



NATIONAL ENGINEERING CENTER

University of the Philippines  
Diliman, Quezon City



# Forecasting

*Module 5 of the Business Intelligence and  
Analytics Track of UP NEC and the UP Center  
of Business Intelligence*

# Schedule of Activities

Topics	Day
Forecasting in Business Intelligence	1
Demand Forecasting Techniques	
1. Qualitative	1
2. Causal	1
3. Time Series	1 & 2
4. Simulation (Definition)	1
Accuracy of Forecasts	2
Monitoring of Forecasts	2
Case Studies and Forecasting Using Software	3

# Our Learning Methodology

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1. Understanding of Concepts  
Discussions with Examples
  2. Solving Practice Problem  
(Open notes and may discuss with co-participants)
  3. Answering Random Concept Tests  
(to ensure retention)
  3. Evaluation/Tests (Closed notes)
- (Questions may be asked anytime!)***



# About the Facilitator

- Iris Ann G. Martinez, Ph.D. is a Professor and former chair of the Department of Industrial Engineering and Operations Research of the University of the Philippines Diliman. She obtained her Bachelor of Science in Industrial Engineering degree cum laude from the University of the Philippines Diliman, Master of Engineering in Precision Machinery Systems degree from the Tokyo Institute of Technology and Doctor of Philosophy in Mechanical Engineering degree from the University of Tokyo. Her main research interest is in Production and Service Systems Planning. She is co-editor of the Philippine Journal for Operations Research and the Journal of Philippine Institute of Industrial Engineers. She is also Associate Editor of the Philippine Engineering Journal.



Over the last 20 years, she has assisted different industries such as Utilities, Food, Personal and Home Care in Production and Operations Management.

# Introduction

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- Why perform business forecasting?



publicdomainpictures.net

# Objectives

At the end of this module, you should be able to:

- Explain why we perform business forecasting.  
(What is the value of business forecasting?)
- State what demand forecasting is.
- State and Explain the recommended process for business forecasting.
- Cite the different techniques of business forecasting and their specific uses.
- Forecast for using the Naïve, Moving Average and Weighted Moving Average, Simple Exponential Method, Trend-adjusted Exponential Smoothing, Linear Trend Equation and Using Seasonal Index.

# Why We Perform Business Forecasting

- Forecasting is part of Business Intelligence



Business Intelligence helps us understand what is happening:

- within our own organization
- within the market we serve

**So we can more efficiently and innovatively respond to market needs**

# Why We Perform Business Forecasting

- BI systems collect, store and analyze data

Collection through:

- sensors
- RFID scanners
- BPM systems
- transaction-processing systems:
  - ERP systems
  - order-entry systems
  - CRM systems



Storage in database (accessed when needed; updated on continuous or real-time basis)



Analysis using:

- simple spreadsheets and charts
- regression anal
- linear program



1. Forecasting:

- Supply
- Demand
- Product Characteristics
- Competitive Environment

# Why We Perform Business Forecasting

## Supply Forecasting:

- determined by
  - number of producers
  - lead time

## Demand Forecasting

- overall market demand for a group of products or services

## Product Characteristic Forecasting:

- features of a product that influence customer demand
  - new or mature
  - can steal demand for other products

## Competitive Environment Forecasting

- actions of a company and its competitors
  - Trends in individual market share
  - Trends in market share of competitors

To determine the general business environment in the future.  
**So we can remain a positive contributor in business.**

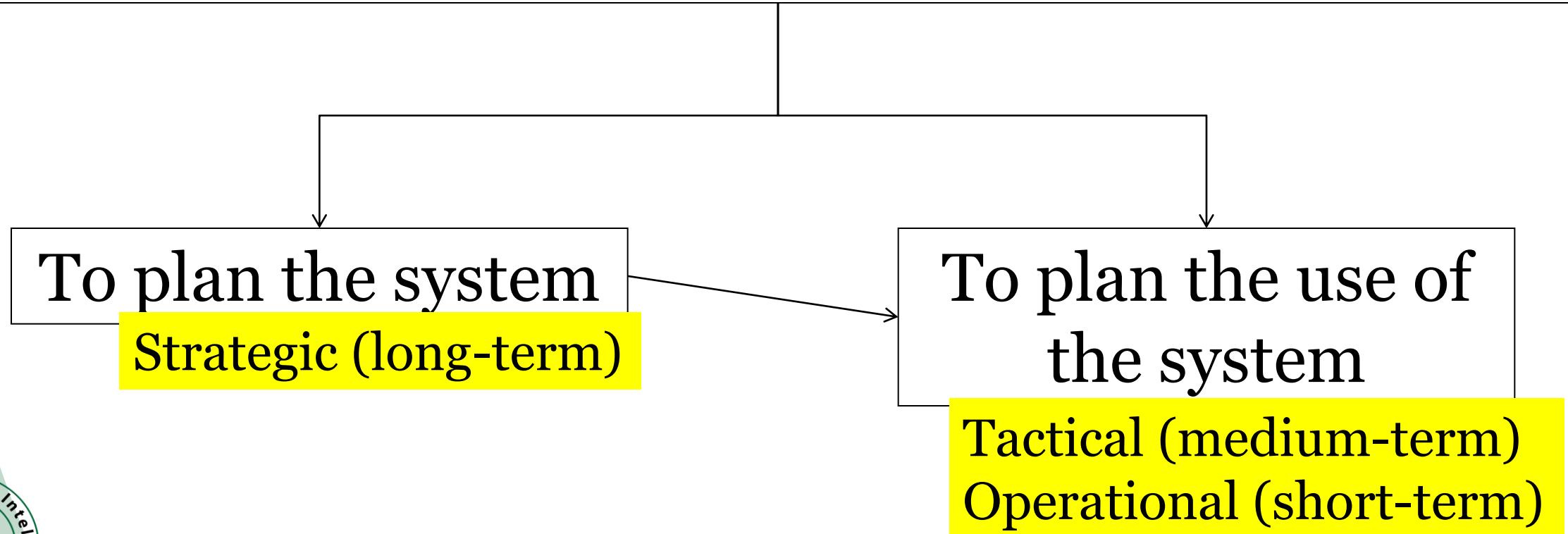
# Business Intelligence Lecture Series

## Module 5:

### Demand Forecasting

# Why We Perform Business Forecasting

So we can anticipate and meet future demand.



# Demand Forecasting for Planning the System (Strategic or Long-term Forecasting)

Building new facilities



[commons.wikimedia.org](https://commons.wikimedia.org)

Enter new markets



[resource-alliance.org](http://resource-alliance.org)

Exit existing market

# Plan the Use of the System

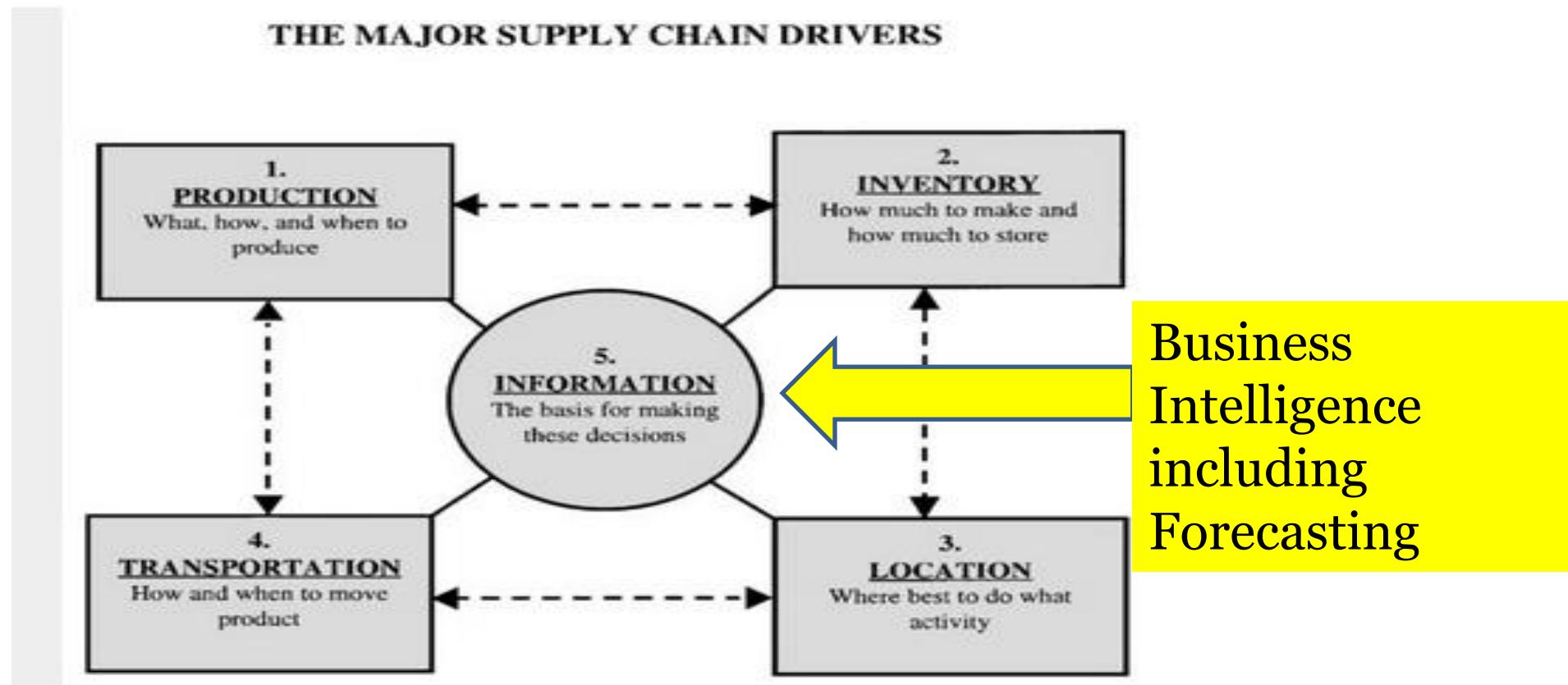
## (Tactical or Medium-term Forecasting Operational or Short-term Forecasting)

- Setting of quarterly targets
- Setting of weekly and daily production and employee schedules



# Why We Perform Demand Forecasting

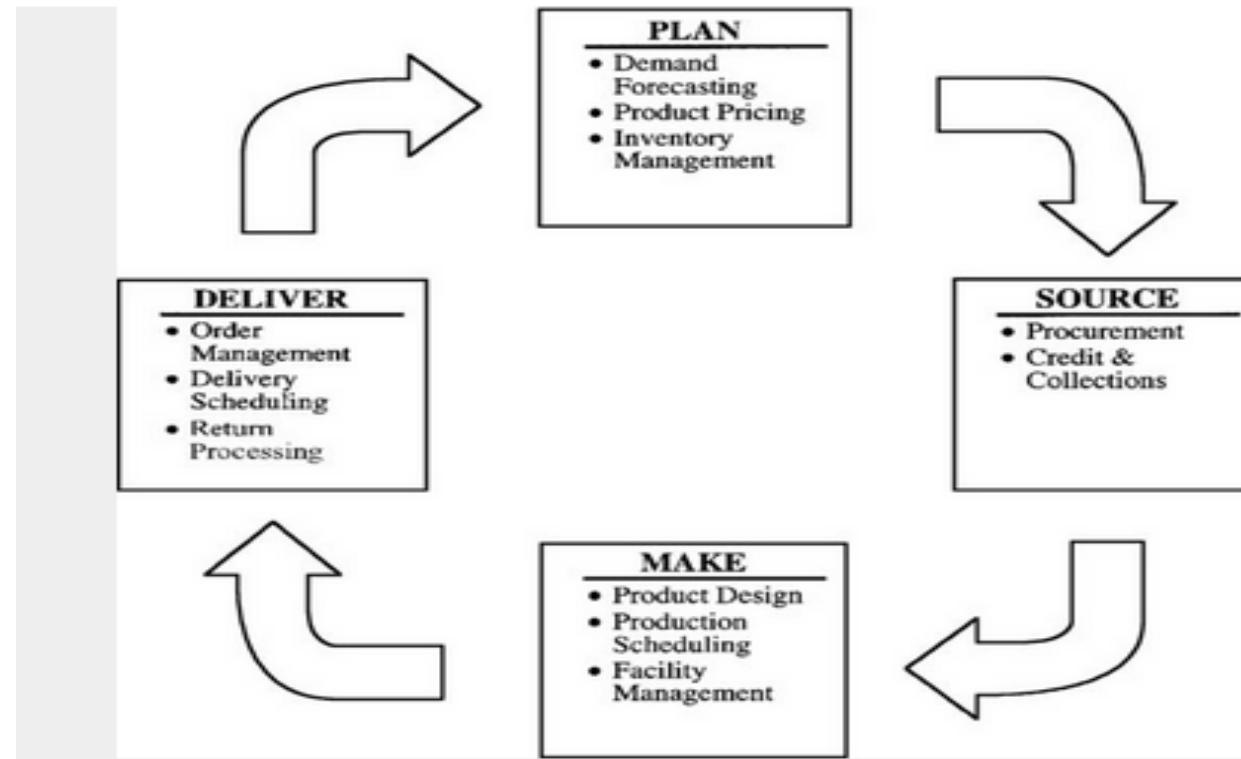
## Within Information as a Supply Chain Driver



# As Part of Supply Chain Management

Simplified  
Supply Chain  
Operations  
Reference  
**(SCOR)**  
**Model**  
developed by  
the Supply  
Chain Council  
USA

Hugos, Michael H., Essentials of Supply Chain Management –



Thus, when we know and practice Forecasting, we are able to help increase our organization's and supply chain's Competitiveness!

# Why We Perform Demand Forecasting

- Specifically, Forecasts define:
  1. which products will be required
  2. what amount of these products will be called for
  3. when these products will be needed
- Forecasts become our bases for us to plan our internal operations.
- Forecasts become our reference for how to cooperate within our organization and with our partners, to meet market demand

# Objectives

At the end of this module, you should be able to:

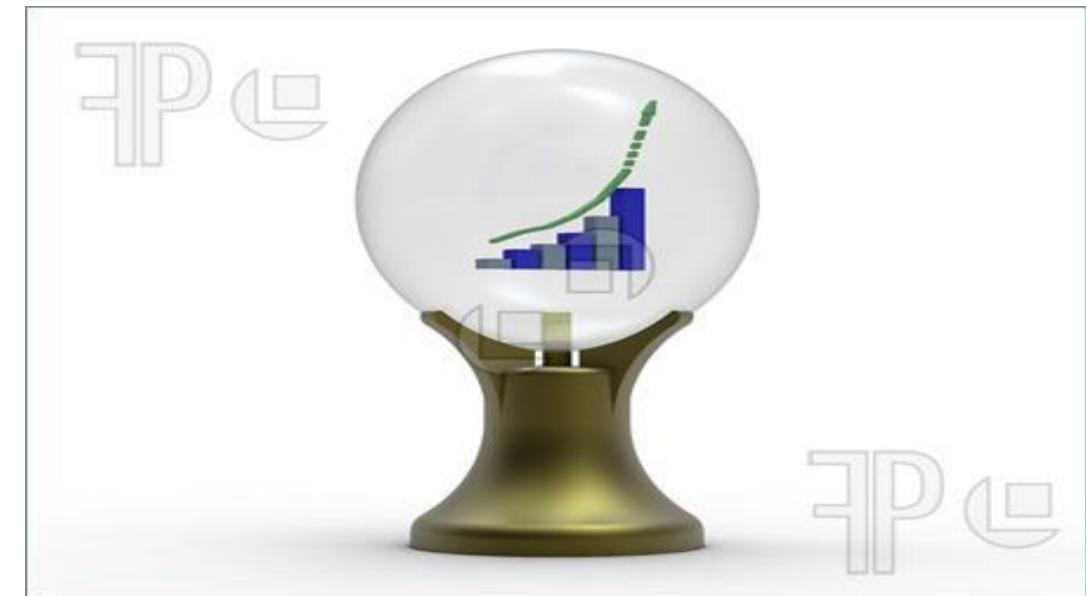
- Explain why we perform business forecasting.  
(What is the value of business forecasting?)
- State what demand forecasting is.
- State and Explain the recommended process for business forecasting.
- Cite the different techniques of business forecasting and their specific uses.
- Forecast for using the Naïve, Moving Average and Weighted Moving Average, Simple Exponential Method, Trend-adjusted Exponential Smoothing, Linear Trend Equation and Using Seasonal Index.

# Demand Forecasting



# Forecasting

- “Forecasting is making a statement about the future.”



# Demand Forecasting

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- Making a statement about the future, specifically on:
  1. which products will be required
  2. what amount of these products will be called for
  3. when these products will be needed



# Demand Forecasting

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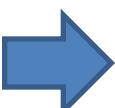
Characteristics common to forecasting methods and techniques:

1. Assumes a causal system (*past → future*).
2. Rarely perfect due to randomness.
3. More accurate for groups than individuals.
4. Accuracy decreases as time horizon increases.



# Demand Forecasting

Characteristics common to forecasting methods and techniques:

1. Assumes a causal system (*past → future*).  You need historical information (Qualitative and/or Quantitative).
2. Rarely perfect due to randomness.  You need to accept some level of error.
3. More accurate for groups than individuals.  If your forecasting accuracy is low for individual products, try grouping them and forecast per group.
4. Accuracy decreases as time horizon increases.  If your forecasting accuracy is low for your chosen time horizon, break down the time horizon into a shorter time

# Objectives

At the end of this module, you should be able to:

- Explain why we perform business forecasting.  
(What is the value of business forecasting?)
- State what demand forecasting is.
- **State and Explain** the recommended process for business forecasting.
- Cite the different techniques of business forecasting and their specific uses.
- Forecast for using the Naïve, Moving Average and Weighted Moving Average, Simple Exponential Method, Trend-adjusted Exponential Smoothing, Linear Trend Equation and Using Seasonal Index.



# Recommended Process for Demand Forecasting

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*Step 1.* Determine the purpose of the forecast.

*Step 2.* Establish the time-horizon for your forecast.

*Step 3.* Select the forecasting technique to use.

*Step 4.* Gather, clean and analyze data.

*Step 5.* Prepare and make the forecast.

*Step 6.* Monitor the forecast.



# Concept Review 1

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What are the six steps in forecasting?

1. D \_\_\_\_\_ the P \_\_\_\_\_.
2. E \_\_\_\_\_ the T \_\_\_\_\_ H \_\_\_\_\_.
3. S \_\_\_\_\_ the F \_\_\_\_\_ T \_\_\_\_\_
4. G \_\_\_\_\_, C \_\_\_\_\_ and A \_\_\_\_\_ the D \_\_\_\_\_.
5. P \_\_\_\_\_ and M \_\_\_\_\_ the F \_\_\_\_\_.
6. M \_\_\_\_\_ the F \_\_\_\_\_.

# Step 1: Determine the Purpose of your Forecast

## Supply Forecasting

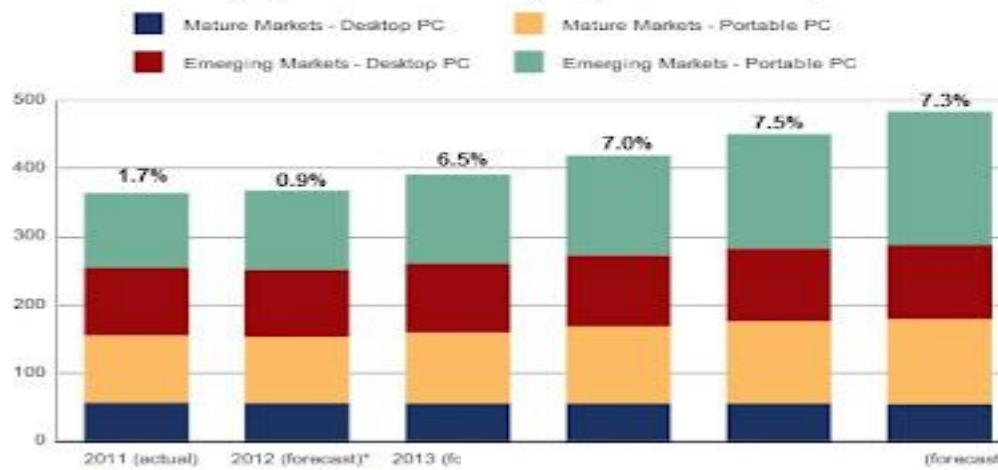


[lanhamassoc.com](http://lanhamassoc.com)

## Competitive Environment Forecasting

Total Worldwide Desktop PC vs. Portable PC Shipments, 2011 - 2016

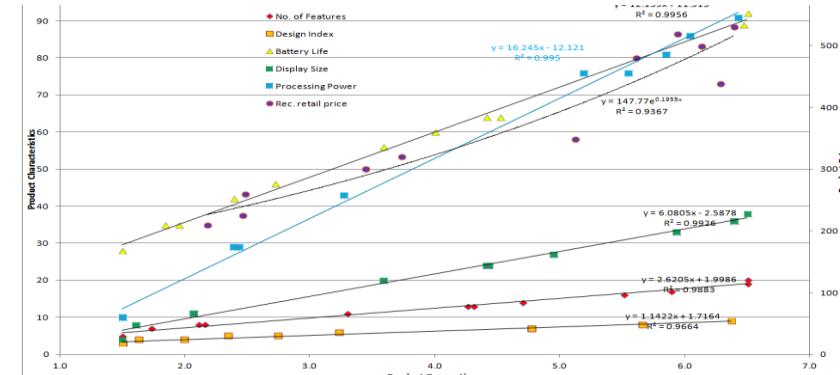
Emerging vs. Mature Markets (Shipments in Millions)



[blog.geoactivegroup.com](http://blog.geoactivegroup.com)

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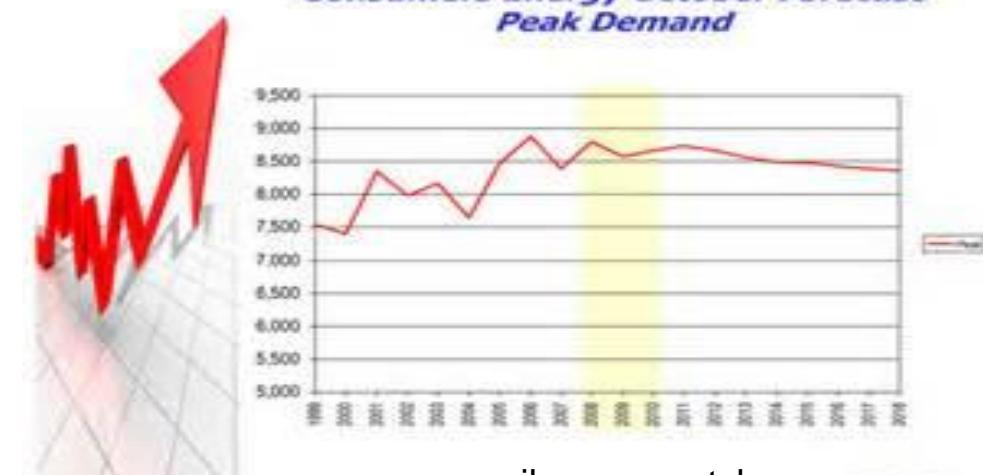
## Product Characteristics Forecasting



[thydzik.com](http://thydzik.com)

## Demand Forecasting

Consumers Energy October Forecast Peak Demand



[mail.sourcewatch.org](http://mail.sourcewatch.org)



# Step 1: Determine the Purpose of your Forecast

## Demand Forecasting



### Plan the system:

- building new factories, distribution centers

### Plan the use of the system:

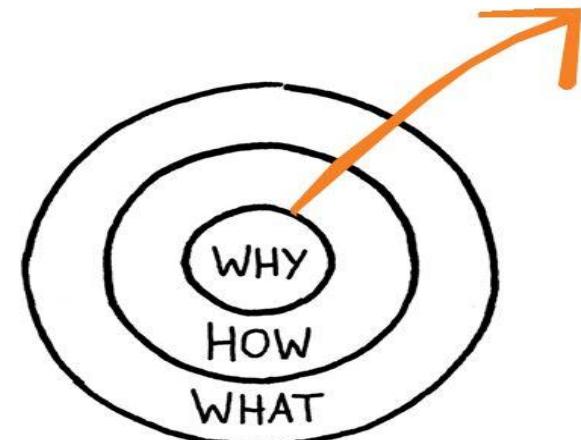
- determine number of workers, levels of inventory,
- determine weekly and daily worker/machine assignments

# Why it matters to know the purpose?

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Knowing the “WHY” will help you answer the:

- **How**
- **What**



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# Step 1: Determine the Purpose

<b>Why (Purpose)</b>	<b>How (General Approach )</b>	<b>What (Candidate Tools and Techniques)</b>
1. Product Characteristics Forecasting	Know which product features will stay through time (for the next 5 years)	Qualitative Forecasting specifically Expert Opinion, Delphi Method
2. Demand Forecasting (ex., to determine the number of workers to have)	Monthly (since workforce planning is on monthly basis)	Quantitative Forecasting specifically Time Series to determine trends across years and trends and/or seasons across months



## Step 2: Establishing the Time Horizon

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1. Establish the Start and End period
2. Define the units of time which the forecast is to be based.

*Question:*

*If forecast accuracy decreases as time horizon increases, why can't we just always forecast on a weekly basis?*

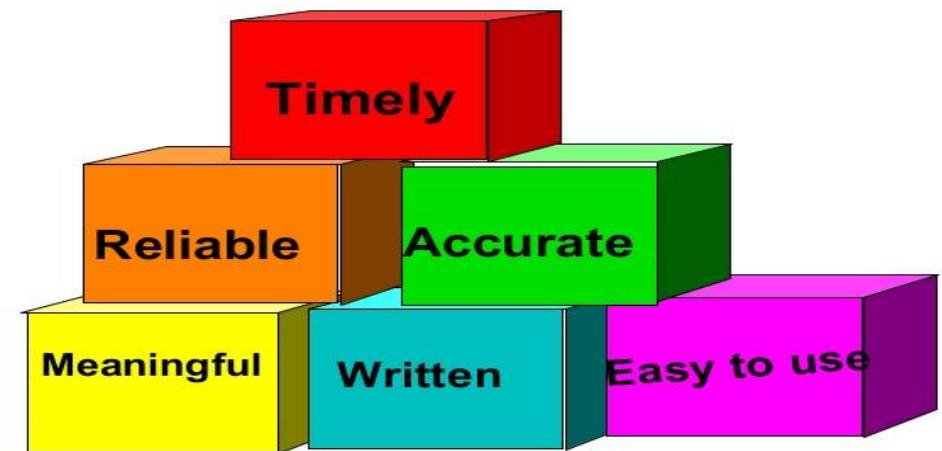


# Step 3: Selecting the Forecasting Technique

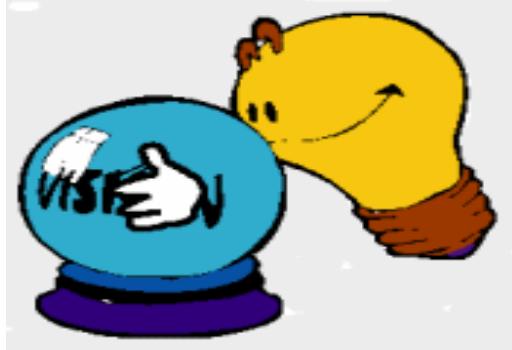
**Things to consider when selecting a forecasting technique:**

1. Meaningful Units
2. Written
3. Easy to Use
4. Reliable
5. Accurate
6. Timely

Elements of a Good Forecast



# General Types of Techniques



1. Qualitative Forecasting
  2. Causal
  3. Time Series
  4. Simulation
- Quantitative

# Concept Review 2

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1. What is a forecast?
2. What are the three types of forecasts?

- Q \_\_\_\_\_
- C \_\_\_\_\_
- T \_\_\_\_\_
- S \_\_\_\_\_



# 1. Qualitative Forecasting

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- uses intuition or subjective opinion
- appropriate when there is little historical data to work with.
- For example:
  - Forecasting production adoption curves of **new products** where the forecast can be based on comparison of the new product with other existing products or situations that the forecasting expert considers similar

# 1. Qualitative Forecasting

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1. Delphi Method
2. Executive Opinion
3. Consumer Surveys
4. Sales Force Polling



## a) Delphi Method

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A panel of experts are questioned on their perceptions on future events.

- Experts do not meet as a group (avoid dominators)
- Inputs by the experts are consolidated and returned to the experts for further questioning.

Advantage: Effective for long-range planning. Geographically convenient .

Disadvantage: Consensus is rarely reached.



## b) Executive Opinion

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Views of Executives or experts from sales, production, purchasing, finance are “averaged” to generate a forecast.

Advantage: Forecasts are done quickly and easily. This is often the only way of forecasting in the absence of adequate data.

Disadvantage: “Group thinking” the opinion of the most outgoing may dominate the forecast.

## c) Consumer Surveys

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Interviews, and distribution of questionnaires as a means of obtaining data.

Extensive statistical analysis is applied to the survey results in order to test hypothesis regarding consumer behavior.

## d) Salesforce Polling

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Forecasts are made by the salespeople.

- Sales people are the closest to the customers.
- They should have insights regarding the state of the future market.

Advantage: Simple and easy to understand. Knowledge is closest to the “Action”. Data can be quickly categorized by product, customer, territory.

Disadvantage: Sales people can be overly optimistic or pessimistic regarding the market due to economic events beyond their control.



# Concept Review 3

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What were the 4 Qualitative Forecasting Techniques discussed?

1. D \_\_\_\_\_ M \_\_\_\_\_

2. E \_\_\_\_\_ O \_\_\_\_\_

3. C \_\_\_\_\_ S \_\_\_\_\_

4. S \_\_\_\_\_ P \_\_\_\_\_



## 2. Causal Forecasting

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### Associative Forecasts

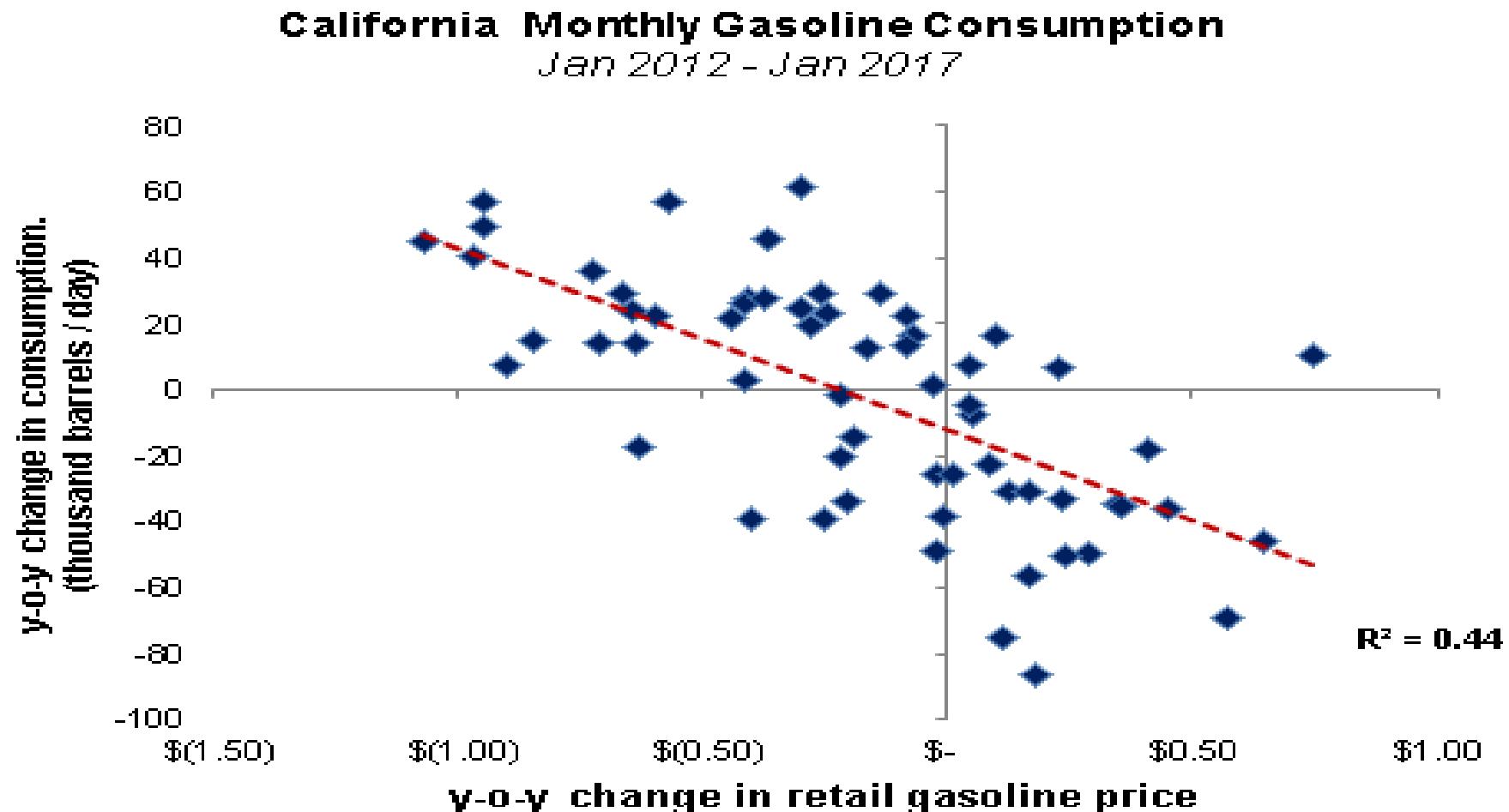
ex.,

demand for commercial loans  $\leftrightarrow$  interest rate

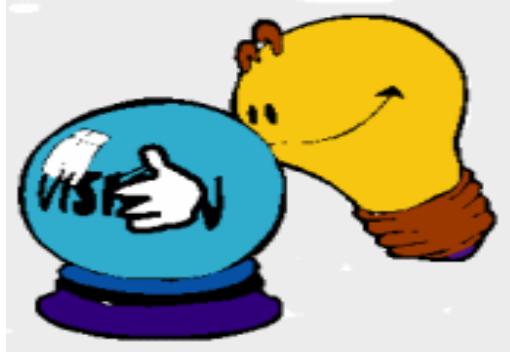
product price  $\leftrightarrow$  product demand



## 2. Causal Forecasting



# General Types of Techniques



1. Qualitative Forecasting
  2. Causal
  3. Time Series
  4. Simulation
- Quantitative

### 3. Simulation Methods for Forecasting (Sensitivity Analysis)

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- use combinations of causal and time series methods to imitate the behavior of consumers under different circumstances
- example of questions answered by this method:
  - what will happen to revenue if prices on a line of products are lowered?
  - what will happen to market share if a competitor introduces a competing product or opens a store nearby

# 4. Time Series Forecasting

- most common form of forecasting
- uses historical data assuming that the future is simply a repetition of the past.  
*(Or the future can be derived from events in the past).*
- best when there is a reliable body of historical data and the markets being forecast are stable and have demand patterns that do not vary much from one year to the next

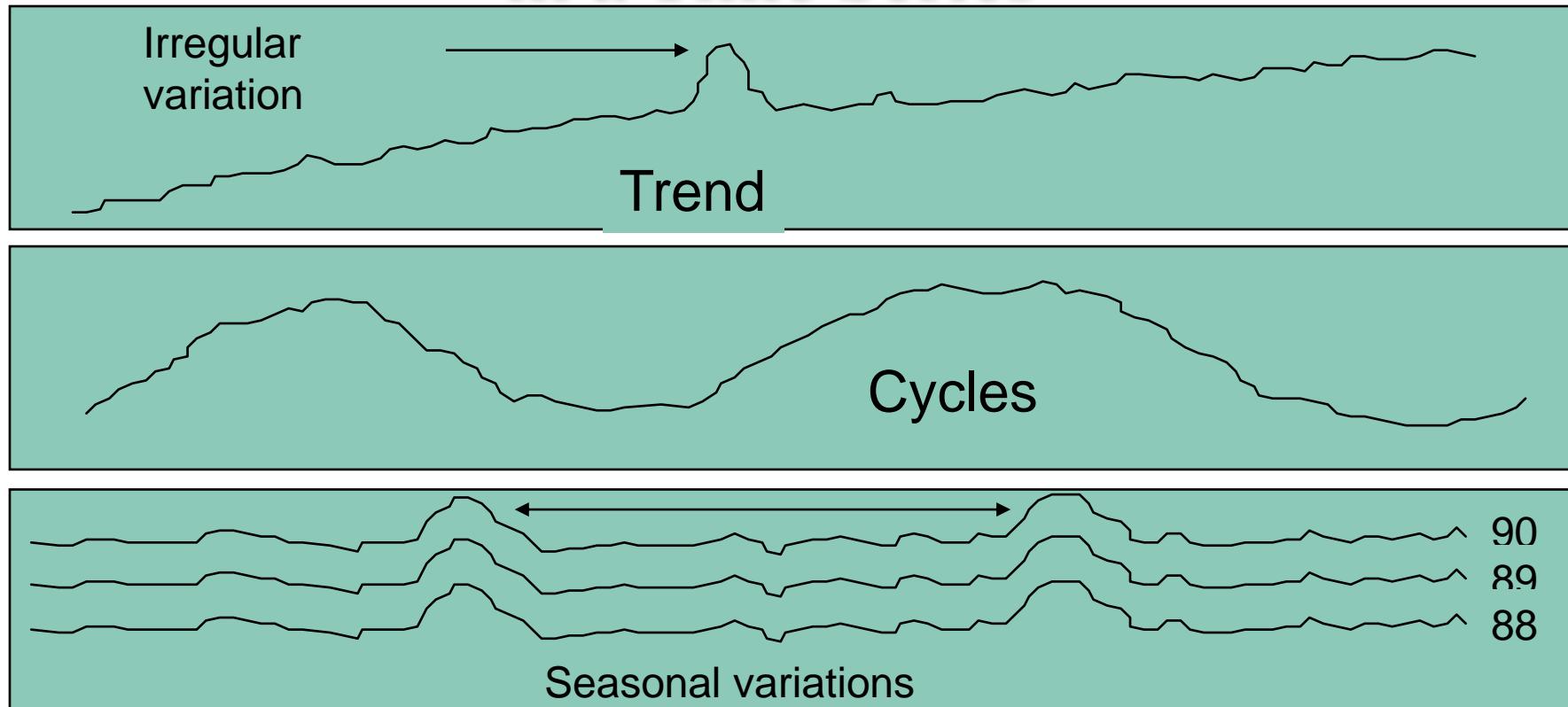
Elements considered are:

- Trend – long term movement in data
- Seasonality – short-term variation
- Cycles – regular variations
- Irregular Variations – unusual occurrences (to be investigated)
- Random variations – caused by chance



# 4. Time Series Forecasting

## Elements of a Demand Plot that are seen in a Time Series



# 4. Time Series Forecasting

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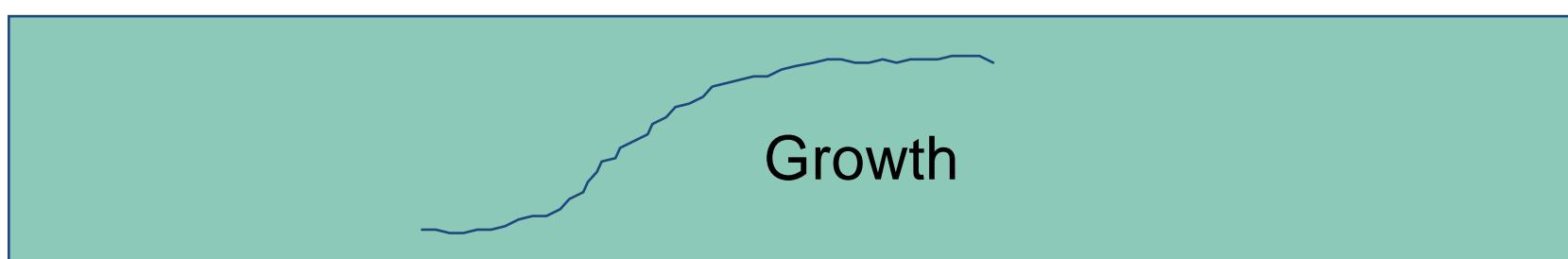
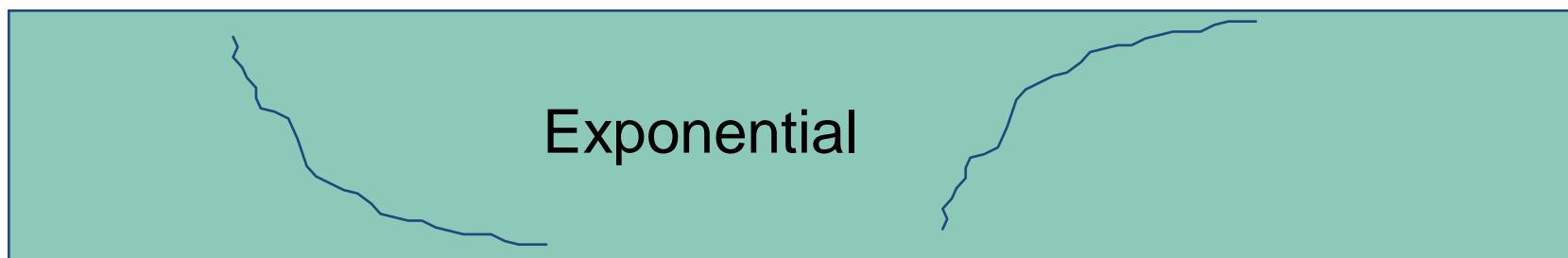
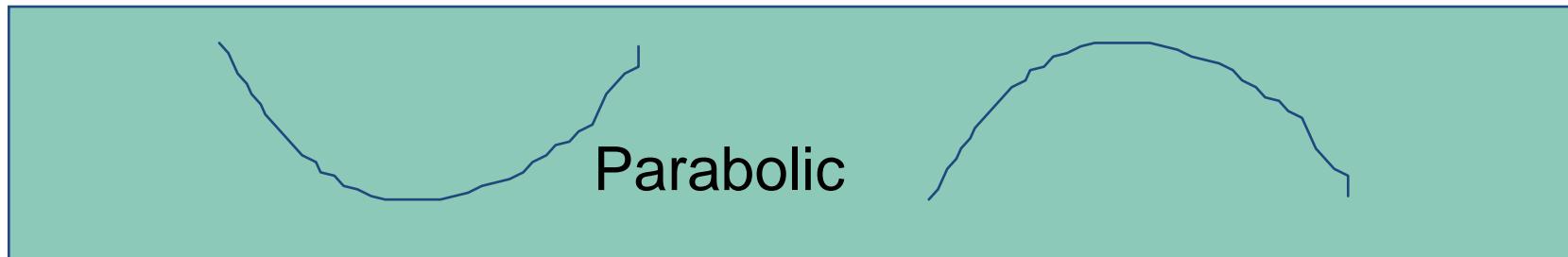
## Elements of a Demand Plot that are seen in a Time Series

1. Trend - long-term (upward or downward) movement in data
2. Seasonality - short-term regular (recurring) variations in data
3. Cycle – regular variation in data that are longer in term (usually beyond years) than seasons
4. Irregular variations - caused by unusual circumstances
5. Random variations - caused by chance



# 4. Time Series Forecasting

## Other Behaviors of a Demand Plot that seen on Time Series



# 4. Time Series Forecasting

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## Notes on the Different Types of Forecasting Techniques

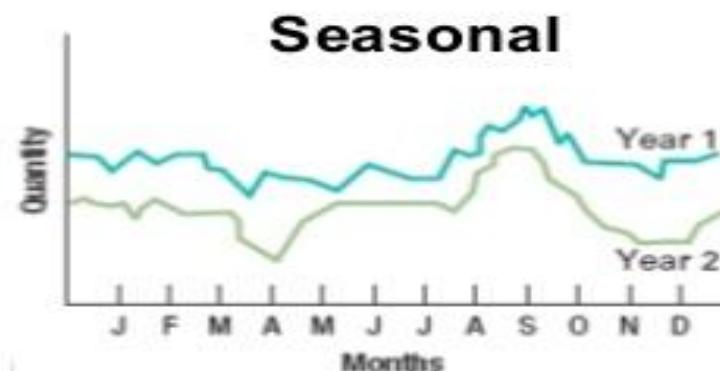
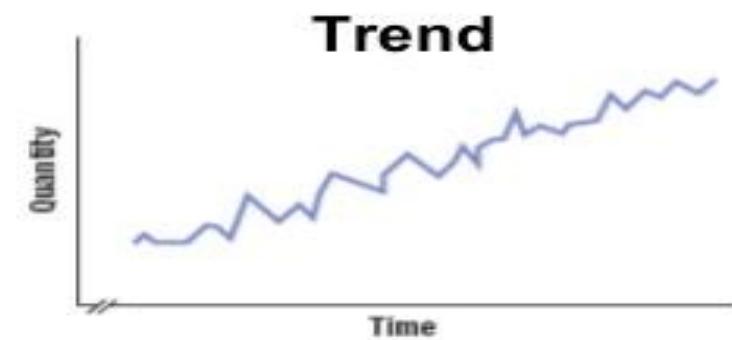
- Few companies use one technique only
- Most companies perform several forecasts using several techniques and combine results
- Combination of forecasts provide better accuracy



# Forecasting using Time Series Techniques

# Appropriate Technique for the Historical Behavior

- Historical Behaviors:



# Appropriate Technique for the Historical Behavior

## If the Historical Pattern is

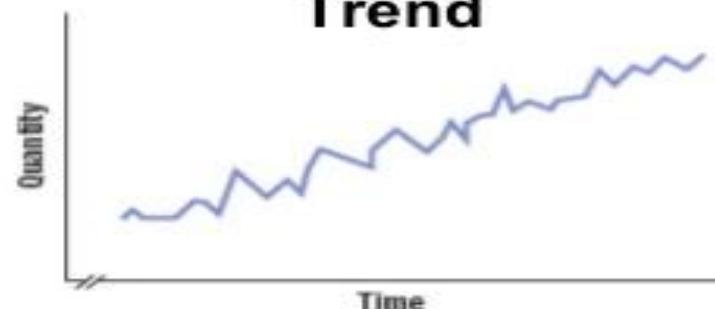
**Horizontal**



## Appropriate Technique(s)

- naive
- moving averages:
  - simple moving average (SMA)
  - weighted moving average (WMA)
- smoothing
  - single exponential smoothing

**Trend**

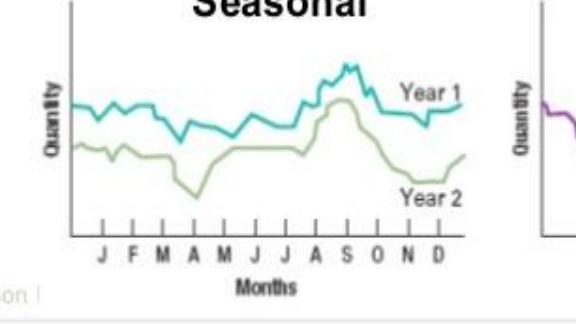


- trend line (trend equation)
  - regression (independent variable: time)
- smoothing
  - double exponential smoothing

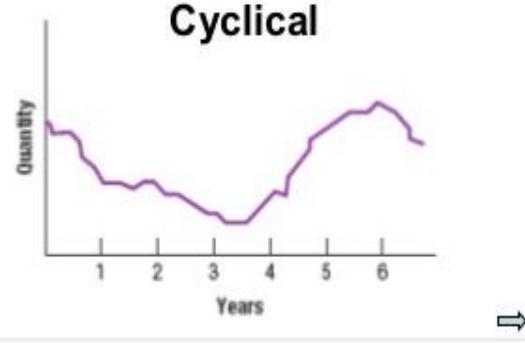
# Appropriate Technique for the Historical Behavior

## If the Historical Pattern is

**Seasonal**

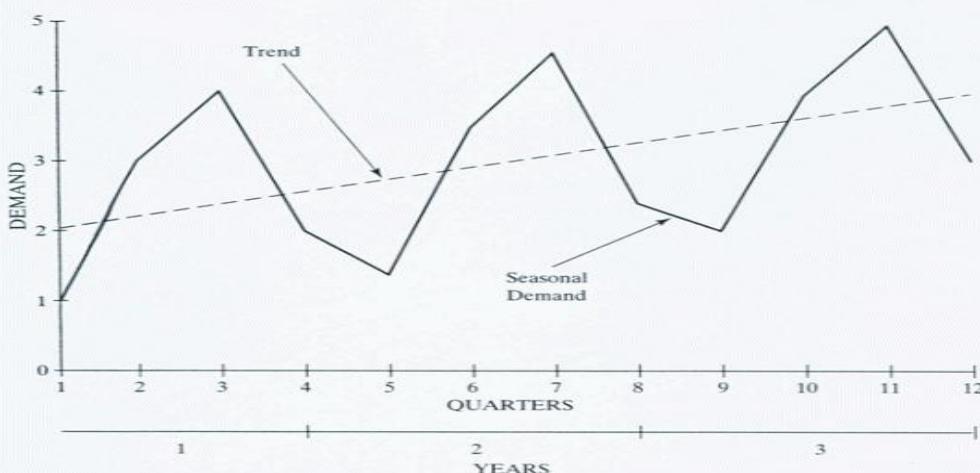


**Cyclical**



## Appropriate Technique(s)

- forecasting using seasonal index



- decomposition of the combination of pattern into individual patterns, forecasting, then combining forecasts of individual patterns

## a. Naïve Method

“What happened today will happen tomorrow”.

Day	M	T	W	Th	F
Actual Demand (pieces)	75	90	100	80	85
Forecast (pieces)		75	90	100	80

## a. Naïve Method

- For plots with seasons (ex. daily seasons)

Day	M	T	W	Th	F	M
Actual Demand (pieces)	75	90	100	80	85	90
Forecast (pieces)						75

\*\*\*Then the next M will have a forecast of 90

- For plots with trend

Day	M	T	W	Th	F	M
Demand	75	90	100			
Forecast	15	60	75	85		

\*\*\*If you think there is trend of +15 between days, then forecast will have +15 between periods

## a. Naïve Method

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### Advantages:

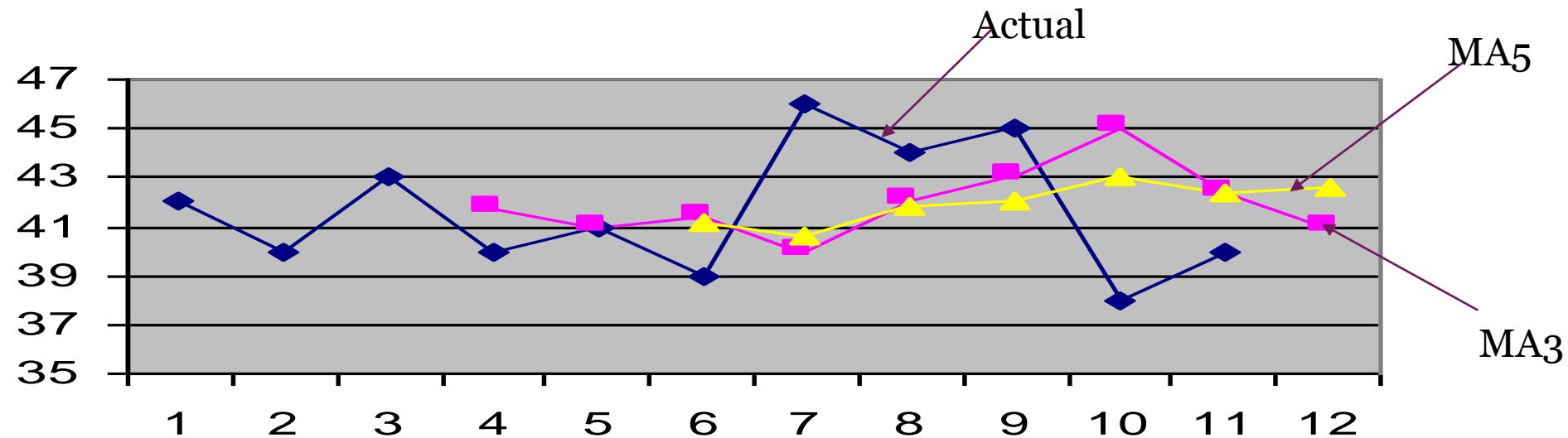
- Simple to use
- Virtually no cost
- Data analysis is non-existent
- Easily understandable

### Disadvantage

- No smoothing of data (forecast values can be highly fluctuating)
- Cannot provide high accuracy



## b. Simple Moving Average



$$\text{Forecast } n+1 = \text{MA}_n = \frac{\sum_{i=1}^n A_i}{n}$$

## b. Simple Moving Average

- **Smoothes out randomness** by averaging positive and negative random elements over several periods
- n -- number of periods (*this example uses n = 4*)

	Day					
	M	T	W	Th	F	S
Actual Demand (pieces)	75	90	100	80	85	90
Forecast by SMA, n = 4 (pieces)					86.25	88.75

$$\text{Forecast for F} = (80 + 100 + 90 + 75)/4 = 86.25$$

# Discussion Questions for SMA

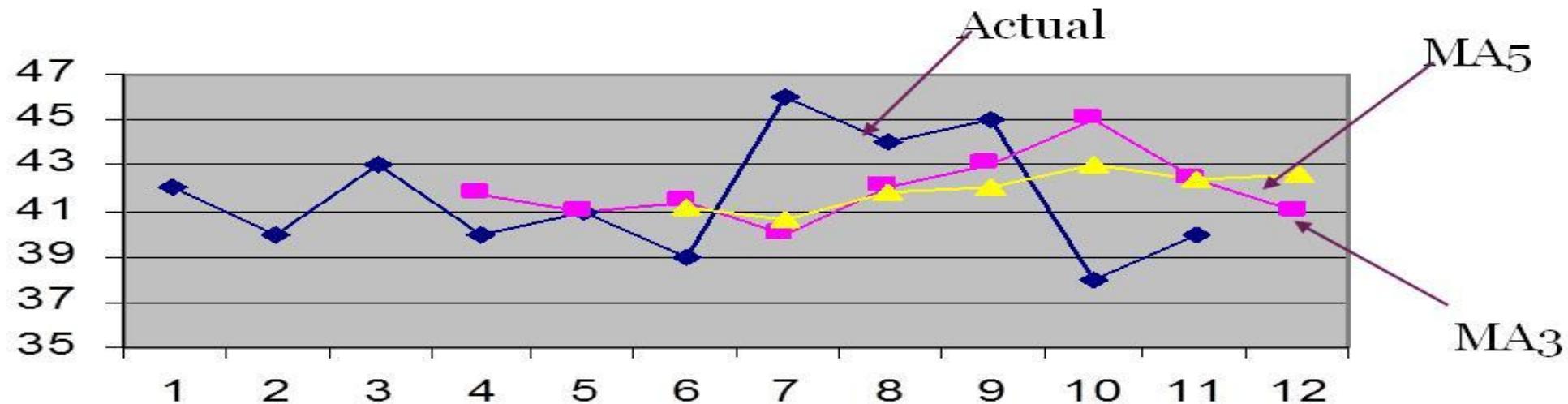
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## Questions:

1. What is the “weight” assigned to each data point?
2. What would be the effect of “n” on the graph?
3. Where would this technique be useful?
4. Where would this likely be inaccurate?



# Behavior of SMA Forecasts using Different Values of n



## c. Weighted Moving Average

- Same idea as SMA, but less smoothing
- Typically, more weight is placed on recent demand data
- n -- number of periods

	Day					
	M	T	W	Th	F	S
Actual Demand (pieces)	75	90	100	80	85	90
Forecast by SMA, n = 3 [0.6, 0.3, 0.1] (pieces)				94.5	87.0	85.0

$$\text{Forecast for Th} = (0.6 * 100) + (0.3 * 90) + (0.1 * 75) = 94.5$$

## d. Exponential Smoothing

- Simpler equation, equivalent to WMA  
 $\alpha$  – exponential smoothing parameter ( $0 < \alpha < 1$ )

Month	1	2	3	4	5	6
Actual Demand	75	90	100	80	85	90
Forecast	80	79	82	87	85	85

Example. If  $\alpha = 0.3$ ,

$$\text{Forecast (2)} = (0.3) \times 75 + (0.7) \times 80 = 79$$

$$\text{Forecast (3)} = (0.3) \times 90 + (0.7) \times 79 = 82$$

$$\text{Forecast (4)} = (0.3) \times 100 + (0.7) \times 82 = 87$$



## d. Exponential Smoothing

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Another way to look at it...

$$\text{Forecast} = (\alpha)(\text{Actual}) + (1-\alpha)(\text{Prev. Forecast})$$

Rearranging Values...

$$\alpha \text{Actual} + \text{Prev. Forecast} - \alpha \text{Prev. Forecast}$$

$$\begin{aligned} &= \text{Prev. Forecast} + \alpha(\text{Actual} - \text{Prev. Forecast}) \\ &= \text{Prev. Forecast} + \alpha(\text{Error}) \end{aligned}$$

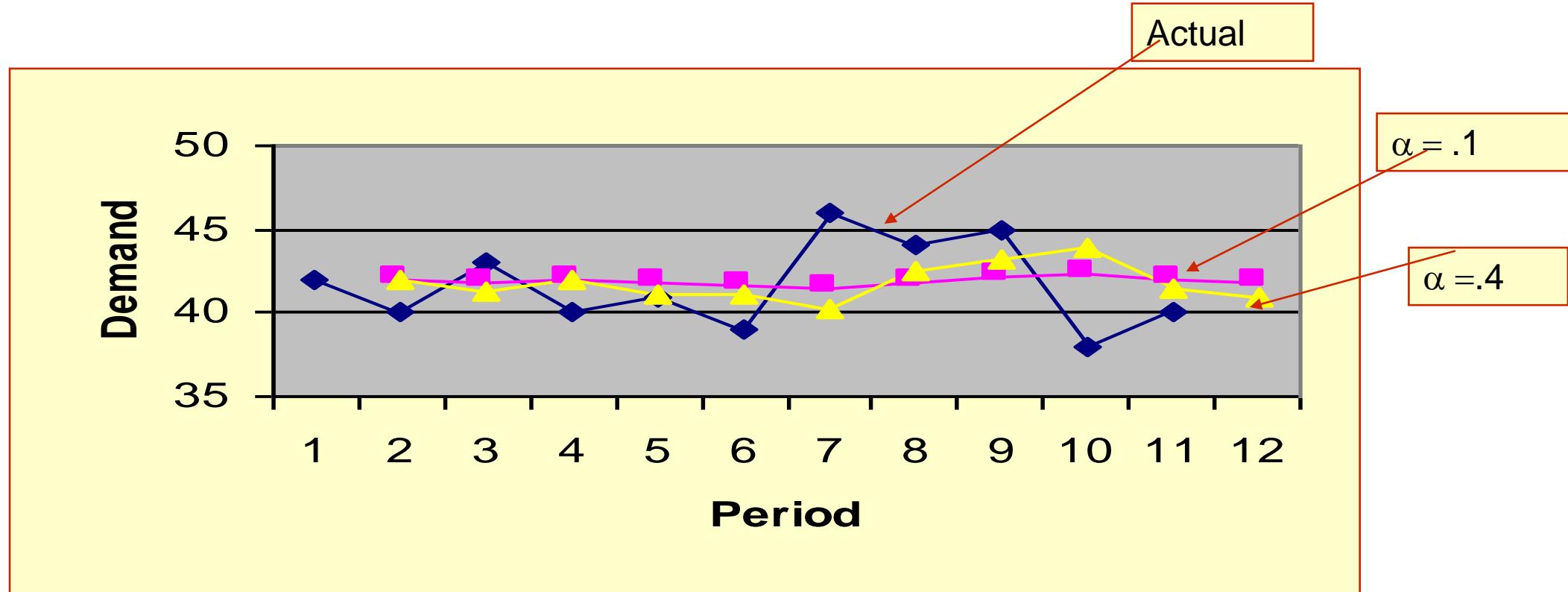


# Discussion Questions for Exponential Smoothing

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- What is the impact (i.e., smoothing) of higher  $\alpha$  to forecasts?
- Compare exponential smoothing with weighted moving average in terms of:
  - Amount (Number of data points) of past data to be stored.
  - Weight of each past data point.

## d. Exponential Smoothing



# Practice 1

## (Open Notes; Worksheet ok)

Create a 12-month forecast for Product A in card units. Starting with Nov 2010, up to Sept 2011. Assume that the forecast for Oct 2010 is 150 units. And  $\alpha$  is 0.2

<b>Product A</b>	Oct 2010	Nov	Dec	Jan 2011	Feb	Mar
Actual Demand	163	132	73	89	128	104
	Apr	May	Jun	Jul	Aug	Sep
Actual Demand	115	102	127	73	69	129

# Recommended Process for Forecasting

Step	Quick Answer
1. Determine the Purpose	Maybe for production planning (monthly production)
2. Establish time horizon	12 months (Oct 2010 – Sep 2011)
3. Select Forecasting Technique	Exponential smoothing, $\alpha = 0.2$ and $F_{\text{Oct2010}} = 150$ units (note: check if moving around an average, no trend, no seasons)
4. Gather, clean and analyze data	Ok
5. Prepare and make the forecast	Ok (please ask the lecturer for the results later)
6. Monitor the forecast	Ok. You may check accuracy (to be discussed later)

# Behavior of Demand in Practice 1



## Practice 2

### (Open Notes; Worksheet ok)

**Problem Solving:** Given the 3 averaging methods, which would you recommend to be used in the following data? Consider accuracy for Feb, Mar, Apr, May and June only. Why?

Let  $\alpha = 0.5$ ,  $F_{\text{Oct2012}} = 22$

Simple Moving Average = 4 months.

WMA = (4 months) 0.1, 0.2, 0.3, 0.4 (highest weight on most recent data point)

<b>Product B</b>	Oct 2012	Nov	Dec 2013	Jan	Feb	Mar
Actual Demand	25	25	31	10	8	11
	Apr	May	Jun			
Actual Demand	11	9	12			

# Recommended Process for Forecasting

Step	Quick Answer
1. Determine the Purpose	To evaluate forecasting techniques to be used maybe for production planning (monthly production)
2. Establish time horizon	At least for 5 months from Feb 2013 – June 2013
3. Select Forecasting Technique	Comparison of exponential smoothing, simple moving average and weighted moving average
4. Gather, clean and analyze data	Ok
5. Prepare and make the forecast	Ok (please ask the lecturer for the results later)
6. Monitor the forecast	Ok. You may check accuracy (to be discussed later)

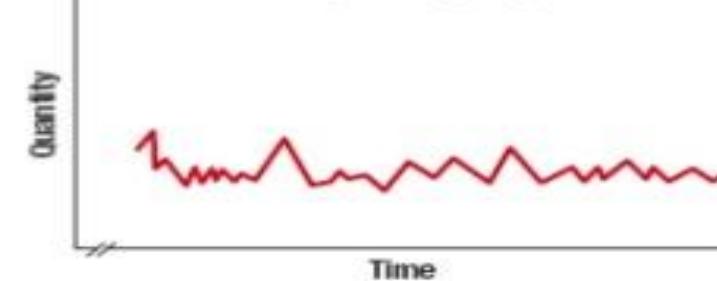
# Behavior of Demand in Practice 2



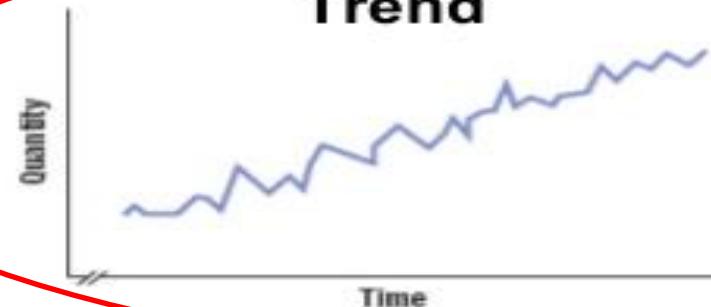
# Appropriate Technique for the Historical Behavior

If the Historical Pattern is

**Horizontal**



**Trend**



Appropriate Technique(s)

- naive
- moving averages:
  - simple moving average (SMA)
  - weighted moving average (WMA)
- smoothing
  - single exponential smoothing

- trend line (trend equation)
  - regression (independent variable: time)
- smoothing
  - double exponential smoothing

## e. Trend Adjusted Exponential Smoothing

---

Recall that:

Exponential Moving Average

$$\begin{aligned} \text{Forecast} &= (\alpha)(\text{Actual}) \\ &+ (1-\alpha)(\text{Prev. Forecast}) \end{aligned}$$

Or

$$\text{Prev. Forecast} + \alpha(\text{Error})$$



## e. Trend Adjusted Exponential Smoothing

*Smoothing Factor:* A number between 0 and 1. This is the weight of the previous actual demand.

Example: Assuming  $\alpha = 0.3$

Month	1	2	3	4	5	6
Actual Demand	75	90	100	80	85	90
Forecast	80	79	82	87	85	85

$$\text{Forecast (2)} = (0.3) \times 75 + (0.7) \times 80 = 79$$

$$\text{Forecast (3)} = (0.3) \times 90 + (0.7) \times 79 = 82$$

$$\text{Forecast (4)} = (0.3) \times 100 + (0.7) \times 82 = 87$$



## e. Trend Adjusted Exponential Smoothing

---

*Smoothing Factor:* A number between 0 and 1. This is the weight of the previous actual demand.

+NEW: *Trend Factor:* Also between 0 and 1. This is the weight of the change in trend.

$$\text{Forecast} = \text{Base} + \text{Trend}$$

$$\text{Base: } (\alpha)(\text{Actual}) + (1-\alpha)(\text{Prev. Forecast})$$

$$\text{Trend: } (\beta)(\text{Base} - \text{Prev.Base})$$

$$+ (1-\beta) (\text{Prev.Trend})$$



## e. Trend Adjusted Exponential Smoothing

*Forecast = Base + Trend       $\alpha = 0.3, \beta = 0.2$*

*Base:  $(\alpha)(Prev.\text{Actual}) + (1-\alpha)(Prev.\text{Forecast})$*

*Trend:  $(\beta)(Base - Prev.\text{Base}) + (1-\beta)(Prev.\text{Trend})$*

Month	1	2	3	4	5	6
Actual Demand	74	90	100	60	92	111
Base	74	74	78.8	85.8	79.6	83.7
Trend	0	0	0.96	2.17	0.49	1.21
Forecast	74	74	79.8	88.0	80.1	84.9

*Month 2: Base:  $(0.3)(74) + (0.7)(74)$       Forecast = 74*

*Month 2: Trend:  $(0.2)(74 - 74) + (0.8)(0)$*

## e. Trend Adjusted Exponential Smoothing

*Forecast = Base + Trend       $\alpha = 0.3, \beta = 0.2$*

*Base:  $(\alpha)(\text{Prev. Actual}) + (1-\alpha)(\text{Prev. Forecast})$*

*Trend:  $(\beta)(\text{Base} - \text{Prev.Base}) + (1-\beta)(\text{Prev.Trend})$*

Month	1	2	3	4	5	6
Actual Demand	74	90	100	60	92	111
Base	74	74	78.8	85.8	79.6	83.7
Trend	0	0	0.96	2.17	0.49	1.21
Forecast	74	74	79.8	88.0	80.1	84.9

$$\text{Month 3: Base: } (0.3)(90) + (0.7)(74)$$

$$\text{Month 3: Trend: } (0.2)(78.8 - 74) + (0.8)(0)$$

$$\text{Forecast} = 79.8$$

## e. Trend Adjusted Exponential Smoothing

*Forecast = Base + Trend       $\alpha = 0.3, \beta = 0.2$*

*Base:  $(\alpha)(\text{Prev. Actual}) + (1-\alpha)(\text{Prev. Forecast})$*

*Trend:  $(\beta)(\text{Base} - \text{Prev.Base}) + (1-\beta)(\text{Prev.Trend})$*

Month	1	2	3	4	5	6
Actual Demand	74	90	100	60	92	111
Base	74	74	78.8	85.8	79.6	83.7
Trend	0	0	0.96	2.17	0.49	1.21
Forecast	74	74	79.8	88.0	80.1	84.9

*Month 4: Base:  $(0.3)(100) + (0.7)(79.8)$  Forecast =  
Month 4: Trend:  $(0.2)(85.8 - 78.8) + 88.0$   
 $(0.8)(0.96)$*



# Discussion Questions for Trend Adjusted Exponential Smoothing

---

- *How does the  $\alpha$  affect the forecast?*
- *How does the  $\beta$  affect the forecast?*



# Practice 3

Use Double Exponential Smoothing for the following actual demand data for a 4-month period: 30, 35, 37, 40 corresponding to Month 1, 2, 3 and 4, respectively

$$\alpha = 0.3, \beta = 0.2$$

*Initial Trend = 0; Initial Base = 30*

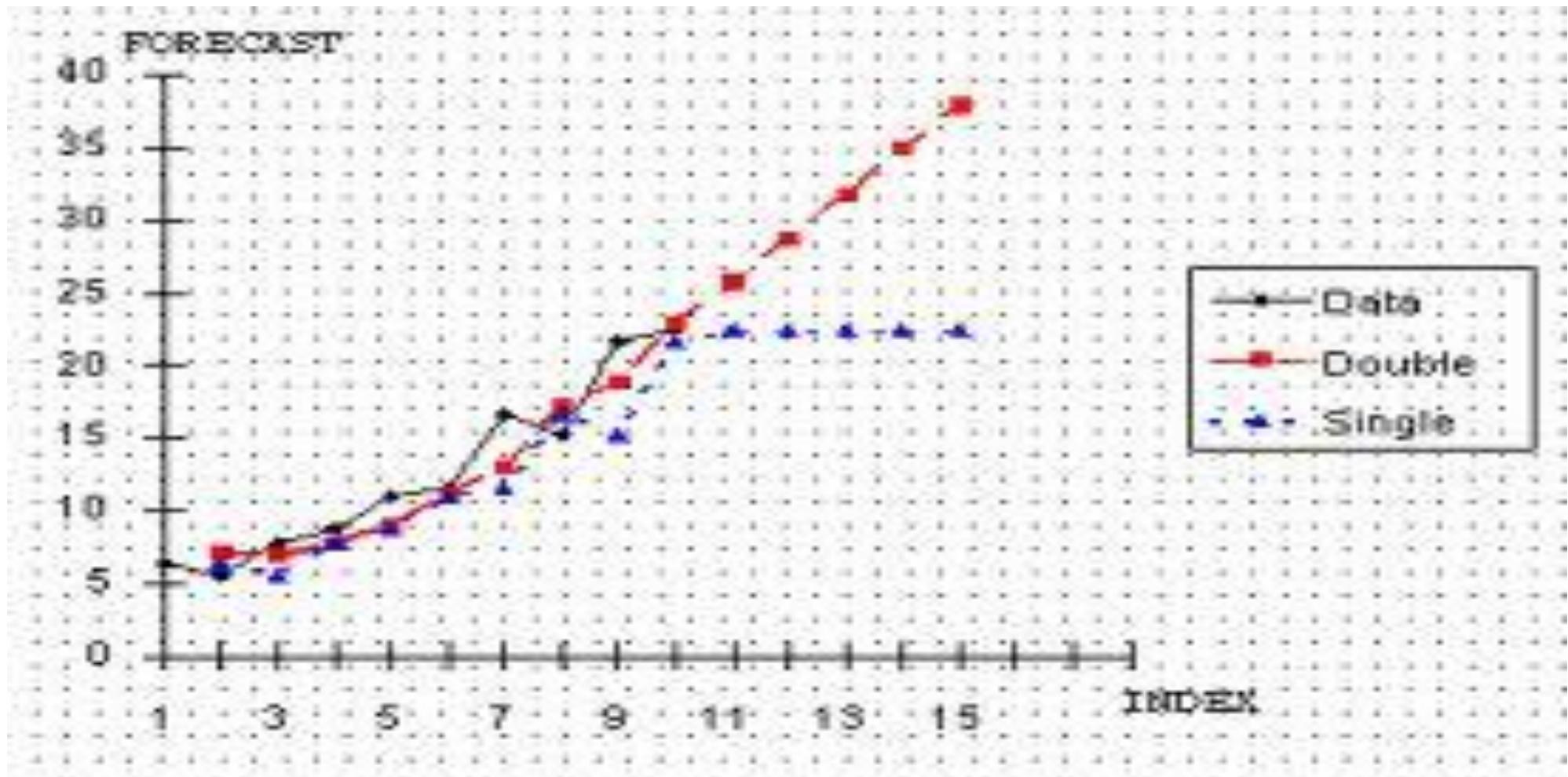
*Forecast = Base + Trend       $\alpha = 0.3, \beta = 0.2$*

*Base:  $(\alpha)(\text{Prev. Actual}) + (1-\alpha)(\text{Prev. Forecast})$*

*Trend:  $(\beta)(\text{Base} - \text{Prev. Base}) + (1-\beta)(\text{Prev. Trend})$*

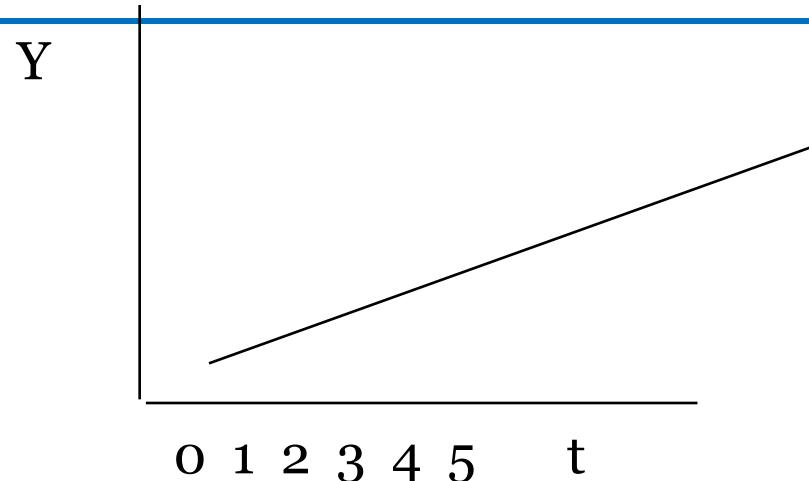


## e. Trend Adjusted Exponential Smoothing



## f. Linear Trend

$$Y_t = a + bt$$



- b is similar to the slope. However, since it is calculated with the variability of the data in mind, its formulation is not as straight-forward as our usual notion of slope.

## f. Linear Trend

---

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

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

## f. Linear Trend

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

## f. Linear Trend

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

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

$$y = 143.5 + 6.3t$$

# Practice 4

---

Sales have been declining since the release of an ineffective radio commercial. The sales (in hundred thousands) for the past 8 weeks are: 80, 74, 73, 68, 71, 65, 61, 60.

Estimate the forecast for the 12<sup>th</sup> week.

Hints:

1. Estimate a and b of the linear equation.
2. Find  $Y = a + b(t)$  where  $t = 12$ .

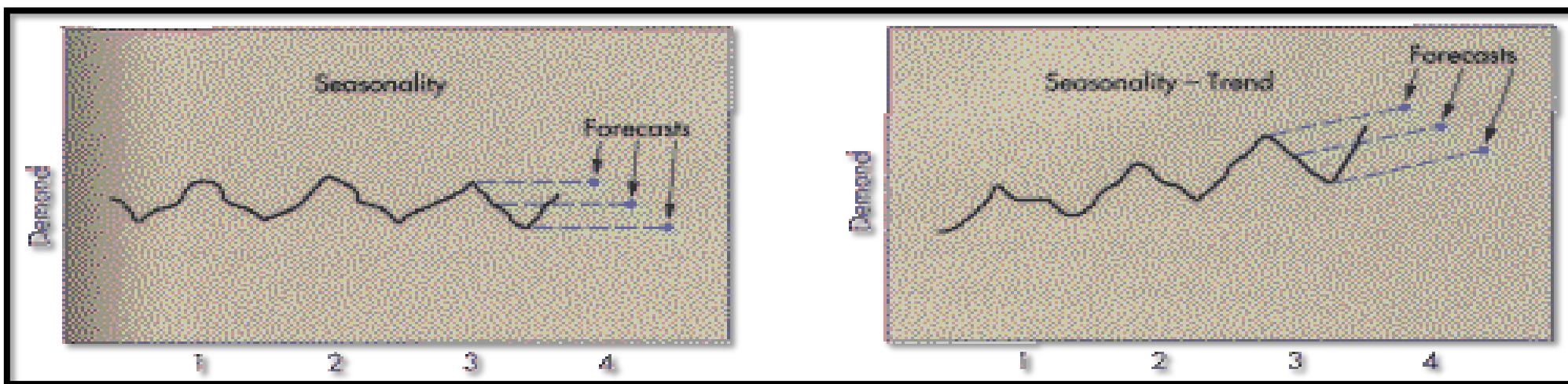


## g. Forecasting using Seasonal Index

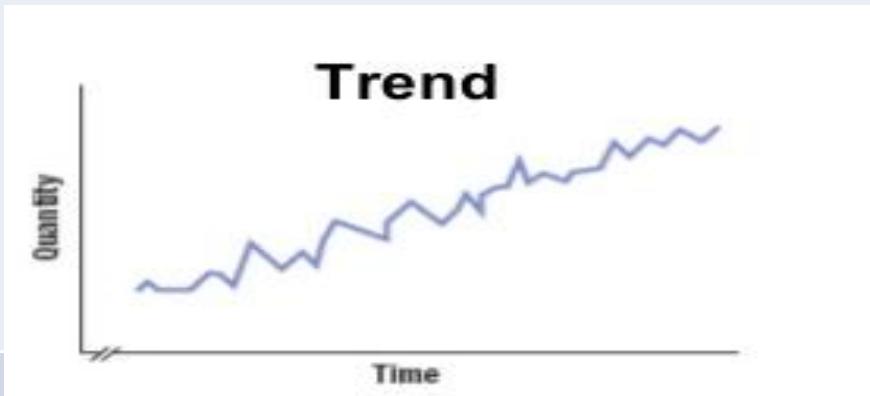
Linear Trends do not consider the effects of the “seasons” and its cycle.

Cycles may vary from: Time of the Day, Week, Month, Year, and so on... for example:

- “At month end, truck utilization always doubles”
- 60% of our customers arrive during 1130am -130pm.



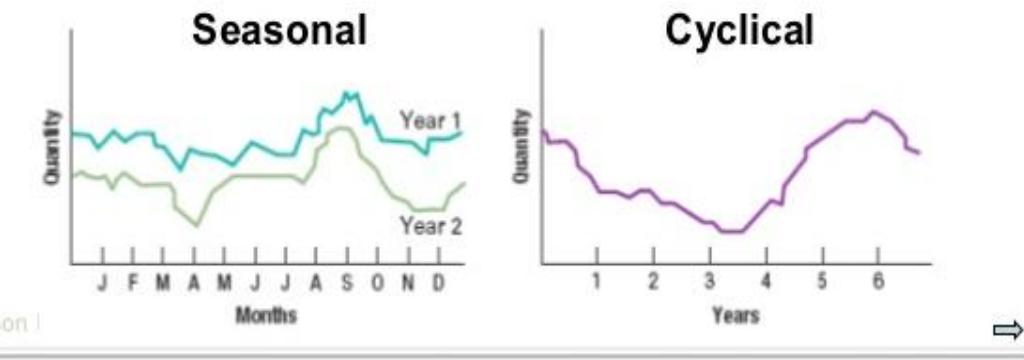
# Appropriate Technique for the Historical Behavior

If the Historical Pattern is	Appropriate Technique(s)
<p><b>Horizontal</b></p> 	<ul style="list-style-type: none"><li>• naive</li><li>• moving averages:<ul style="list-style-type: none"><li>• simple moving average (SMA)</li><li>• weighted moving average (WMA)</li></ul></li><li>• smoothing<ul style="list-style-type: none"><li>• single exponential smoothing</li></ul></li></ul>
<p><b>Trend</b></p> 	<ul style="list-style-type: none"><li>• trend line (trend equation)<ul style="list-style-type: none"><li>• regression (independent variable: time)</li></ul></li><li>• smoothing<ul style="list-style-type: none"><li>• double exponential smoothing</li></ul></li></ul>

# Appropriate Technique for the Historical Behavior

## If the Historical Pattern is

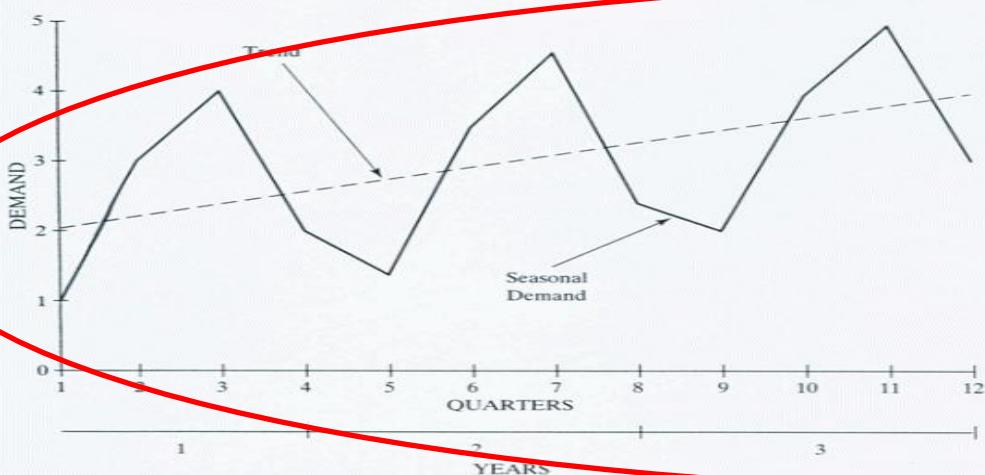
**Seasonal**



**Cyclical**

## Appropriate Technique(s)

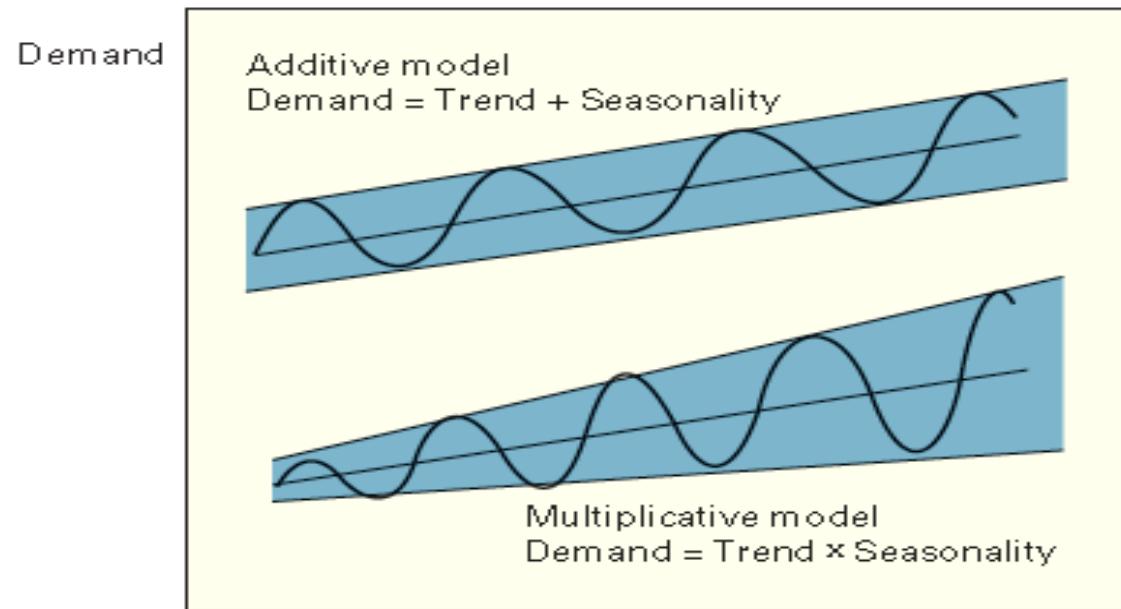
- forecasting using seasonal index



- decomposition of the combination of pattern into individual patterns, forecasting, then combining forecasts of individual patterns

# Two kinds of models for forecasting given Seasonality

- Additive
- Multiplicative



Source: Stevenson, Operations Management

## g. Forecasting using Seasonal Index

---

### Usual Approach

1. Determine the length of the cycle.
2. Estimate the Seasonal Relatives
  - What is the effect of each “season”
3. Estimate the linear trend
4. Forecast using the linear trend
5. Adjust using the Seasonal Relatives



# g. Forecasting using Seasonal Index

---

## Usual Approach

1. Determine the length of the cycle.
2. Estimate the Seasonal Relatives
  - What is the effect of each “season”
3. Estimate the linear trend
4. Forecast using the linear trend
5. Adjust using the Seasonal Relatives



# g. Forecasting using Seasonal Index

## Determining Seasonal Relatives

The following shows the number of visitors of an online bulk sales site on a weekly basis.

What are the patterns?

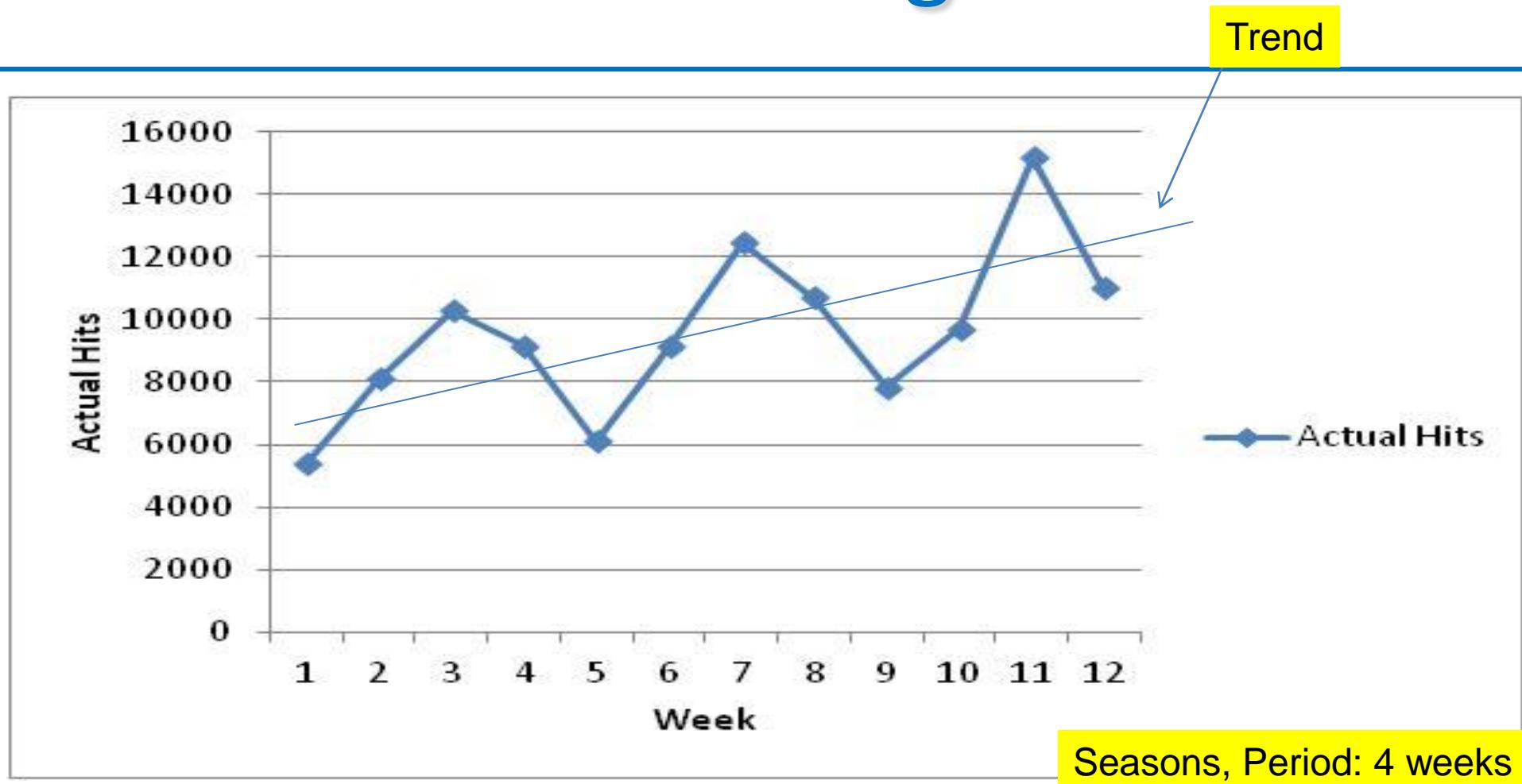
Every 3 weeks?

4 weeks?

6 weeks?

Week	Actual Hits	Week	Actual Hits
1	5,384	7	12,460
2	8,081	8	10,717
3	10,282	9	7,825
4	9,156	10	9,693
5	6,118	11	15,177
6	9,139	12	10,990

# Period of Recurring Pattern



# g. Forecasting using Seasonal Index

1. Split the data into 4 week-cycles.
2. Get the average per week per cycle. .
3. Divide each period by the grand average.

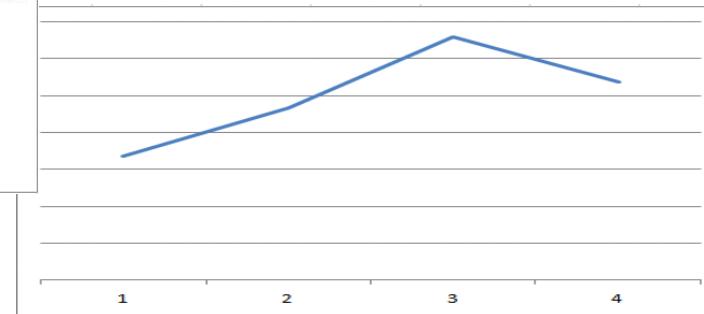
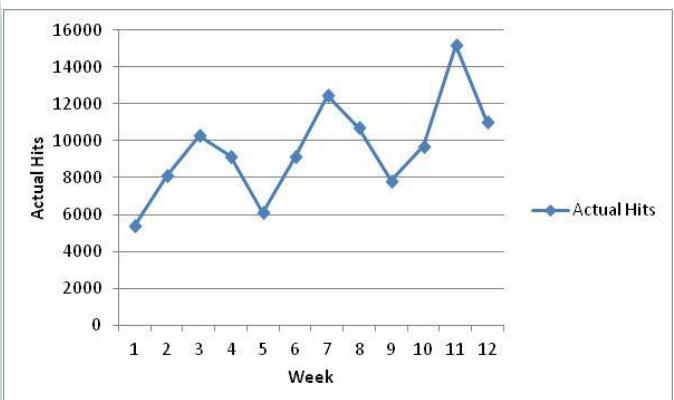
Week	Cycle 1	Cycle 2	Cycle 3	Average	Seasonal Relative
1	5,384	6,118	7,825	<b>6,442</b>	*0.672
2	8,081	9,139	9,693	<b>8,971</b>	0.936
3	10,282	12,460	15,177	<b>12,639</b>	1.319
4	9,156	10,717	10,990	<b>10,287</b>	1.073
Grand Average				<b>9,585</b>	

$$*6,442 / 9,585 = 0.672$$

## g. Forecasting using Seasonal Index

These seasonal relatives mean that every start of a cycle (1<sup>st</sup>, 5<sup>th</sup>, 9<sup>th</sup>, 13<sup>th</sup>... week) the number of visitors are around 67% of the average number of visitors.

It also means that every 3<sup>rd</sup> week of the cycle, one can expect 31% more visitors (compared to the average) in the website.



<i>Week</i>	<i>Seasonal Relative</i>
1	*0.672
2	0.936
3	1.319
4	1.073

# g. Forecasting using Seasonal Index

## Complete Approach for Decomposing the **Season Pattern** and **Trend Pattern**

1. Determine the length of the cycle  
(in this example, length = 4 weeks)
2. Estimate the Seasonal Relatives
  - What is the effect of each “season”
3. Remove the seasonal component from the data to get the “non-seasonal” component. (Divide each data point with the seasonal relative.)
4. Obtain trend estimate for the desired period using the trend equation.  
Add the seasonality by multiplying the seasonal relative.

## g. Forecasting using Seasonal Index

---

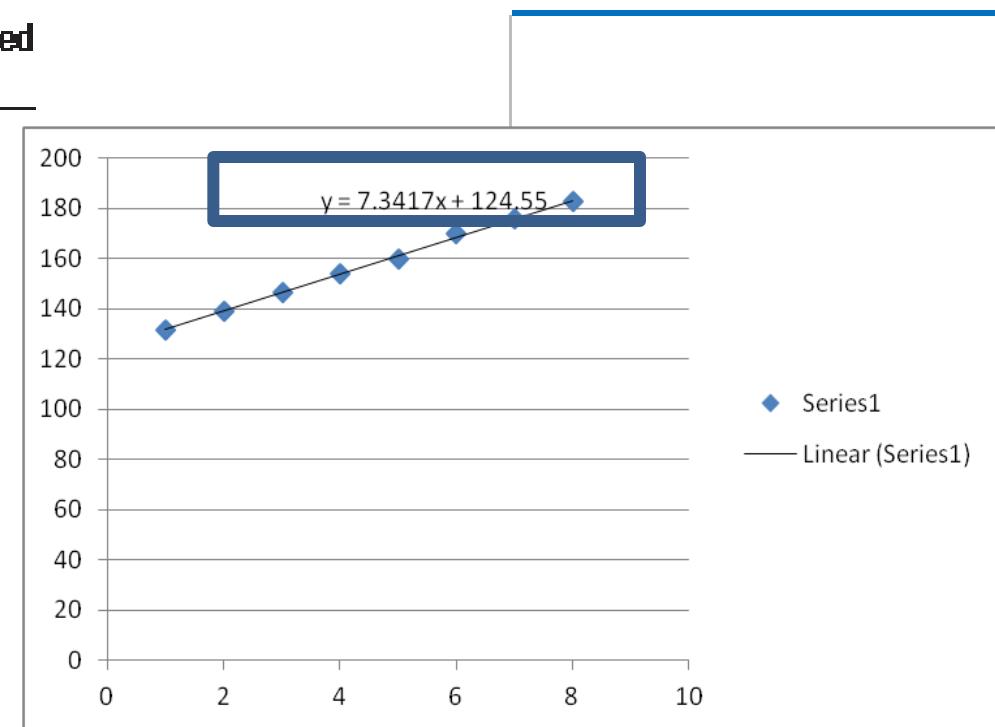
- A coffee shop owner wants to estimate demand for the next two quarters for hot chocolate.
  - Sales data consist of **trend and seasonality**.
- a) Quarter relatives are 1.20 for the first quarter, 1.10 for the second quarter, 0.75 for the third quarter, and 0.95 for the fourth quarter. Use this information to deseasonalize sales for quarters 1 through 8.
- b) Using the appropriate values of quarter relatives and the equation  $F_t = 124 + 7.5t$  for the trend component, estimate demand for periods 9 and 10.



# g. Forecasting using Seasonal Index

a.

Period	Quarter	Sales (gal)	÷	Quarter Relative	=	Deseasonalized Sales
1	1	158.4	÷	1.20	=	132.0
2	2	153.0	÷	1.10	=	139.1
3	3	110.0	÷	0.75	=	146.7
4	4	146.3	÷	0.95	=	154.0
5	1	192.0	÷	1.20	=	160.0
6	2	187.0	÷	1.10	=	170.0
7	3	132.0	÷	0.75	=	176.0
8	4	173.8	÷	0.95	=	182.9



b. The trend values are:

$$\text{Period 9: } F_t = 124 + 7.5(9) = 191.5$$

$$\text{Period 10: } F_t = 124 + 7.5(10) = 199.0$$

Period 9 is a first quarter and period 10 is a second quarter. Multiplying each trend value by the appropriate quarter relative results in:

$$\text{Period 9: } 191.5(1.20) = 229.8$$

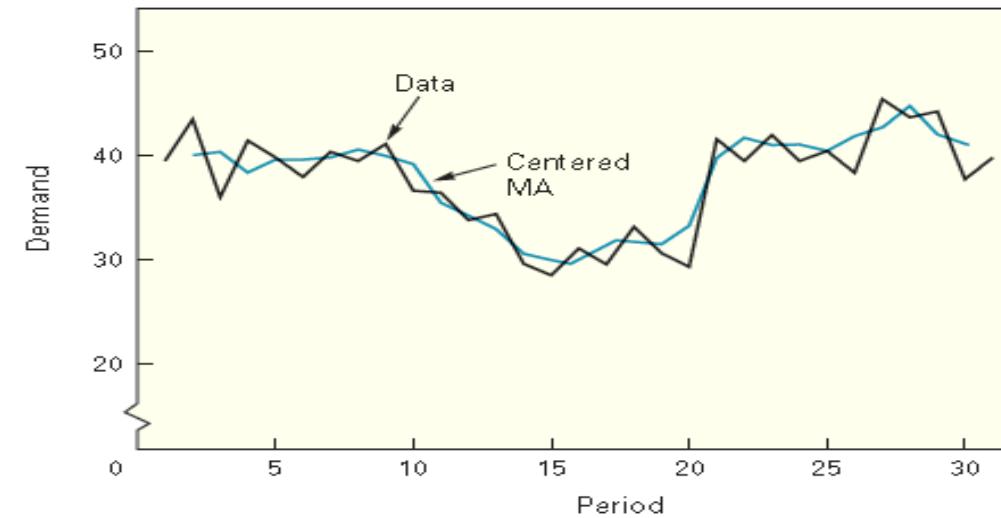
$$\text{Period 10: } 199.0(1.10) = 218.9$$

# How to Compute for the Seasonal Index/Relative

Two Ways:

1. Simple Average Method
2. Centered Moving Average

(accounts very well for any trend – linear, curvilinear)



# Example



[www.mhhe.com/stevenson11e](http://www.mhhe.com/stevenson11e)

Day	Volume	Day	Volume	Day	Volume
Tues	67	Tues	60	Tues	64
Wed	75	Wed	73	Wed	76
Thurs	82	Thurs	85	Thurs	87
Fri	98	Fri	99	Fri	96
Sat	90	Sat	86	Sat	88
Sun	36	Sun	40	Sun	44
Mon	55	Mon	52	Mon	50

# Simple Average Method

Season	Week 1	Week 2	Week 3	Season Average	SA Index	
					Step 1: Compute the season averages	Step 3: Compute the SA relatives
Tues	67	60	64	63.667	$63.667/71.571 = 0.8896$	
Wed	75	73	76	74.667	$74.667/71.571 = 1.0432$	
Thurs	82	85	87	84.667	$84.667/71.571 = 1.1830$	
Fri	98	99	96	97.667	$97.667/71.571 = 1.3646$	
Sat	90	86	88	88.000	$88.000/71.571 = 1.2295$	
Sun	36	40	44	40.000	$40.000/71.571 = 0.5589$	
Mon	55	52	50	<u>52.333</u>	$52.333/71.571 = 0.7312$	
				<u>71.571</u>		
Step 2: Compute the overall average						

From: Stevenson

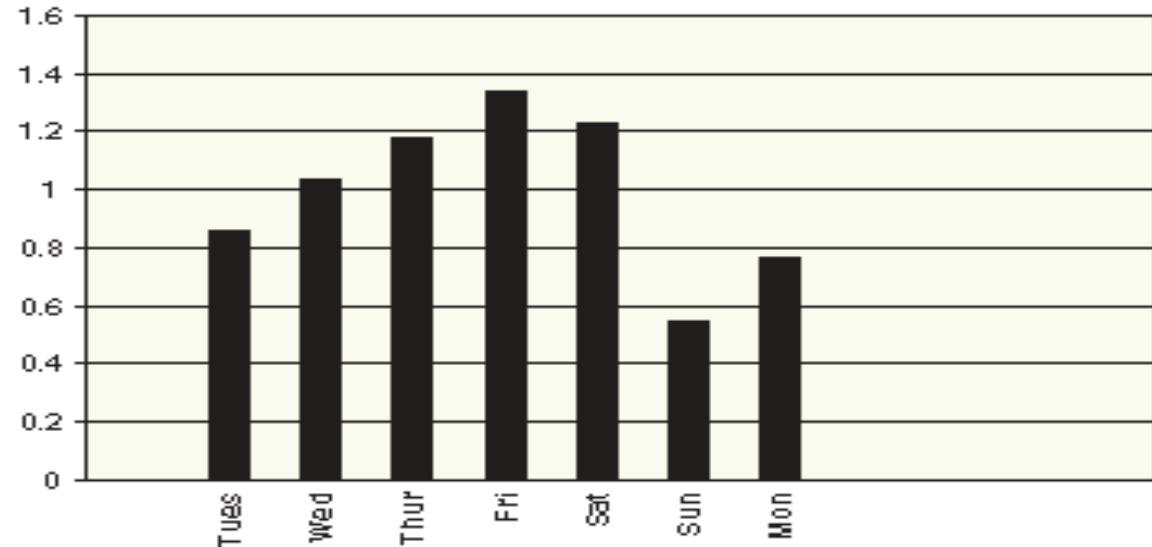
# Centered Moving Average Method

### Compute Seasonal Indexes

[Back](#)

Number of "seasons" = **7**

Season	Average Index
Tues	0.8688
Wed	1.0460
Thur	1.1980
Fri	1.3648
Sat	1.2383
Sun	0.5339
Mon	0.7484



Period	Season	Actual	MA	Center	Index
1	Tues	67			
2	Wed	75			
3	Thur	82			
4	Fri	98		71.857143	1.363817
5	Sat	90		70.857143	1.270161
6	Sun	90		70.571429	0.510121
7	Mon	36	71.857143	71	0.774647
8	Tues	60	70.857143	71.142857	0.843373
9	Wed	73	70.571429	70.571429	1.034413
10	Thur	85	71	71.142857	1.194779
11	Fri	99	71.142857	70.714286	1.4
12	Sat	86	70.571429	71.285714	1.206412
13	Sun	40	71.142857	71.714286	0.557768
14	Mon	62	70.714286	72	0.722222
15	Tues	64	71.285714	71.571429	0.894211
16	Wed	76	71.714286	71.857143	1.057654
17	Thur	87	72	72.428571	1.201183
18	Fri	96	71.571429	72.142857	1.330693
19	Sat	98	71.285714		

Compute the Index as  
Index as Index (Period)  
= Actual/Center

# Practice 5

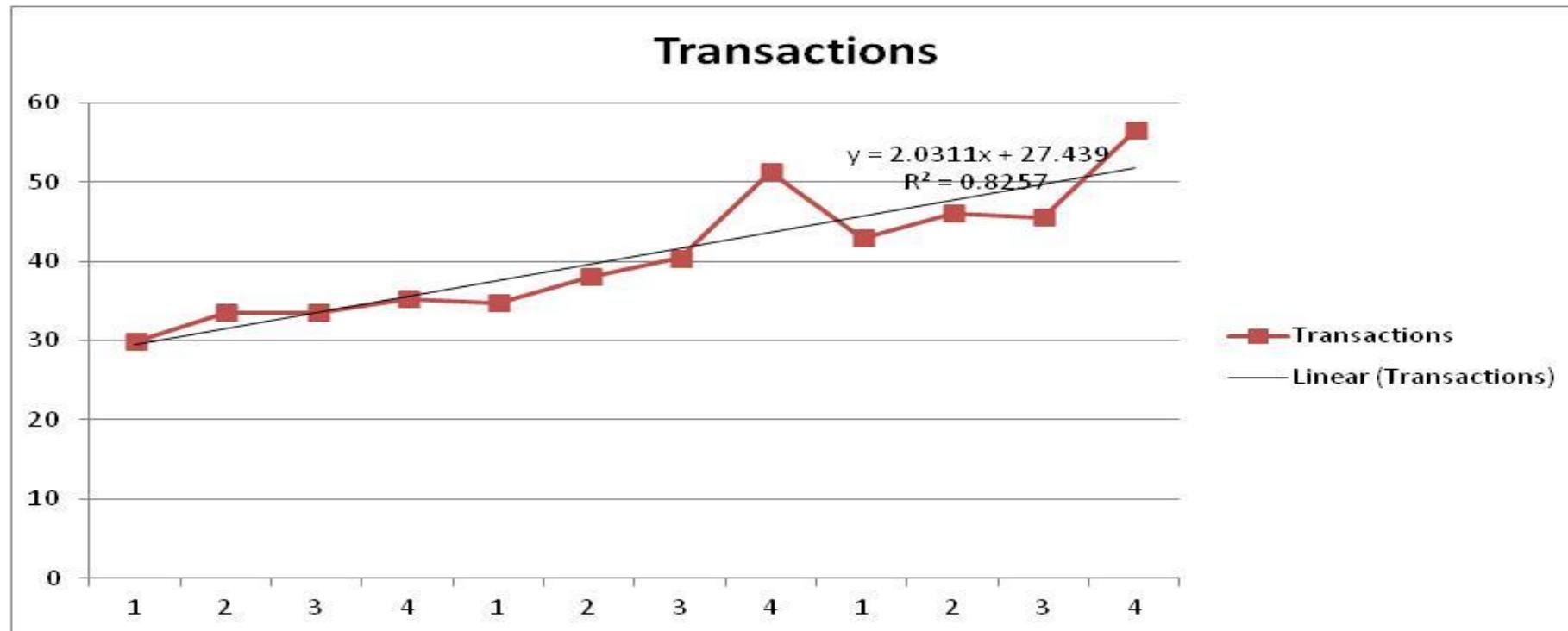
Practice: The volume of transactions of a BPO are as follows (in thousands).

Qtr	2008	2009	2010
1	29.8	34.7	42.9
2	33.5	38.1	46.1
3	33.5	40.4	45.6
4	35.3	51.3	56.5

Determine the seasonal relatives, and the forecasted number of transactions being handled by the year 2015.



# Historical Behavior of BPO Transactions in Practice 5



2015 forecasts may be based on linear trend equation only

# g. Forecasting using Seasonal Index

## Complete Approach

1. Determine the length of the cycle.
2. Estimate the Seasonal Relatives
  - What is the effect of each “season”
3. Remove the seasonal component from the data to get the “non-seasonal” component. (Divide each data point with the seasonal relative.)
4. Obtain trend estimate for the desired period using the trend equation.

Add the seasonality by multiplying the seasonal relative.



# **ADDITIONAL PROBLEMS/OPEN FORUM**

# Summary

---

Today, Day 1 of Module 5 of Business Intelligence Series of Lectures, we:

- Explained why we perform business forecasting.  
(What is the value of business forecasting?)
- Stated what demand forecasting is.
- Stated and Explained the recommended process for business forecasting.
- Cited the different techniques of business forecasting and their specific uses.
- Forecasted for using the Naïve, Moving Average and Weighted Moving Average, Simple Exponential Method, Trend-adjusted Exponential Smoothing, Linear Trend Equation and Using Seasonal Index.



# Summary

- Explained why we perform business forecasting.

(What is the value of business forecasting?)

So we can anticipate and meet future demand.



- Stated what demand forecasting is.
  - Making a statement about the future, specifically on:
    1. which products will be required
    2. what amount of these products will be called for
    3. when these products will be needed

# Summary

---

- Stated and Explained the recommended process for business forecasting.

*Step 1.* Determine the purpose of the forecast.

*Step 2.* Establish the time-horizon for your forecast.

*Step 3.* Select the forecasting technique to use.

*Step 4.* Gather, clean and analyze data.

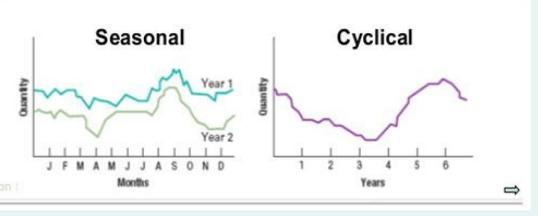
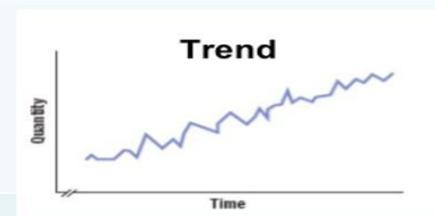
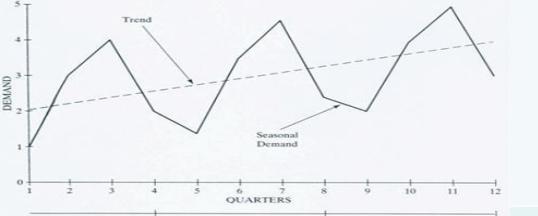
*Step 5.* Prepare and make the forecast.

*Step 6.* Monitor the forecast.



# Summary

- Cited the different techniques of business forecasting and their specific uses.

If the Historical Pattern is	Appropriate Technique(s)	If the Historical Pattern is	Appropriate Technique(s)
<b>Horizontal</b> 	<ul style="list-style-type: none"><li>• naive</li><li>• moving averages:<ul style="list-style-type: none"><li>• simple moving average (SMA)</li><li>• weighted moving average (WMA)</li></ul></li><li>• smoothing<ul style="list-style-type: none"><li>• single exponential smoothing</li></ul></li></ul>	<b>Seasonal</b> 	<ul style="list-style-type: none"><li>• forecasting using seasonal index</li></ul>
<b>Trend</b> 	<ul style="list-style-type: none"><li>• trendline (trend equation)<ul style="list-style-type: none"><li>• regression (independent variable: time)</li></ul></li><li>• smoothing<ul style="list-style-type: none"><li>• double exponential smoothing</li></ul></li></ul>	<b>Cyclical</b> 	<ul style="list-style-type: none"><li>• decomposition of the combination of pattern into individual patterns, forecasting, then combining forecasts of individual patterns</li></ul>

- Practiced Forecasting using the different techniques ☺

---

Now you are ready for more applications and for measuring accuracy and monitoring forecasts to be discussed in Day 2!

*Enjoy forecasting and see you again!  
Thank you.*



# References

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- Hugos, M. H. (2011). Essentials of supply chain management. Hoboken: Wiley.
  - Stevenson, W. J. (2008). *Operations management*. New York, NY: McGraw-Hill Education.
- (various reading materials on forecasting and supply chain management)

Reference for each photo is cited with the photo.

