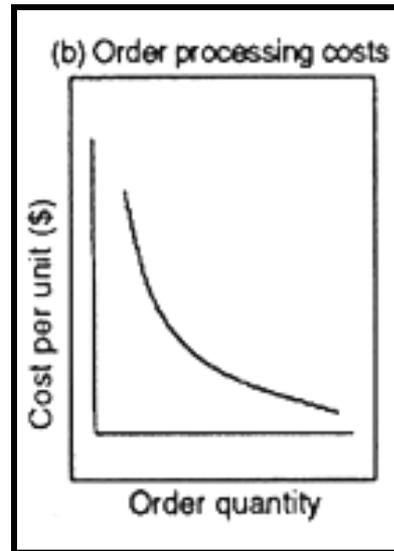
- Asumsi :
  - Besarnya permintaan (*demand*) tertentu dengan laju permintaan konstan
  - Harga persatuan barang konstan (tidak ada diskon)
  - *Lead time* konstan ( $L = 0$ )
  - Biaya simpan (*holding cost*) diketahui
  - Begitu datang, semua barang yang dipesan bisa langsung masuk *inventory* (kedatangan barang seketika)
  - Tidak terjadi *stockout*.

# How EOQ Works

*The Principles Behind EOQ: The Total Cost Curve*

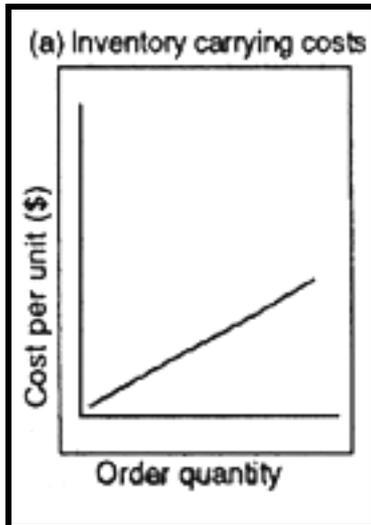


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# How EOQ Works

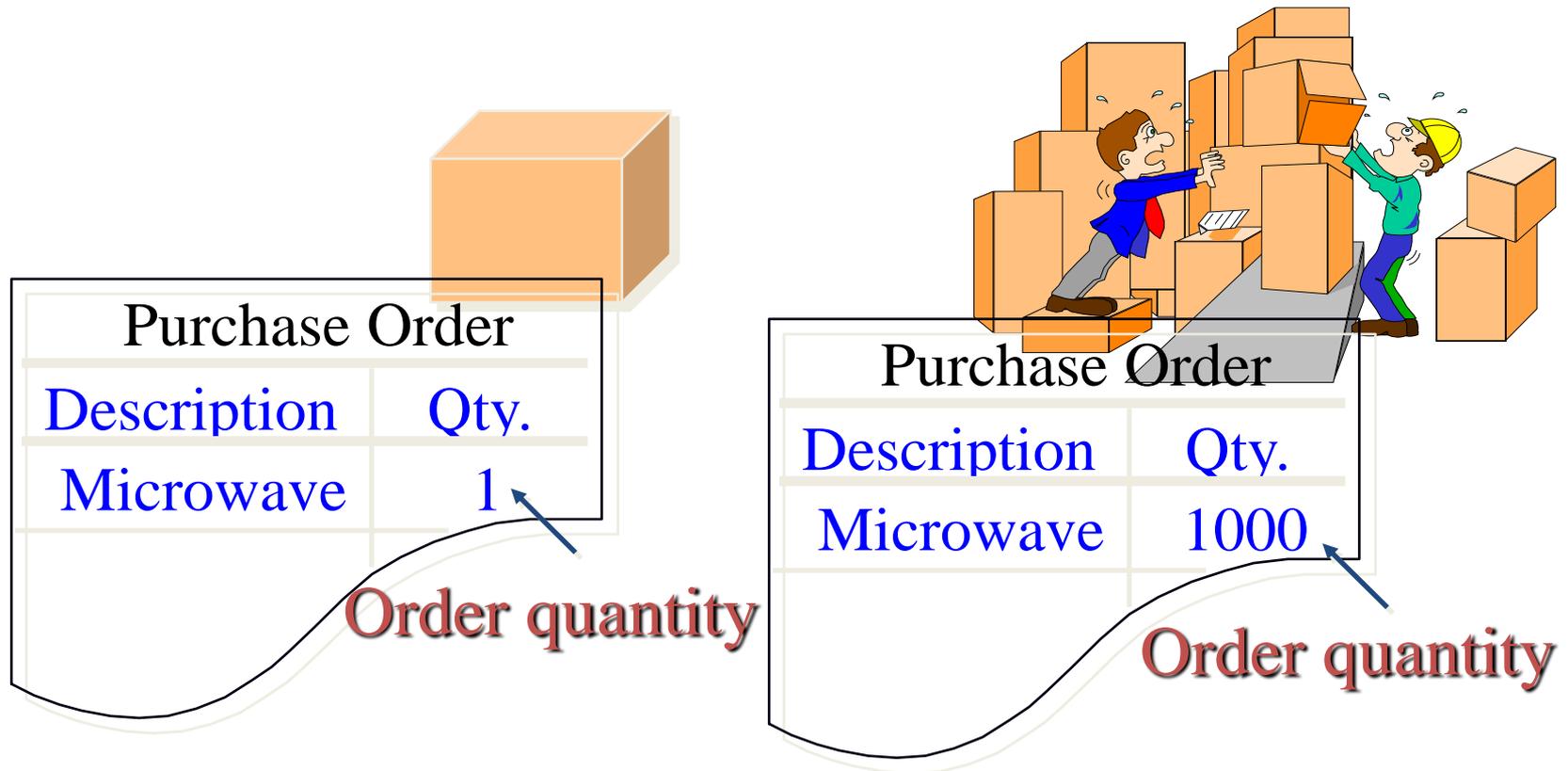
## *The Principles Behind EOQ: The Holding Costs*



- Keeping inventory on hand
- Interest
- Insurance
- Taxes
- Theft
- Obsolescence
- Storage Costs

# Mengapa *Holding Cost* Naik?

- Banyak unit yang harus disimpan



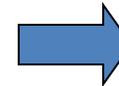
# How EOQ Works

*The Principles Behind EOQ: The Holding Costs*

Interest



Obsolescence

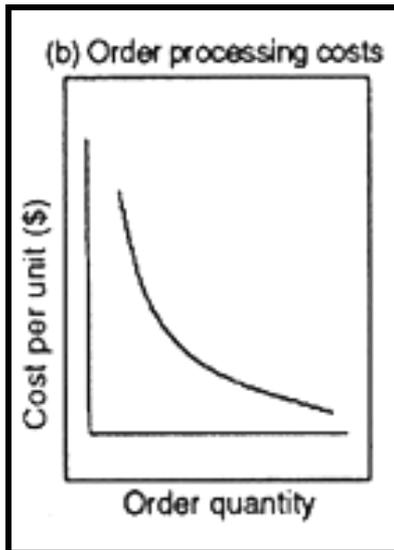


Storage



# How EOQ Works

## *The Principles Behind EOQ: The Order Costs*



**Primarily the labor costs associated with processing the order:**

- Ordering and requisition
- A portion of the freight if the amounts vary according to the size of the order
- Receiving, inspecting, stocking
- Invoice processing

# Mengapa *Order Costs* Turun?

- Cost is spread over more units

1 Order (Postage \$ 0.32)

Purchase Order	
Description	Qty.
Microwave	1000

1000 Orders (Postage \$320)

Purchase Order	
Description	Qty.
Microwave	1

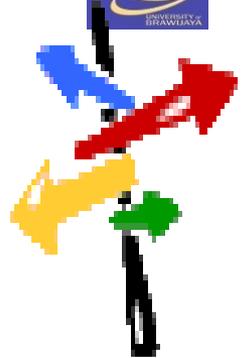
Jumlah  
Order



# How large should your orders be?

- If your orders are too large, you'll have excess inventory and high holding costs
- If your orders are too small, you will have to place more orders to meet demand, leading to high ordering costs

<b>Order Size</b>	<b>Holding Costs</b>	<b>Ordering Costs</b>
<b>Too LARGE</b>	High	Low
<b>Too SMALL</b>	Low	High



$D$  = jumlah permintaan (*demand*)

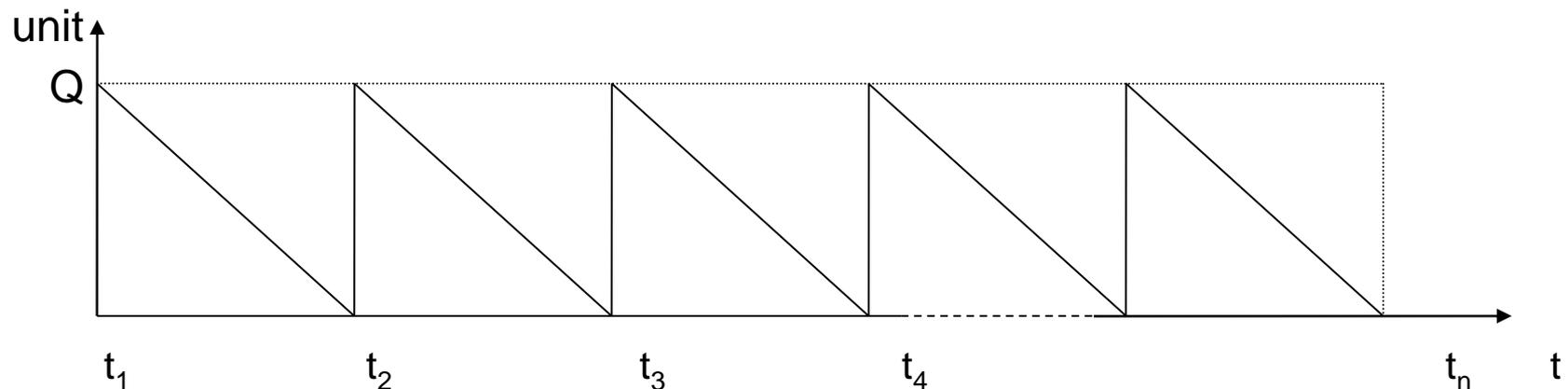
$P$  = *purchase cost* perunit

$C$  = *ordering cost* persatu kali pesan

$I$  = prosentase biaya simpan perunit perperioda

$H$  = *holding cost* perunit perperioda =  $IP$

$Q$  = besarnya pemesanan perkali pesan



- *Ordering cost* perperioda = frekuensi pemesanan dalam 1 perioda x

$$C = \frac{D}{Q} C$$

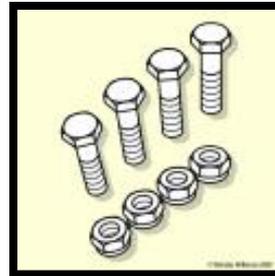
- *Purchase cost* perperioda = jumlah kebutuhan perperioda x P = DP

- *Holding cost* perperioda = rata-rata banyaknya barang yang

disimpan perperioda x H =  $\frac{Q}{2} H$

- **Total cost inventory** : TC =  $\frac{D}{Q} C + DP + \frac{Q}{2} H$

- TC akan minimum jika : =  $\frac{dTC}{dQ} = 0$  dan  $\frac{d^2TC}{d^2Q} > 0$



- Q (besarnya pemesanan) yang memberikan biaya total minimum adalah :

$$Q^* = \sqrt{\left(\frac{2DC}{H}\right)}$$

- Nilai  $Q^*$  biasa disebut dengan *Economic Order Quantity* (*EOQ*) atau jumlah pemesanan yang paling ekonomis.

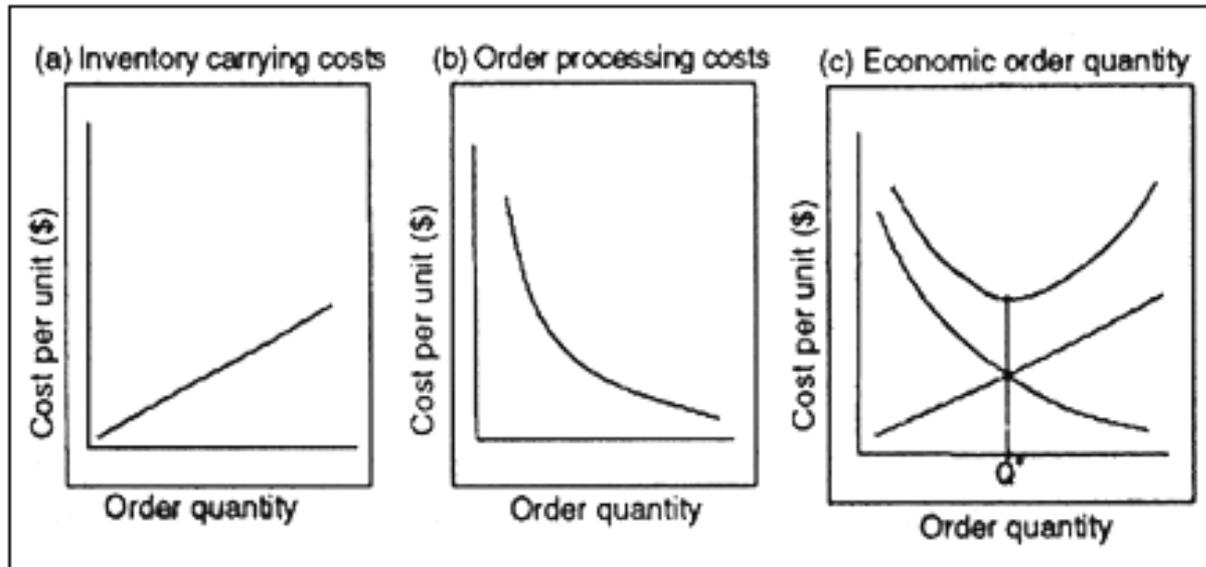
# How EOQ Works



## *The EOQ Formula*

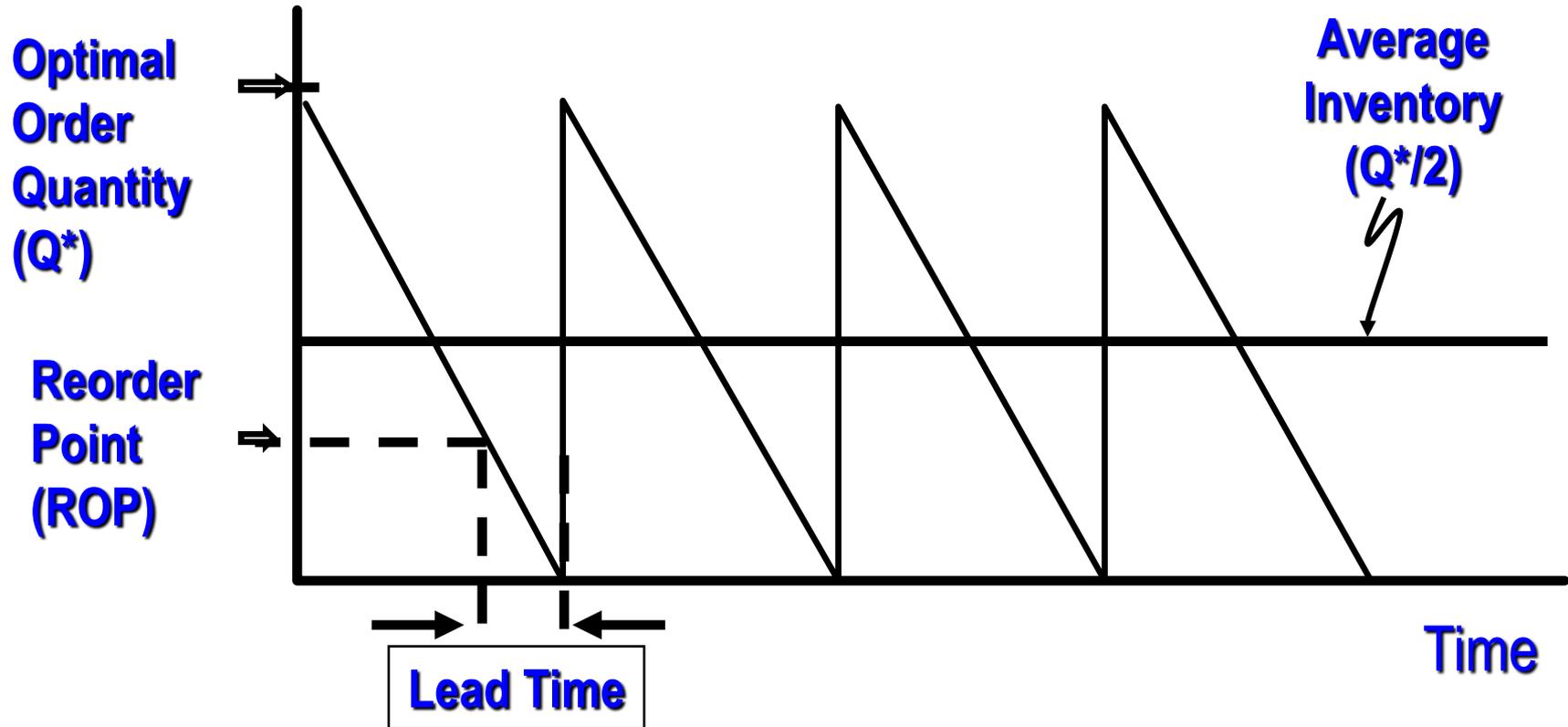
Review and Summary of the EOQ Formula

Here is the a graphic representation of the EOQ equation



# Model EOQ (kapan pesan?)

## Level Inventori





- Jika *lead time* ( $L$ )  $\neq 0$  ; maka  $\frac{DL}{n}$  *unit*
- **Reorder point (ROP) =**  
 $n =$  banyaknya unit / satuan waktu  $L$  dalam 1 perioda
- Misal: 1 perioda = 1 tahun
  - Jika  $L =$  dalam satuan bulan  $\rightarrow n = 12$
  - Jika  $L =$  dalam satuan minggu  $\rightarrow n = 52$
  - Jika  $L =$  dalam satuan hari  $\rightarrow n = 365$
- Frekuensi Pemesanan Optimal perperioda =  $\frac{D}{Q^*}$  *kali*
- Waktu Siklus Opimal (Rata-rata waktu antar pemesanan) =  
 $t_s = \frac{Q^*}{D}$  *x banyaknya unit / satuan waktu dalam 1 periode*

# Example 2

- Sebuah perusahaan manufaktur pertahunnya membutuhkan 10.000 unit bahan baku tertentu dengan harga Rp. 300.000,- perunit. Biaya pemesanan bahan tersebut Rp. 400.000,- setiap kali pesan. Biaya simpan perunit bahan baku pertahun adalah 33% dari harga beli perunit. Jika laju penggunaan bahan baku tersebut konstan, maka tentukan :
  - Besarnya pemesanan yang paling optimal
  - Biaya total *inventory*
  - Frekuensi pemesanan dalam 1 tahun
  - Rata-rata waktu antar pemesanan
  - *Reorder point*, jika *lead time* kedatangan bahan baku tersebut adalah 1 minggu
  - *Reorder point*, jika *lead time* kedatangan bahan baku tersebut adalah 4 hari

-

- $D = 10.000$  unit pertahun
- $C = \text{Rp. } 400.000,-$  perkali pesan
- $P = \text{Rp. } 300.000,-$  perunit
- $I = 33\%$ ; sehingga  $H = IP = 33\%(300.000) = \text{Rp. } 100.000,-$  perunit perthn



a. Besarnya pemesanan paling optimal :

$$Q^* = \sqrt{\frac{2(10.000)(400.000)}{100.000}} = 284,27 \approx 284 \text{ unit}$$

b. Biaya Total (TC)

$$\begin{aligned} &= \frac{D}{Q^*} C + DP + \frac{Q^*}{2} H \\ &= \frac{10.000}{284} 400.000 + (10.000)(300.000) + \frac{284}{2} 100.000 \\ &= Rp.3.028.284.507,- \end{aligned}$$

c. Frekuensi pemesanan dalam 1 tahun =

$$\frac{D}{Q^*} = \frac{10.000}{284} = 35,211 \approx 36 \text{ kali}$$

## d. Rata-rata waktu antar pemesanan

$$\begin{aligned}t_s &= \frac{Q^*}{D} = \frac{284}{10.000} \times 12 \text{ bulan} = 0,3408 \text{ bulan} \\ &= \frac{284}{10.000} \times 52 \text{ min ggu} = 1,4768 \text{ min ggu} \\ &= \frac{284}{10.000} \times 365 \text{ hari} = 10,366 \text{ hari}\end{aligned}$$

## e. Reorder point, jika $L = 1$ minggu :

$$ROP = \frac{DL}{52} \text{ unit} = \frac{(10.000) \times 1}{52} = 192,307 \approx 192 \text{ unit}$$

## f. Reorder point, jika $L = 4$ hari :

$$ROP = \frac{DL}{365} \text{ unit} = \frac{(10.000) \times 4}{365} = 109,589 \approx 110 \text{ unit}$$

See you soon