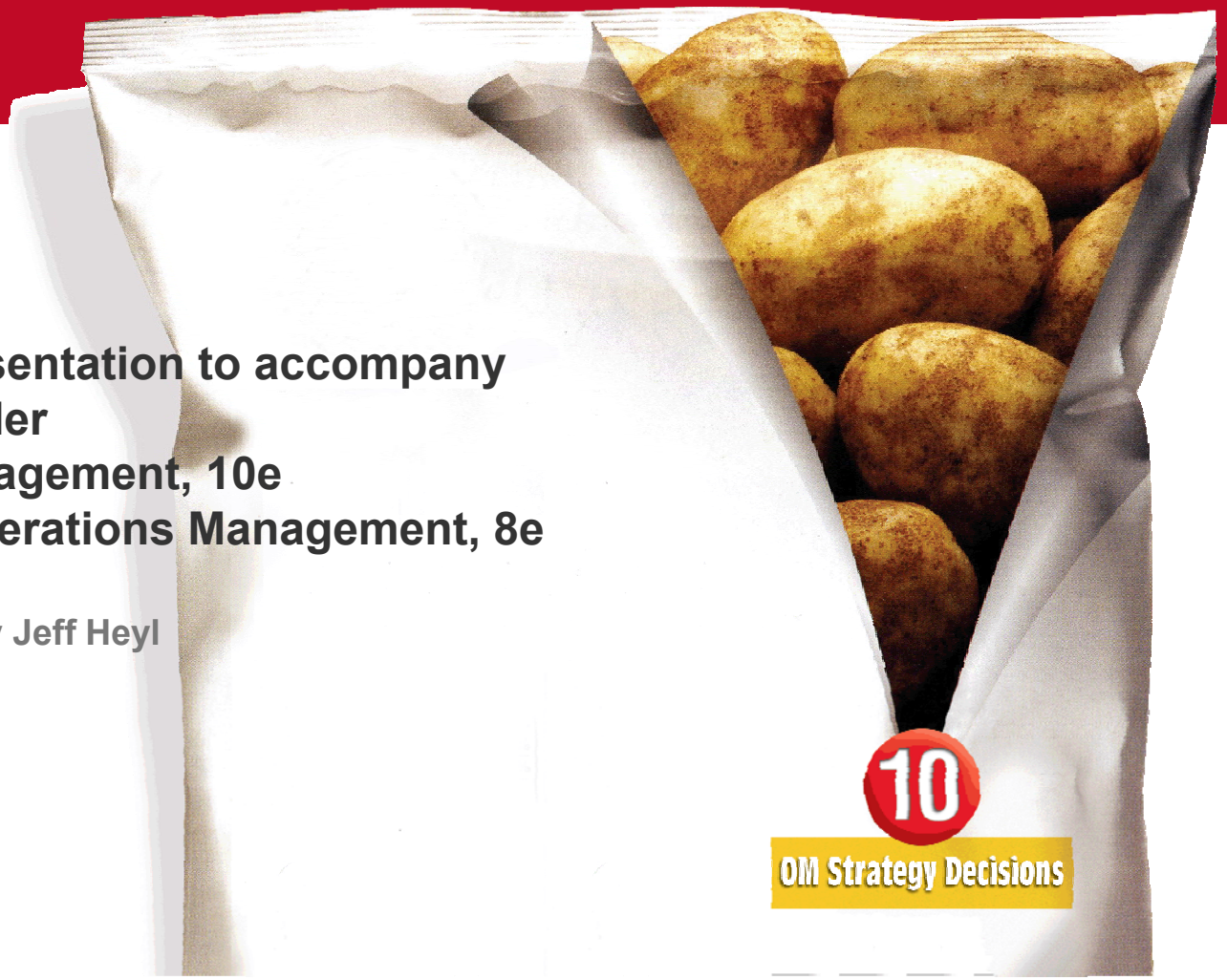
4 Forecasting

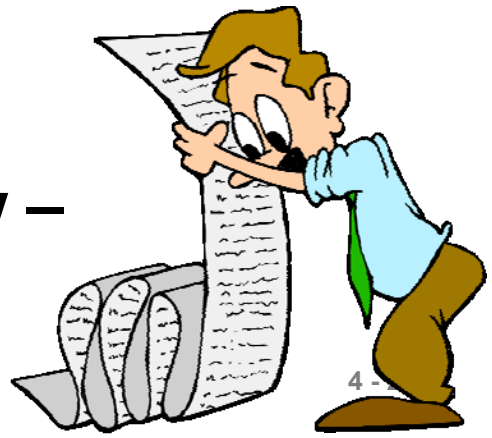


PowerPoint presentation to accompany
Heizer and Render
Operations Management, 10e
Principles of Operations Management, 8e

PowerPoint slides by Jeff Heyl

Outline – Part 1

- What is Forecasting?
- Case Study
- Forecasting Time Horizons
- Product Life Cycle - Overview
- Influence of Product Life Cycle
- Types of Forecast
- Strategic Importance of Forecasting
- Seven Steps in Forecasting
- Forecasting Approaches & Overview – Qualitative



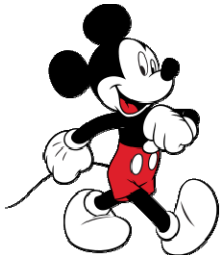
WHAT IS FORECASTING?

What is Forecasting?

- Process of predicting a future event
- Underlying basis of all business decisions
  - Production
  - Inventory
  - Personnel
  - Facilities

Guess which place is this?

https://www.youtube.com/watch?v=pr8MS6QvkwE



Walt Disney Parks and Resorts

About – Walt Disney Parks & Resorts

- Walt Disney opened Disneyland on July 17, 1955
- $40 billion corporation
- Ranked in the top 100 (both in Fortune 500 and Financial Times Global

Walt Disney Parks and Resorts

About – Walt Disney Parks & Resorts

- (WDPR) - one of the world's leading providers of **family travel and leisure experiences**
- **Five world-class vacation destinations** with 11 theme parks and 47 resorts
- Operates in **North America, Europe and Asia - with a sixth destination opening in Shanghai in June 2016**

Walt Disney Parks and Resorts

Forecasting provides a Competitive Advantage for Disney – Case Study

- **Disney's CEO** – Robert Iger
- Disney's **global portfolio includes:**
  - Hong Kong Disneyland (2005)
  - Disneyland Paris (1992)
  - Tokyo Disneyland (1983)
  - **Walt Disney World Resort (Florida)**
  - **Disneyland Resort (California)**

Walt Disney Parks and Resorts

Disney
What are they selling?

Walt Disney Parks and Resorts

MEMORABLE EXPERIENCE

Walt Disney Parks and Resorts

Disney's Case

- **Disney's revenue** depends on people
  - How many **people visit** the Disney parks
  - How these visitors **spend their money at the Disney parks**

Walt Disney Parks and Resorts

Disney Case

- **Robert Eager, CEO,** receives a daily report from his four theme parks and two water parks (Orlando)
- **The daily report** contains only two numbers:
  - Forecast of **yesterday's attendance**
  - The **actual attendance**

Walt Disney Parks and Resorts

Disney's Forecasting Team

- **Disney's forecast**
  Daily, weekly, monthly, annual and 5-year forecasts
- **For the following internal departments:**
  - Labor Management
  - Maintenance
  - Operations
  - Finance and
  - Park Scheduling
  - **Walt Disney Imagineering**

Walt Disney Parks and Resorts

- **Walt Disney Imagineering -** design and development arm of **The Walt Disney Company**, responsible for the creation and construction of **Disney Theme Parks** worldwide

Walt Disney Parks and Resorts

Disney's Forecasting helps

- To examine visitors **future travel plans**
- To understand people **experiences** at the parks
- **Capacity** on any day can be increased by opening at 8 AM instead at 9 AM (usual time)
- To understand people **behavior** at each ride
  - How long people will wait in a queue for the ride
  - How many times they will ride

Walt Disney Parks and Resorts

Disney's Forecasting helps

- In **managing the Demand** by:
  - Opening **more shows and rides**
  - By adding **more food/ beverage** carts (9 million hamburgers and 50 million cokes are sold per year)
  - Recruiting more employees/ **cast members (mickey mouse, Donald duck)**
  - By **shifting crowds from rides to more street parades**

Walt Disney Parks and Resorts

Cast Members

Walt Disney Parks and Resorts

If Forecasting Fails!!

Walt Disney Parks and Resorts

Disney's Forecasting Accuracy

- **The daily attendance report –** An error close to almost zero
- **Five years attendance** forecast yields only 5% error only
- **Annual attendance forecasts** have 0% to 3% error only

Walt Disney Parks and Resorts

Walt Disney Parks and Resorts

At Disney, Forecasting is a key driver in the company's success and competitive advantage

Forecasting Time Horizons

- **Short-range forecast**
  - Up to 1 year, generally less than 3 months
  - Purchasing, job scheduling, workforce levels, job assignments, production levels
- **Medium-range forecast**
  - 3 months to 3 years
  - Sales and production planning, budgeting
- **Long-range forecast**
  - 3^+ years
  - New product planning, facility location, research and development

Distinguishing Differences

- **Medium/long range forecasts deal with more comprehensive issues and support management decisions regarding planning and products, plants and processes**
- **Short-term forecasting usually employs different methodologies than longer-term forecasting**
- **Short-term forecasts tend to be more accurate than longer-term forecasts**

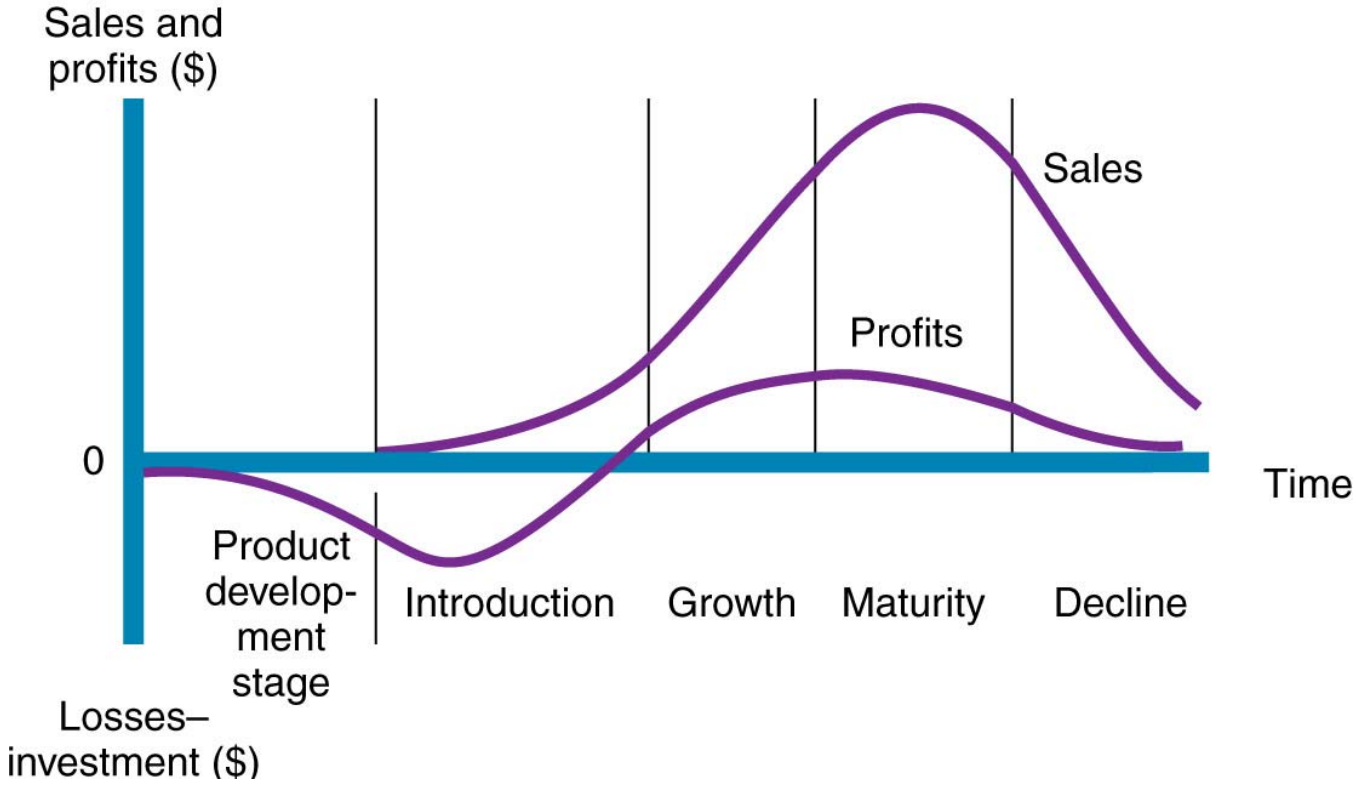
Outline – Part 1

- ✓ What is Forecasting?
- ✓ Case Study - Walt Disney Parks & Resorts
- ✓ Forecasting Time Horizons
- ◆ Product Life Cycle - Overview
- ◆ Influence of Product Life Cycle
- ◆ Types of Forecast
- ◆ Strategic Importance of Forecasting
- ◆ Seven Steps in Forecasting
- ◆ Forecasting Approaches & Overview – Qualitative

Product Life Cycle - Stages

- **The Typical Product Life Cycle (PLC) Has Five Stages**
  - **Product Development, Introduction, Growth, Maturity, Decline**

Sales & Profits Over a Product's Life

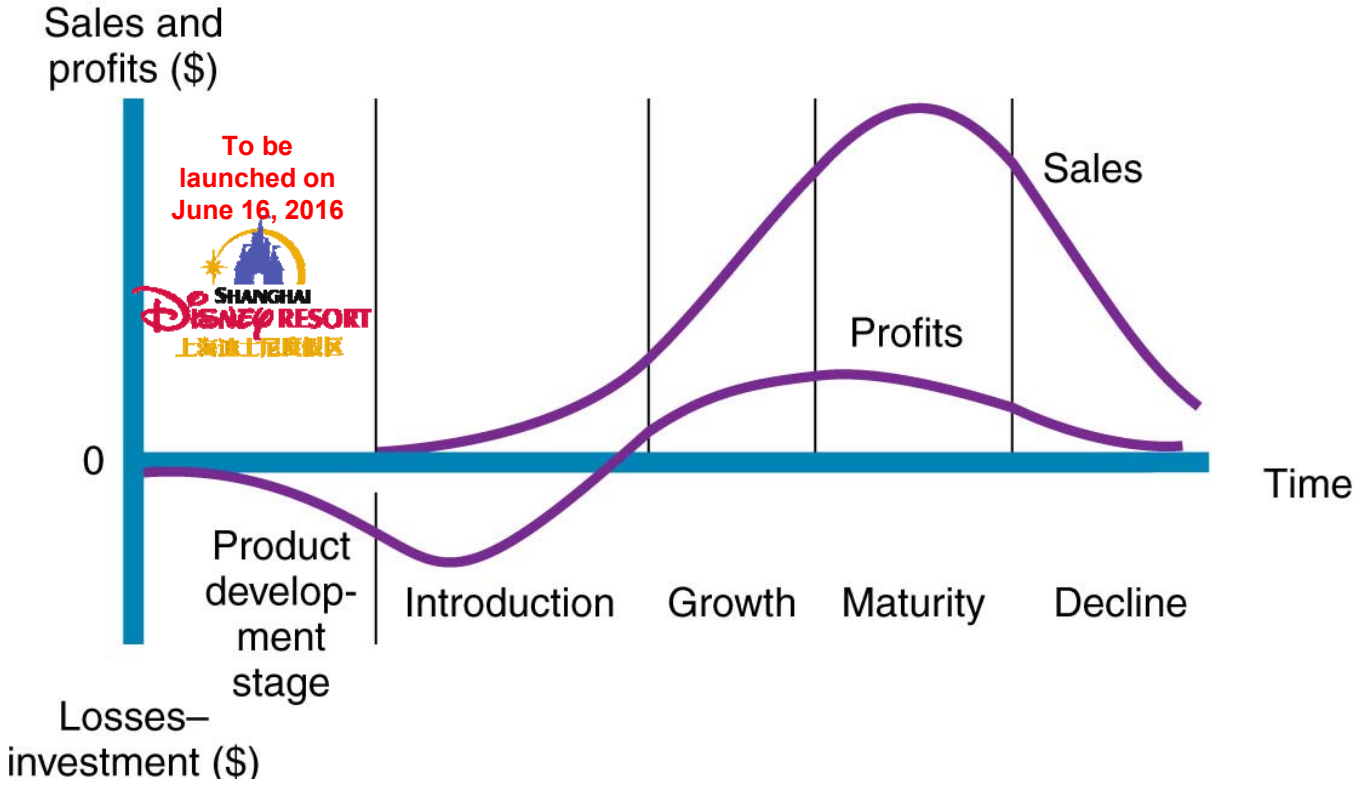


Product Life Cycle - Stages

- ***Product development***
- *Introduction*
- *Growth*
- *Maturity*
- *Decline*

- **Begins when the company develops a new-product idea**
- **Sales are zero**
- **Investment costs are high**
- **Profits are negative**

Sales & Profits Over a Product's Life

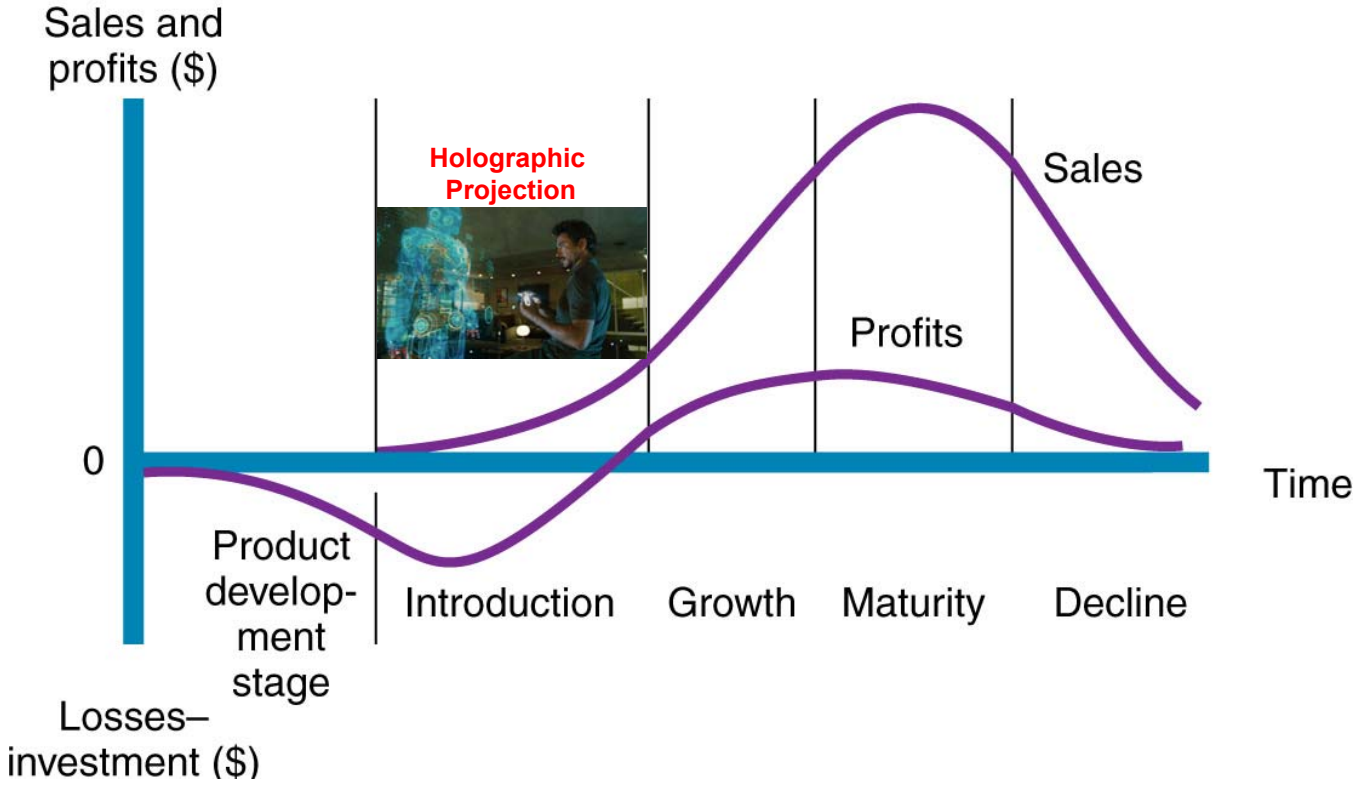


Product Life Cycle - Stages

- *Product development*
- ***Introduction***
- *Growth*
- *Maturity*
- *Decline*

- **Low sales**
- **High cost per customer acquired**
- **Negative profits**
- **Innovators are targeted**
- **Little competition**

Sales & Profits Over a Product's Life

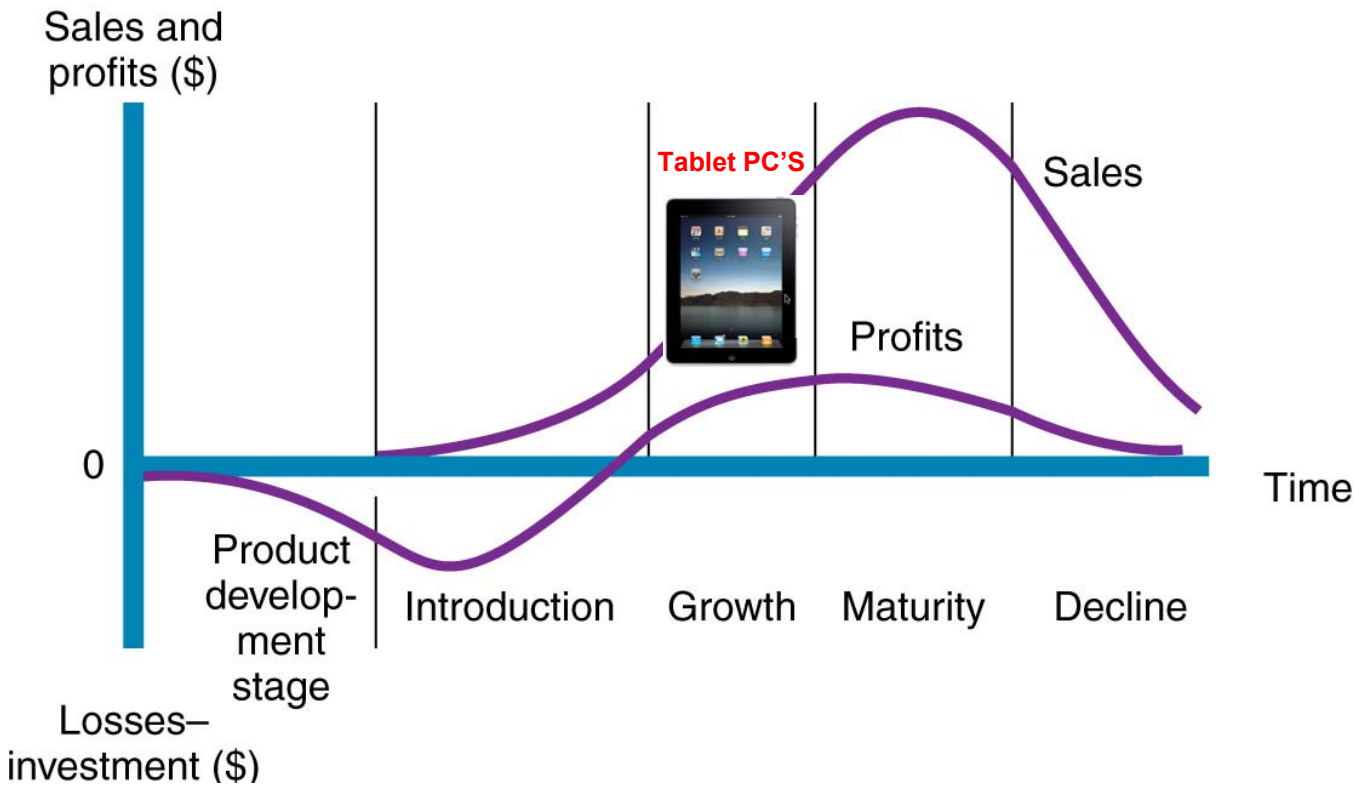


Product Life Cycle - Stages

- *Product development*
- *Introduction*
- ***Growth***
- *Maturity*
- *Decline*

- **Rapidly rising sales**
- **Average cost per customer**
- **Rising profits**
- **Early adopters are targeted**
- **Growing competition**

Sales & Profits Over a Product's Life

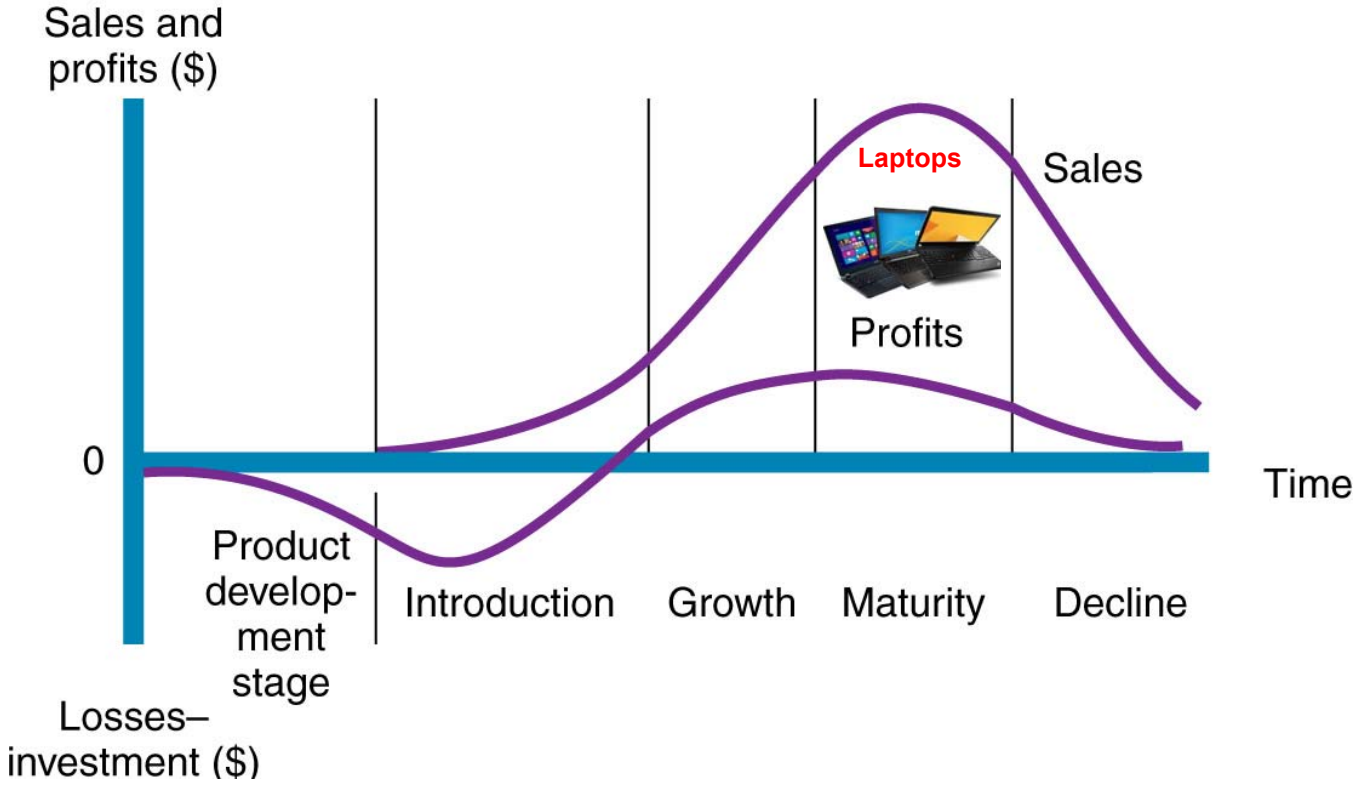


Product Life Cycle - Stages

- *Product development*
- *Introduction*
- *Growth*
- ***Maturity***
- *Decline*

- **Sales peak**
- **Low cost per customer**
- **High profits**
- **Middle majority are targeted**
- **Competition begins to decline**

Sales & Profits Over a Product's Life

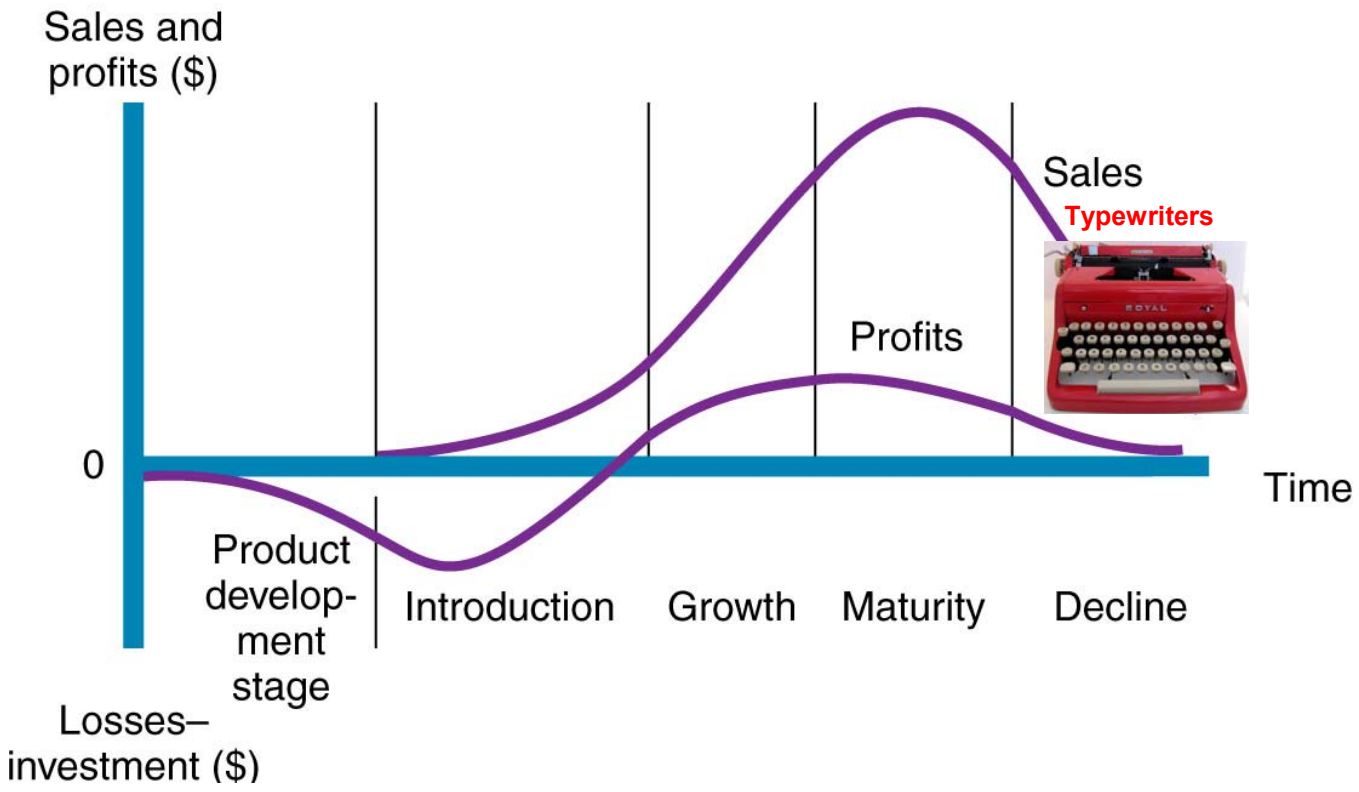


Product Life Cycle - Stages

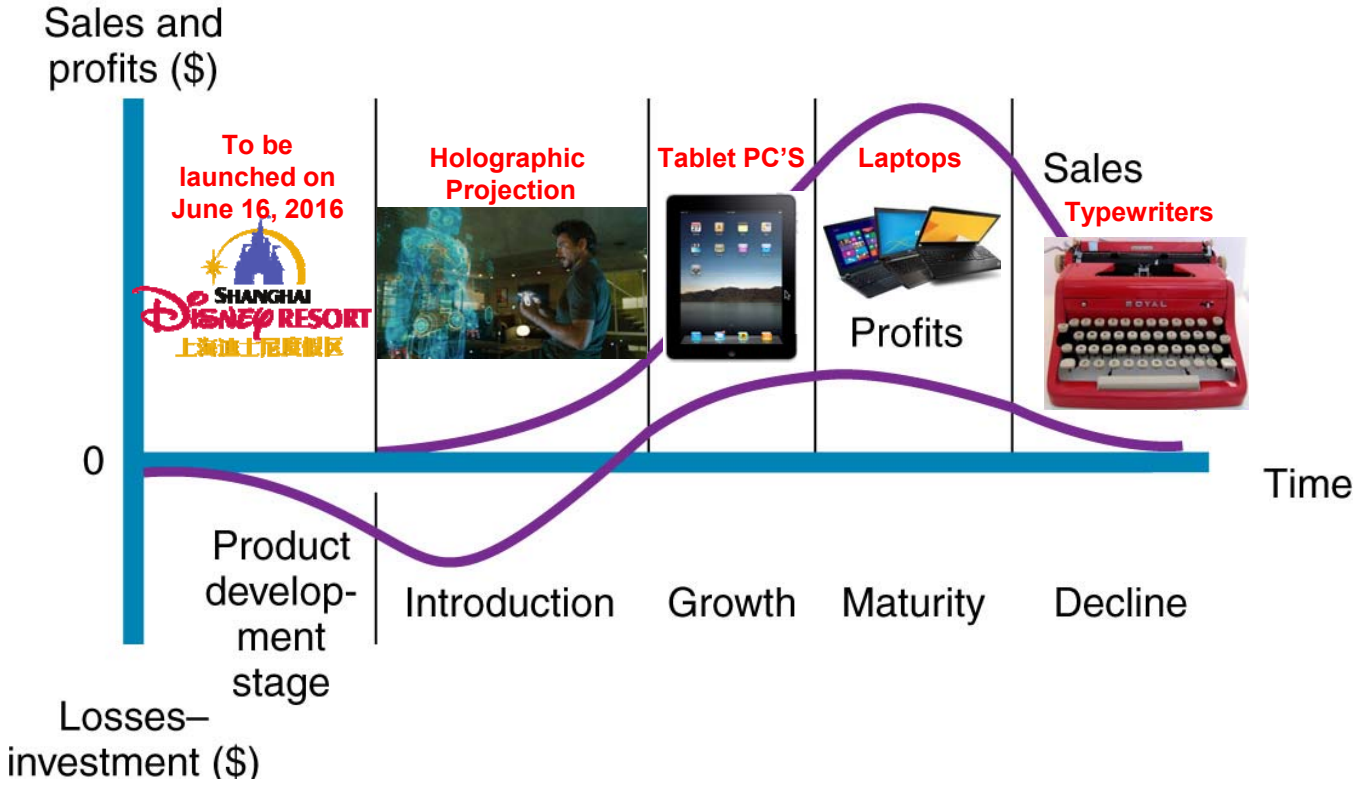
- *Product development*
- *Introduction*
- *Growth*
- *Maturity*
- ***Decline***

- **Declining sales**
- **Low cost per customer**
- **Declining profits**
- **Laggards are targeted**
- **Declining competition**

Sales & Profits Over a Product's Life



Sales & Profits Over a Product's Life



Influence of Product Life Cycle

Introduction – Growth – Maturity – Decline

- **Introduction and growth require longer forecasts than maturity and decline**
- **As product passes through life cycle, forecasts are useful in projecting**
  - **Staffing levels**
  - **Inventory levels**
  - **Factory capacity**

Product Life Cycle

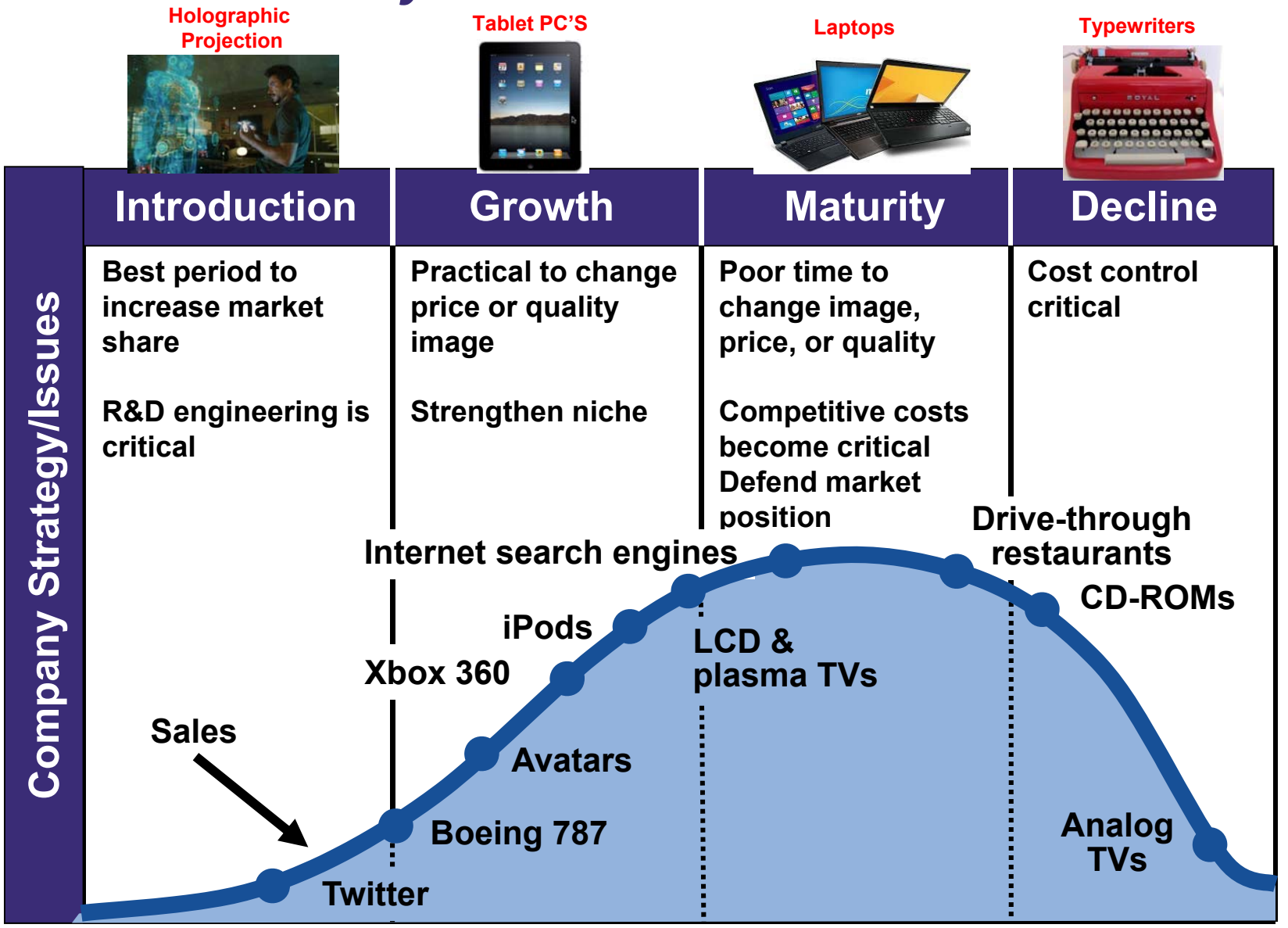


Figure 2.5

Product Life Cycle…Contd.

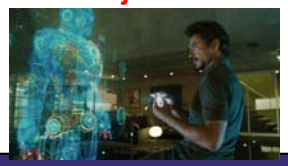
	Introduction	Growth	Maturity	Decline
	Holographic Projection 	Tablet PC'S 	Laptops 	Typewriters 
OM Strategy/Issues	Product design and development critical Frequent product and process design changes Short production runs High production costs Limited models Attention to quality	Forecasting critical Product and process reliability Competitive product improvements and options Increase capacity Shift toward product focus Enhance distribution	Standardization Fewer product changes, more minor changes Optimum capacity Increasing stability of process Long production runs Product improvement and cost cutting	Little product differentiation Cost minimization Overcapacity in the industry Prune line to eliminate items not returning good margin Reduce capacity

Figure 2.5

Types of Forecasts

- Economic forecasts
  - Address business cycle – inflation rate, money supply, housing starts, etc.
- Technological forecasts
  - Predict rate of technological progress
  - Impacts development of new products
- Demand forecasts
  - Predict sales of existing products and services

Strategic Importance of Forecasting

- **Human Resources – Hiring, training, laying off workers**
- **Capacity – Capacity shortages can result in undependable delivery, loss of customers, loss of market share**
- **Supply Chain Management – Good supplier relations and price advantages**

Seven Steps in Forecasting

1. Determine the use of the forecast
2. Select the items to be forecasted
3. Determine the time horizon of the forecast
4. Select the forecasting model(s)
5. Gather the data
6. Make the forecast
7. Validate and implement results

The Realities!

- **Forecasts are seldom perfect**
- **Most techniques assume an underlying stability in the system**
- **Product family and aggregated forecasts are more accurate than individual product forecasts**

Forecasting Approaches

Qualitative Methods

- Used when situation is vague and little data exist
  - New products
  - New technology
- Involves intuition, experience
  - e.g., forecasting sales on Internet

Forecasting Approaches

Quantitative Methods

- Used when situation is 'stable' and historical data exist
  - Existing products
  - Current technology
- Involves mathematical techniques
  - e.g., forecasting sales of color televisions

Overview of Qualitative Methods

1. **Jury of executive opinion**
   - **Pool opinions of high-level experts, sometimes augment by statistical models**
2. **Delphi method**
   - **Panel of experts, queried iteratively**

Overview of Qualitative Methods

3. **Sales force composite**
   - **Estimates from individual salespersons are reviewed for reasonableness, then aggregated**
4. **Consumer Market Survey**
   - **Ask the customer**

Overview of Qualitative Methods – In Detail

Jury of Executive Opinion

- Involves small group of high-level experts and managers
- Group estimates demand by working together
- Combines managerial experience with statistical models
- Relatively quick
- 'Group-think' disadvantage

Sales Force Composite

- Each salesperson projects his or her sales
- Combined at district and national levels
- Sales reps know customers' wants
- Tends to be overly optimistic

Delphi Method

- Iterative group process, continues until consensus is reached
- 3 types of participants
  - Decision makers
  - Staff
  - Respondents

Consumer Market Survey

- Ask customers about purchasing plans
- What consumers say, and what they actually do are often different
- Sometimes difficult to answer

Overview of Quantitative Approaches

1. Naive approach
2. Moving averages
3. Exponential smoothing
4. Trend projection

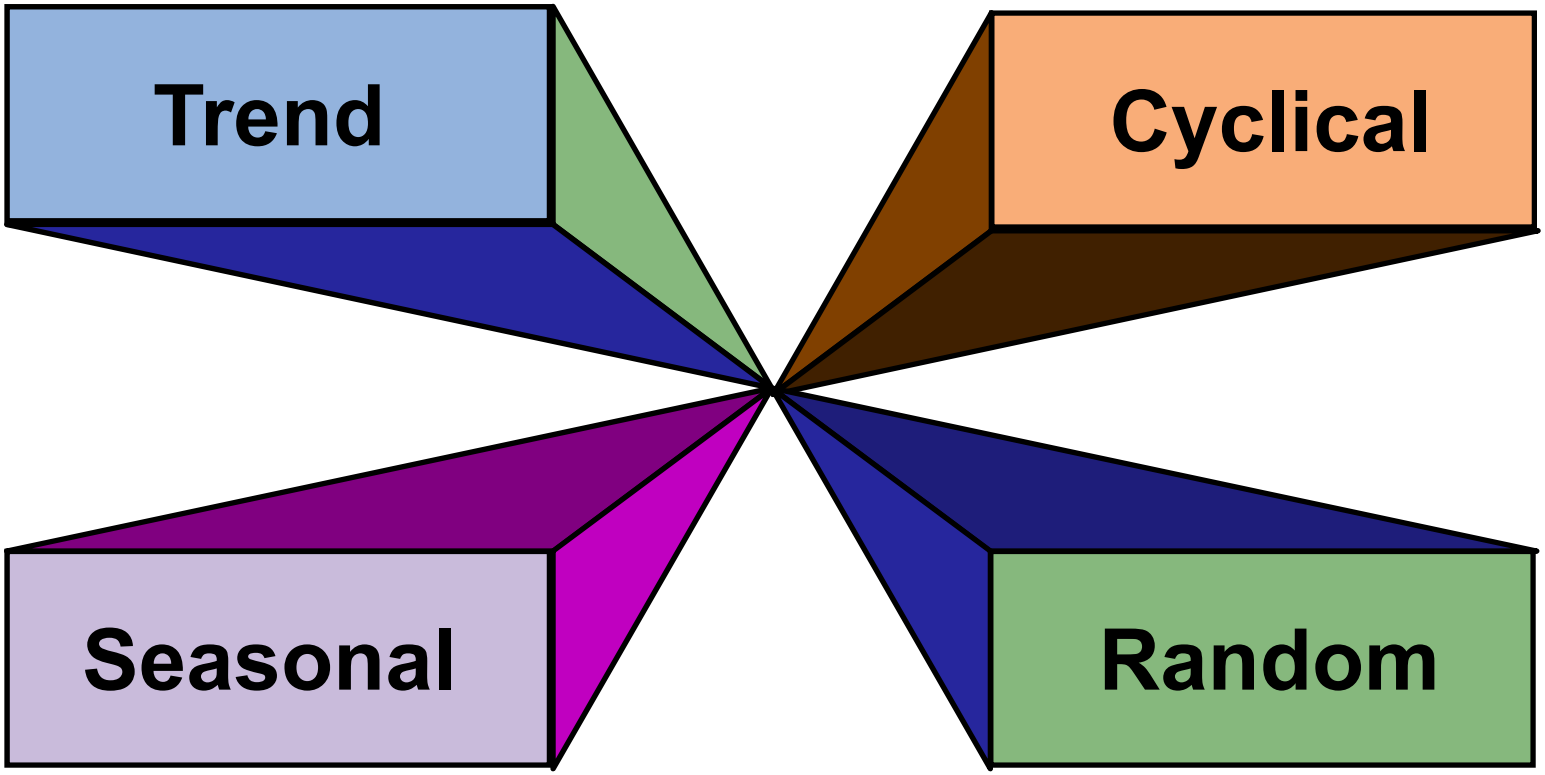
} time-series models

5. Linear regression } associative model

Time Series Forecasting

- **Set of evenly spaced numerical data**
  - **Obtained by observing response variable at regular time periods**
- **Forecast based only on past values, no other variables important**
  - **Assumes that factors influencing past and present will continue influence in future**

Time Series Components



Components of Demand

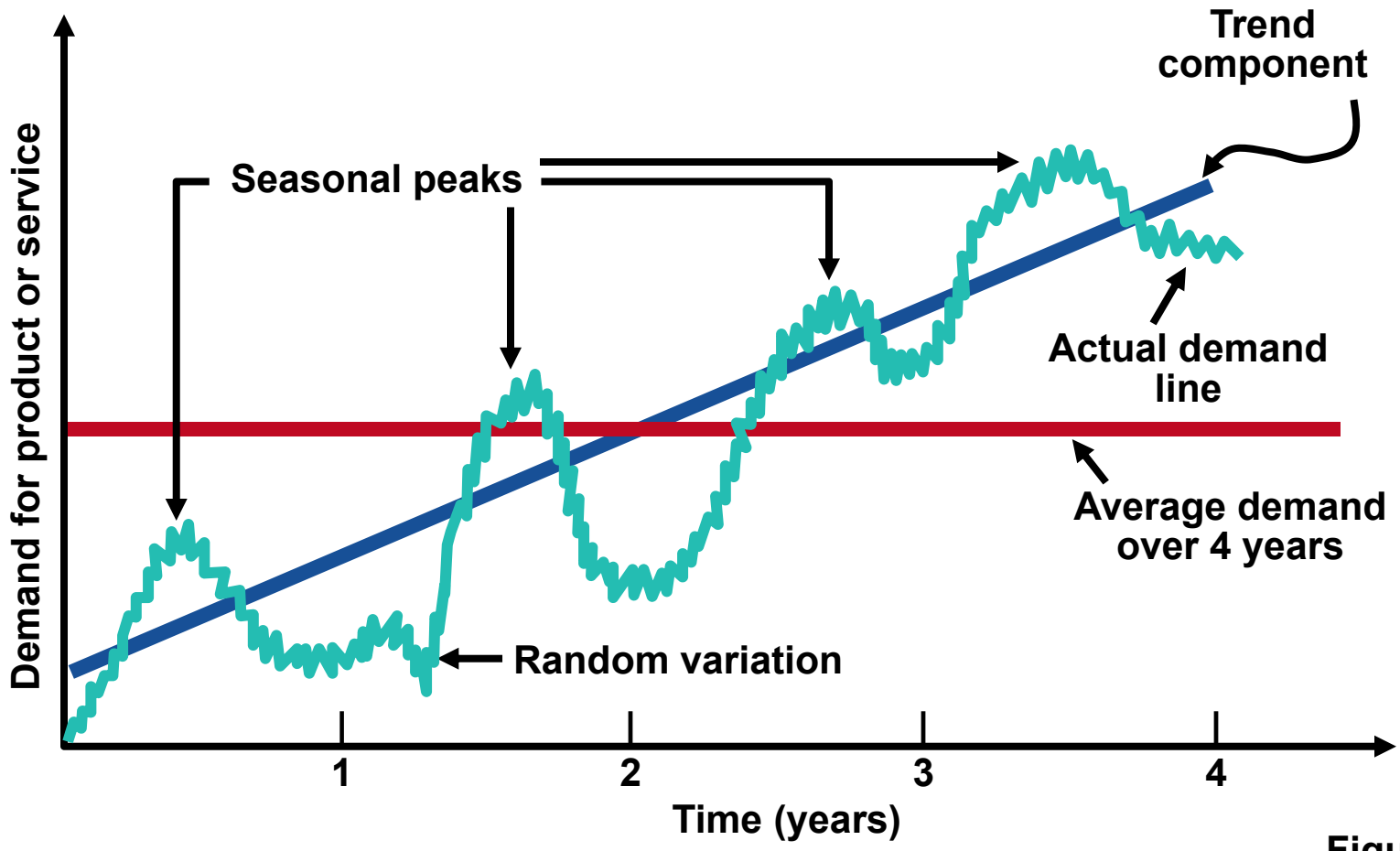
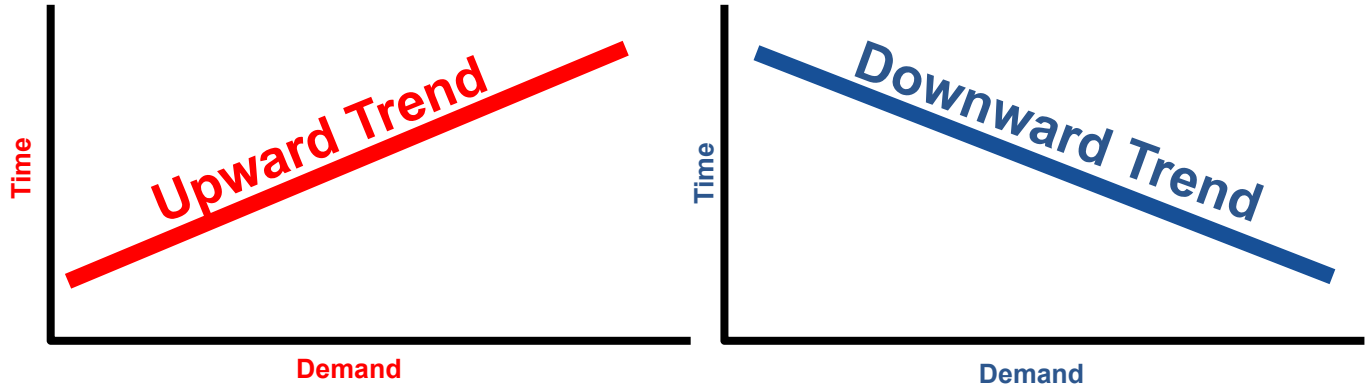


Figure 4.1

Trend Component

- **Persistent, overall upward or downward pattern**
- **Changes due to population, technology, age, culture, consumers demands etc. over a period of time**
- **Typically several years duration**



Seasonal Component

- Regular pattern of up and down fluctuations
- Due to weather conditions, customs of the people, etc.
- Occurs within a single year

Period	Length	Number of Seasons
Week	Day	7
Month	Week	4-4.5
Month	Day	28-31
Year	Quarter	4
Year	Month	12
Year	Week	52

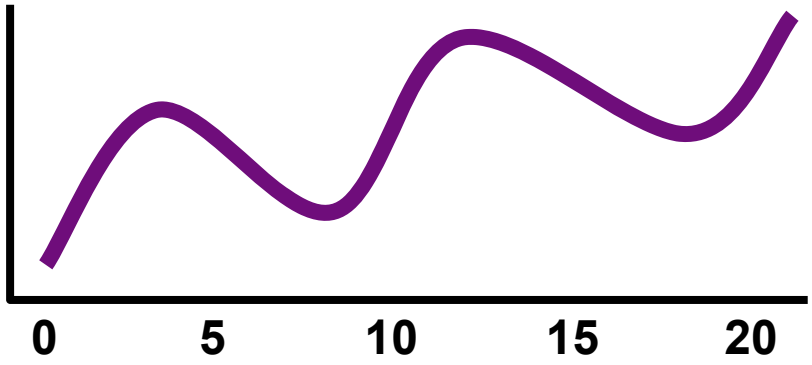
Seasonal Component Examples

- More woolen clothes are sold in winter than in the summer season
- More ice creams are sold in summer and very little in Winter season
- The sales in the departmental stores are more during festive seasons than in the normal days

Cyclical Component

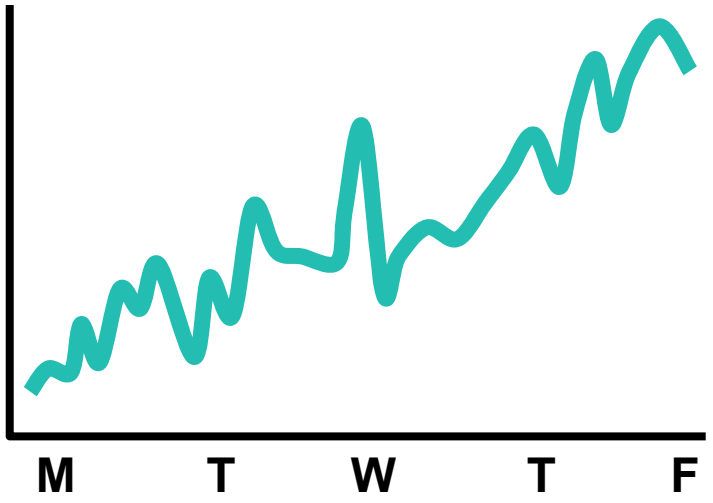
- Repeating up and down movements
- Affected by business cycle, political, and economic factors
- Multiple years duration or several years duration
- Often causal (cause based) or associative relationships.

e.g. The ups and downs in business activities are the effects of cyclical variation

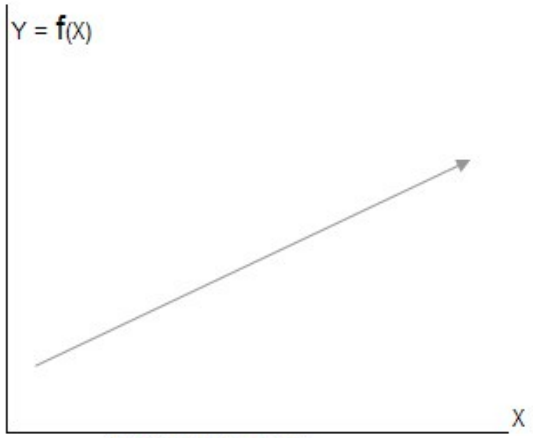


Random Component

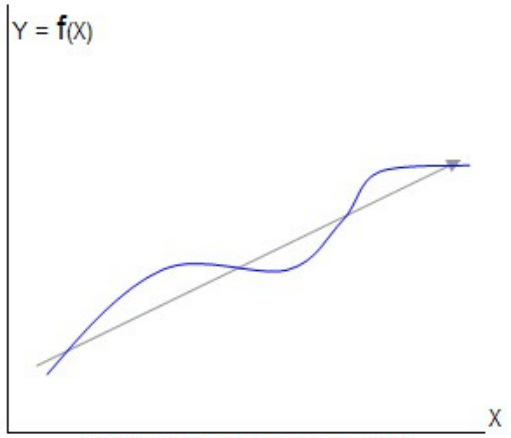
- **Short in duration and nonrepeating, Erratic, unsystematic, no regularity in the occurrence, 'residual' fluctuations**
- **Due to random variation or unforeseen events**
- **Short duration Results due to the occurrence of unforeseen events like floods, earthquakes, wars, famines, etc.**



Components of Demand

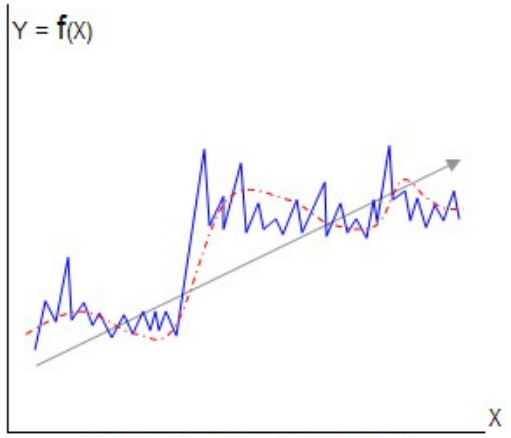


(1) Long-term Trend



(2) Long-term Trend with Cyclical Variations/Movements

(3) Long-term Trend with Cyclical and Seasonal Variations/Movements



(4) Long-term Trend with Cyclical, Seasonal, and Random Variations/Movements

Forecasting Part 1 Rapid Review

- ✓ What is Forecasting?
- ✓ Case Study - Walt Disney Parks & Resorts
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- ✓ Product Life Cycle - Overview
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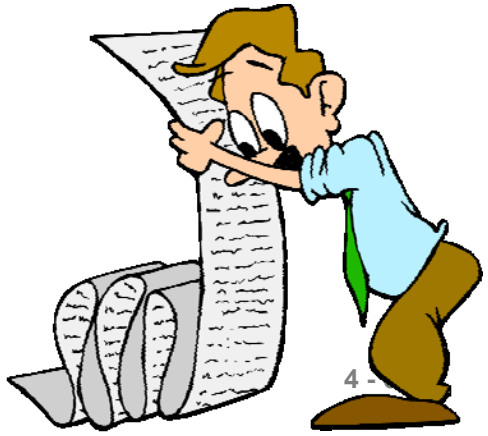
Outline – Part 2

- Naive Approach
- Moving Average Method
- Weighted Moving Average
- Exponential Smoothing
- Trend Projection
- Least Squares Method
- Associative Forecasting
- Adaptive Forecasting
- Focus Forecasting



Naive Approach

- Assumes demand in next period is the same as demand in most recent period
  - e.g., If January sales were 68, then February sales will be 68
- Sometimes cost effective and efficient
- Can be good starting point

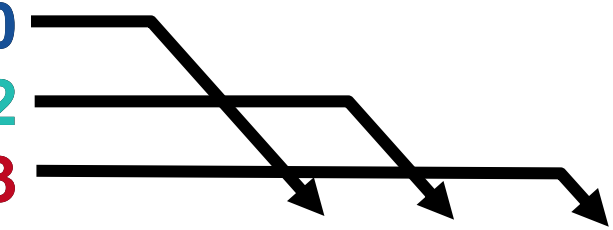
Moving Average Method

- MA is a series of arithmetic means
- Used if little or no trend
- Used often for smoothing
  - Provides overall impression of data over time

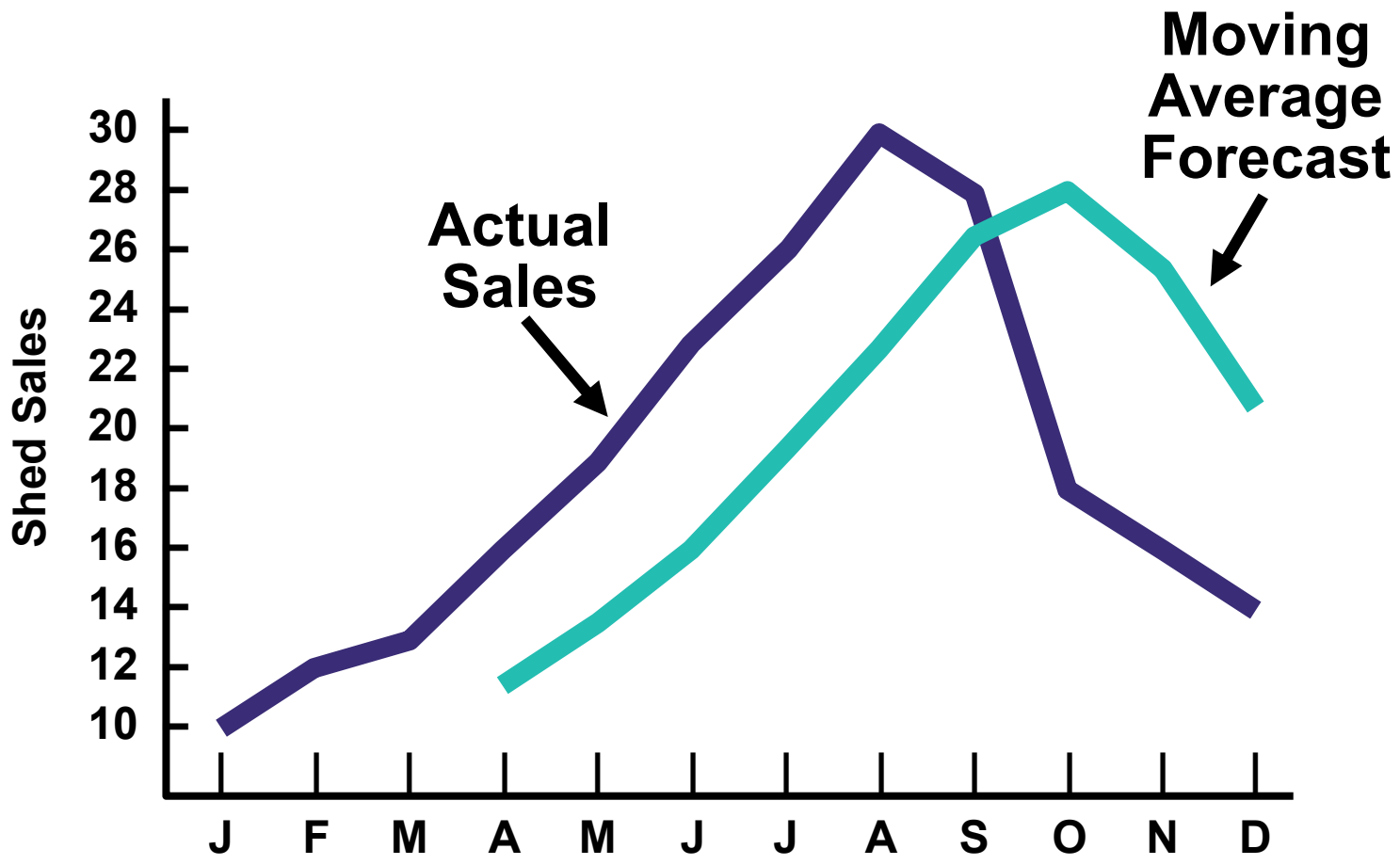
$$\text{Moving average} = \frac{\sum \text{demand in previous } n \text{ periods}}{n}$$

Moving Average Example

Month	Actual Shed Sales	3-Month Moving Average
January	10	
February	12	
March	13	
April	16	(10 + 12 + 13)/3 = 11 $^{2}/_{3}$
May	19	(12 + 13 + 16)/3 = 13 $^{2}/_{3}$
June	23	(13 + 16 + 19)/3 = 16
July	26	(16 + 19 + 23)/3 = 19 $^{1}/_{3}$



Graph of Moving Average



Weighted Moving Average

- Used when some trend might be present
  - Older data usually less important
- Weights based on experience and intuition

$$\text{Weighted moving average} = \frac{\sum (\text{weight for period } n) \times (\text{demand in period } n)}{\sum \text{weights}}$$

Weigh

Weights Applied	Period
3	Last month
2	Two months ago
1	Three months ago
6	Sum of weights

Month	Actual Shed Sales	3-Month Weighted Moving Average
January	10	
February	12	
March	13	
April	16	[(3 x 13) + (2 x 12) + (10)]/6 = $12^1/_6$
May	19	[(3 x 16) + (2 x 13) + (12)]/6 = $14^1/_3$
June	23	[(3 x 19) + (2 x 16) + (13)]/6 = 17
July	26	[(3 x 23) + (2 x 19) + (16)]/6 = $20^1/_2$

Potential Problems With Moving Average

- **Increasing *n* smooths the forecast but makes it less sensitive to changes**
- **Do not forecast trends well**
- **Require extensive historical data**

Moving Average And Weighted Moving Average

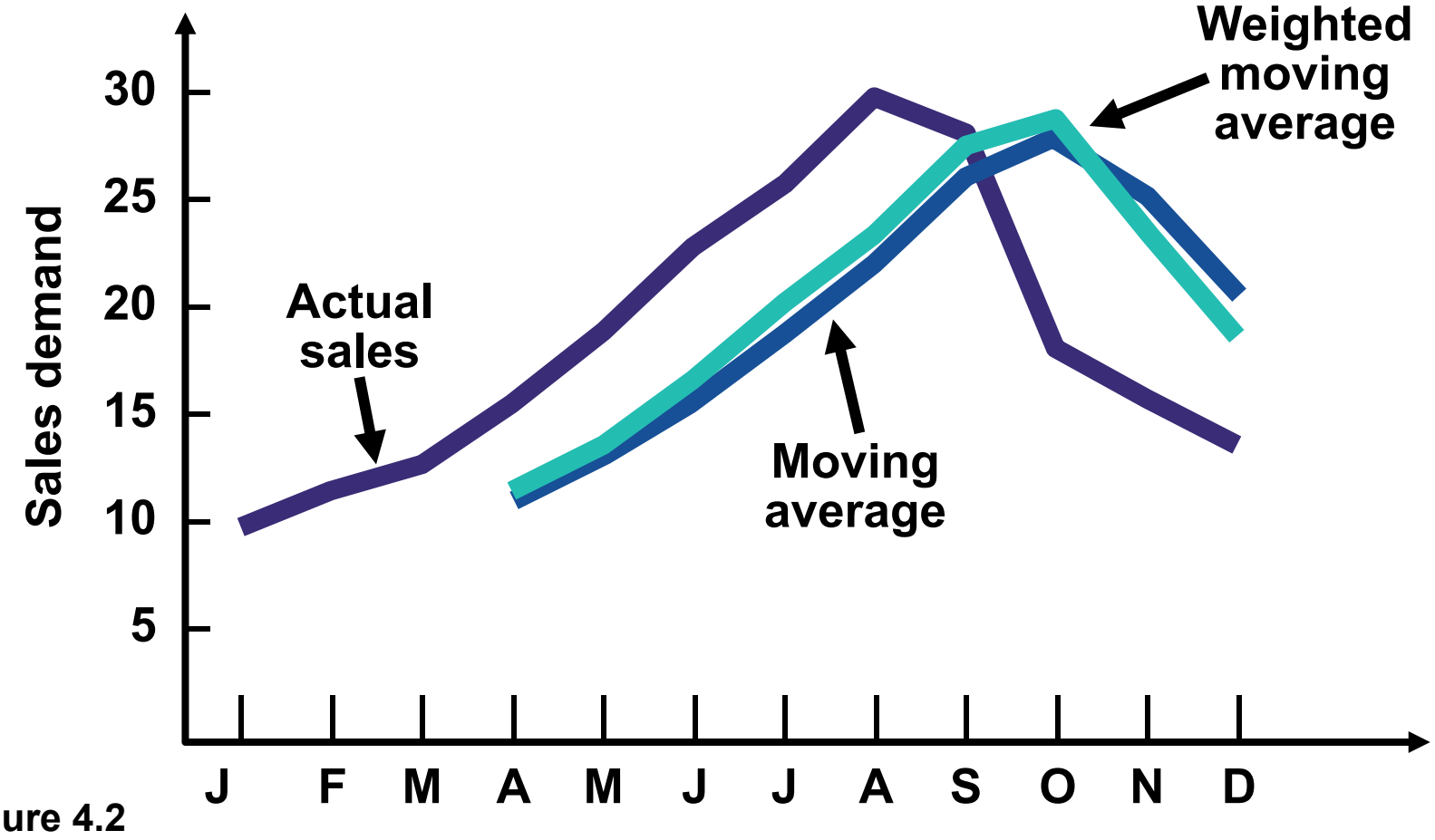


Figure 4.2

Exponential Smoothing

- Form of weighted moving average
  - Weights decline exponentially
  - Most recent data weighted most
    (if we have to find 3 months weighted moving average, it will be 3)
- Requires smoothing constant (α)
  - Ranges from 0 to 1
  - Subjectively chosen
- Involves little record keeping of past data

Exponential Smoothing

New forecast = Last period's forecast
+ α (Last period's actual demand
– Last period's forecast)

$$F_t = F_{t-1} + \alpha(A_{t-1} - F_{t-1})$$

where

F_t = **new forecast**

F_{t-1} = **previous forecast**

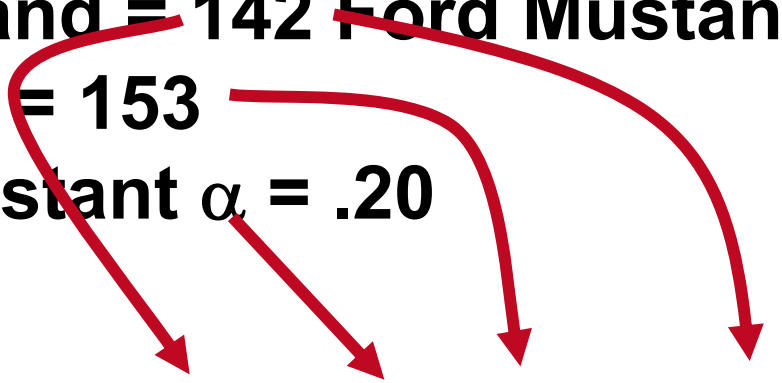
α = **smoothing (or weighting) constant ($0 \leq \alpha \leq 1$)**

Exponential Smoothing Example

Predicted demand = 142 Ford Mustangs
Actual demand = 153
Smoothing constant α = .20

Exponential Smoothing Example

Predicted demand = 142 Ford Mustangs
Actual demand = 153
Smoothing constant α = .20



New forecast = 142 + .2(153 – 142)

Exponential Smoothing Example

Predicted demand = 142 Ford Mustangs
Actual demand = 153
Smoothing constant α = .20

$$\text{New forecast} = 142 + .2(153 - 142)$$
$$= 142 + 2.2$$
$$= 144.2 \approx 144 \text{ cars}$$

Trend Projections

Fitting a trend line to historical data points to project into the medium to long-range

Linear trends can be found using the least squares technique

$$\hat{y} = a + bx$$

where $\hat{y}$ = computed value of the variable to be predicted (dependent variable)

a = y-axis intercept

b = slope of the regression line

x = the independent variable

Least Squares Method

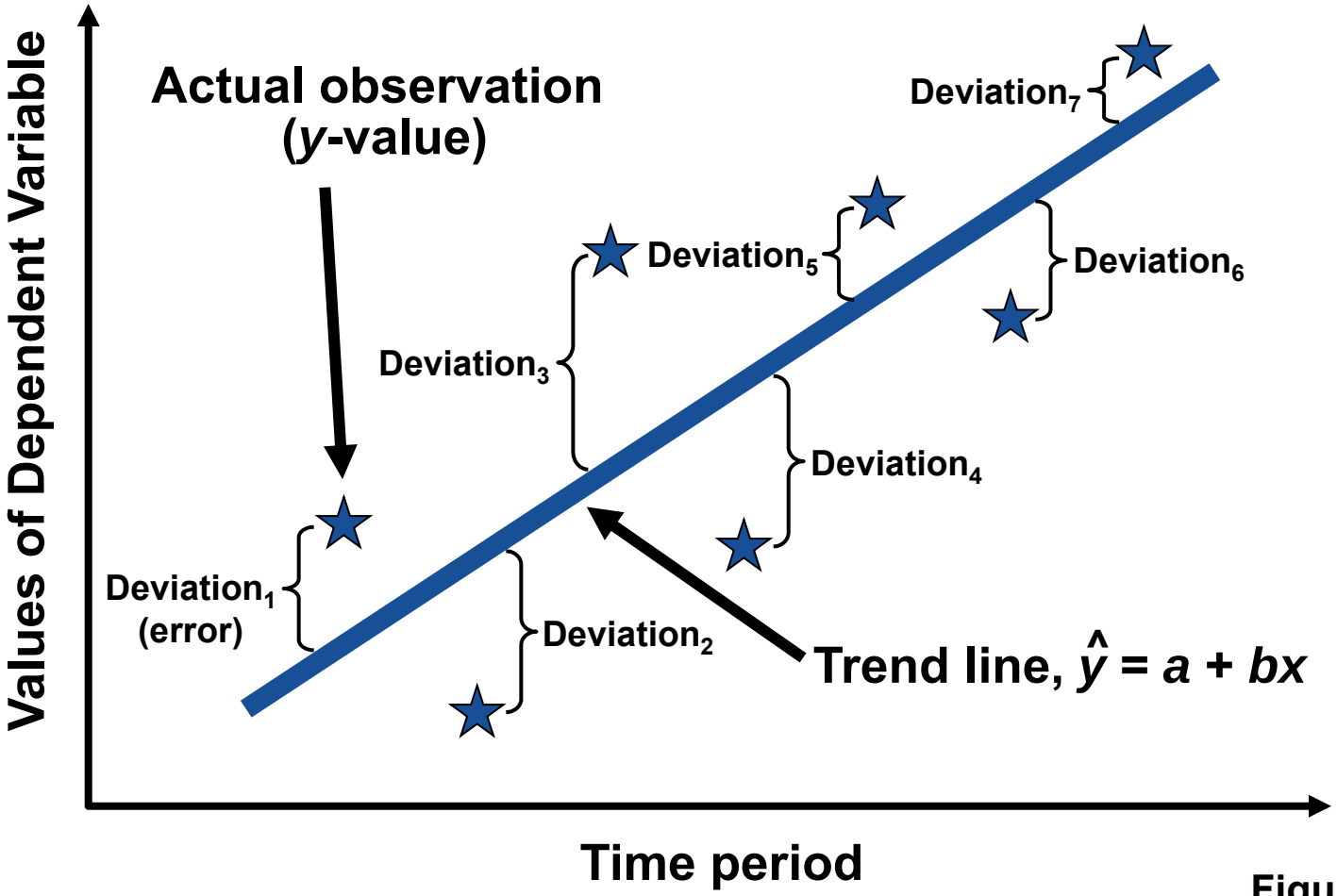


Figure 4.4

Least Squares Method

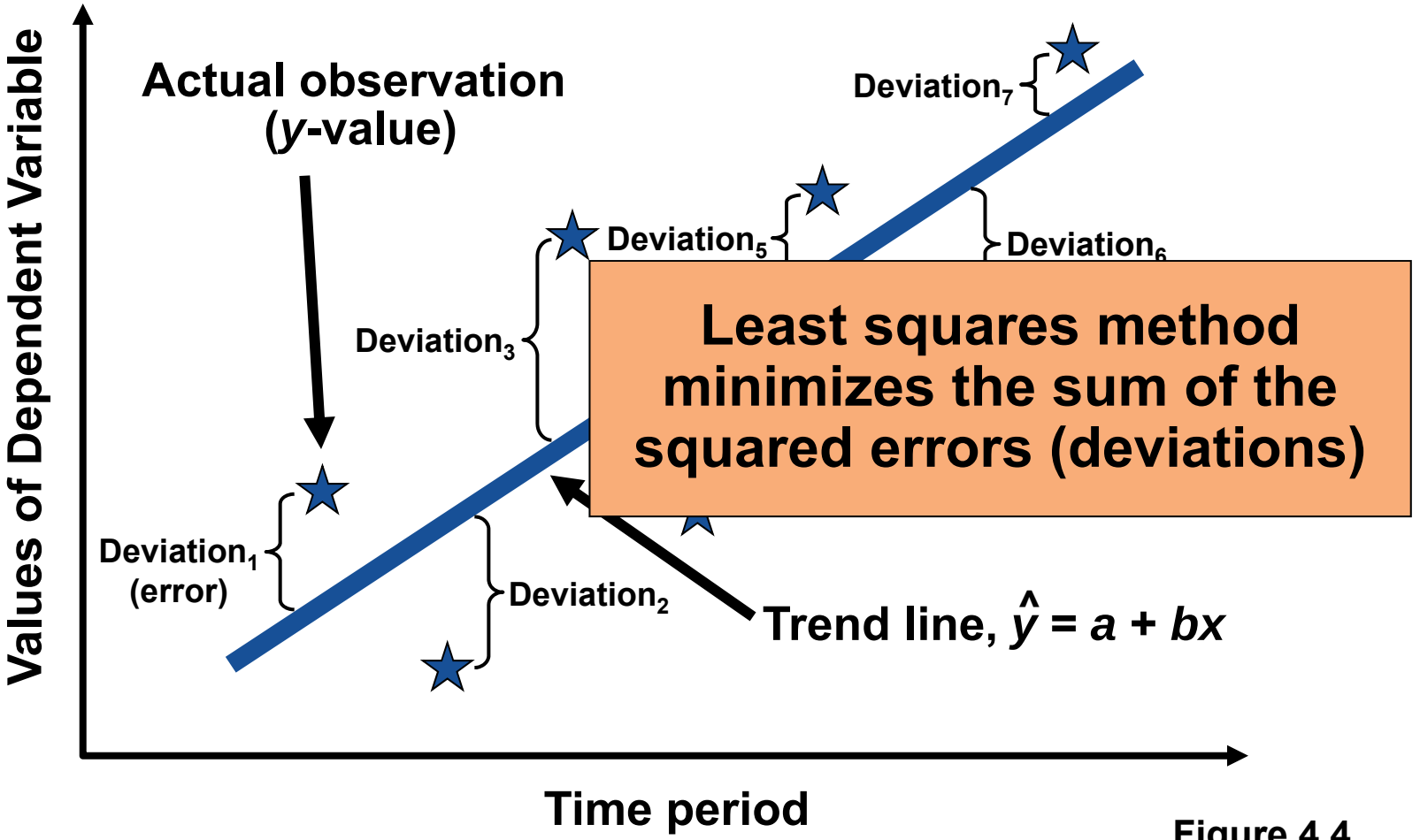


Figure 4.4

Least Squares Method

Equations to calculate the regression variables

$$\hat{y} = a + bx$$

$$b = \frac{\Sigma xy - n\bar{x}\bar{y}}{\Sigma x^2 - n\bar{x}^2}$$

$$a = \bar{y} - b\bar{x}$$

Least Squares Example

Year	Time Period (x)	Electrical Power Demand	x^2	xy
2003	1	74	1	74
2004	2	79	4	158
2005	3	80	9	240
2006	4	90	16	360
2007	5	105	25	525
2008	6	142	36	852
2009	7	122	49	854
	$\sum x = 28$	$\sum y = 692$	$\sum x^2 = 140$	$\sum xy = 3{,}063$
	$\bar{x} = 4$	$\bar{y} = 98.86$		

$$b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum x^2 - n\bar{x}^2} = \frac{3{,}063 - (7)(4)(98.86)}{140 - (7)(4^2)} = 10.54$$

$$a = \bar{y} - b\bar{x} = 98.86 - 10.54(4) = 56.70$$

Least Squares Example

Year	Time Period (x)	Electrical Power Demand	x^2	xy
2003	1	74	1	74
2004	2	79	4	158
2005	3	80	9	240
2006	4	90	16	360
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2009	7	122	49	854
	$\sum x = 28$	$\sum y = 692$	$\sum x^2 = 140$	$\sum xy = 3{,}063$
	$\bar{x} = 4$	$\bar{y} = 98.86$		

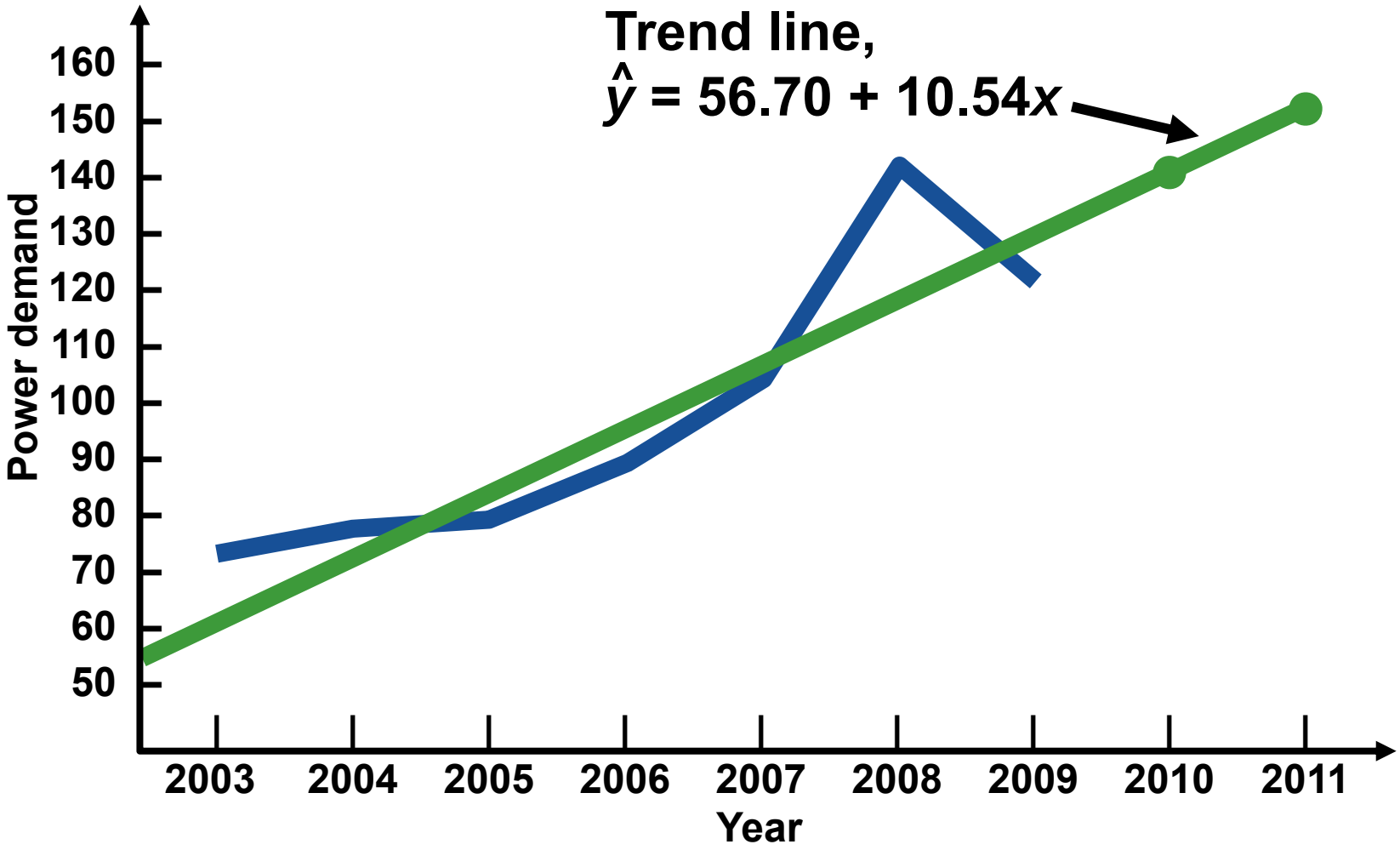
The trend line is

$$\hat{y} = 56.70 + 10.54x$$

$$b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum x^2 - n\bar{x}^2} = \frac{3{,}063 - (7)(4)(98.86)}{140 - (7)(4^2)} = 10.54$$

$$a = \bar{y} - b\bar{x} = 98.86 - 10.54(4) = 56.70$$

Least Squares Example



Least Squares Requirements

1. We always plot the data to insure a linear relationship
2. We do not predict time periods far beyond the database
3. Deviations around the least squares line are assumed to be random

Associative Forecasting

Used when changes in one or more independent variables can be used to predict the changes in the dependent variable

Most common technique is linear regression analysis

We apply this technique just as we did in the time series example

Associative Forecasting

Forecasting an outcome based on predictor variables using the least squares technique

$$\hat{y} = a + bx$$

where $\hat{y}$ = computed value of the variable to be predicted (dependent variable)

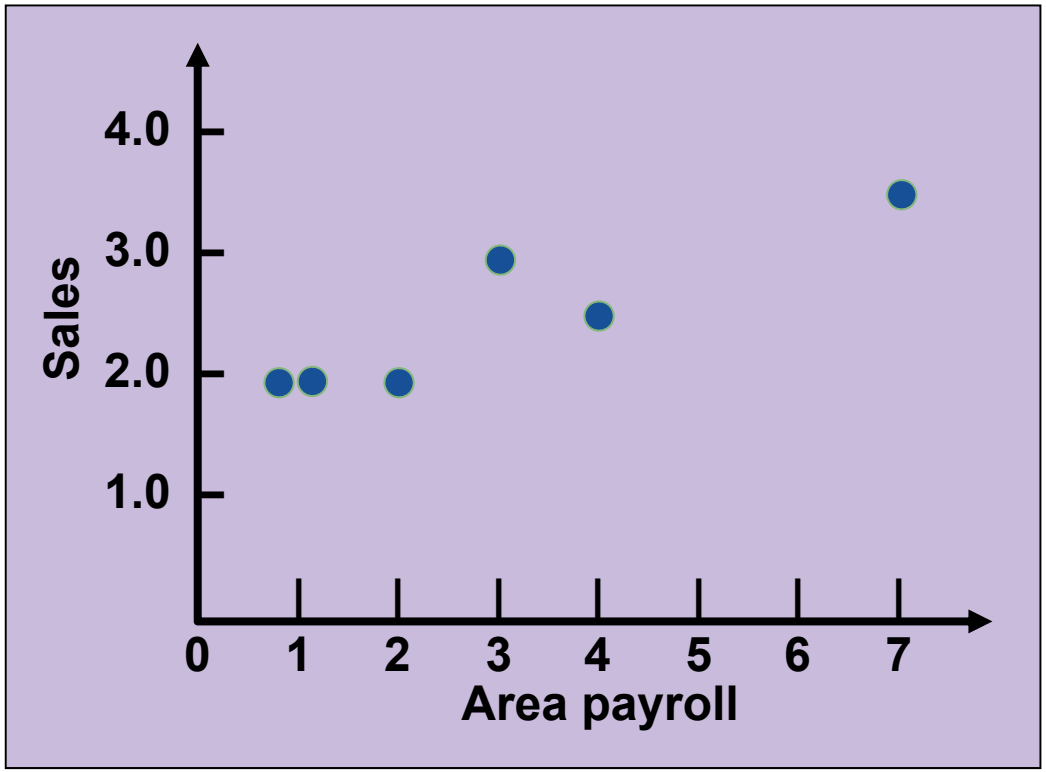
a = y-axis intercept

b = slope of the regression line

x = the independent variable though to predict the value of the dependent variable

Associative Forecasting Example

Sales ($ millions), y	Area Payroll ($ billions), x
2.0	1
3.0	3
2.5	4
2.0	2
2.0	1
3.5	7



Associative Forecasting Example

Sales, y	Payroll, x	x^2	xy
2.0	1	1	2.0
3.0	3	9	9.0
2.5	4	16	10.0
2.0	2	4	4.0
2.0	1	1	2.0
3.5	7	49	24.5
$\sum y = 15.0$	$\sum x = 18$	$\sum x^2 = 80$	$\sum xy = 51.5$

$$\bar{x} = \sum x/6 = 18/6 = 3 \qquad b = \frac{\sum xy - n\bar{x}\bar{y}}{\sum x^2 - n\bar{x}^2} = \frac{51.5 - (6)(3)(2.5)}{80 - (6)(3^2)} = .25$$

$$\bar{y} = \sum y/6 = 15/6 = 2.5 \qquad a = \bar{y} - b\bar{x} = 2.5 - (.25)(3) = 1.75$$

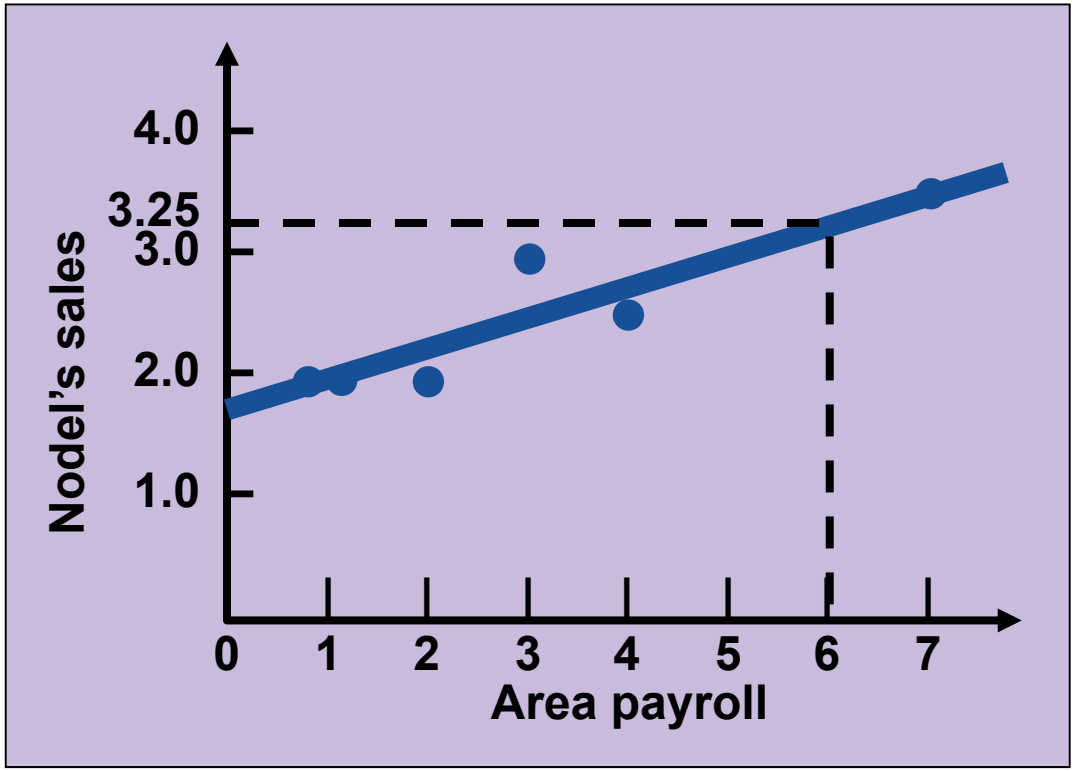
Associative Forecasting Example

$\hat{y} = 1.75 + .25x$ Sales = 1.75 + .25(payroll)

If payroll next year is estimated to be $6 billion, then:

Sales = 1.75 + .25(6)

Sales = $3,250,000



Correlation

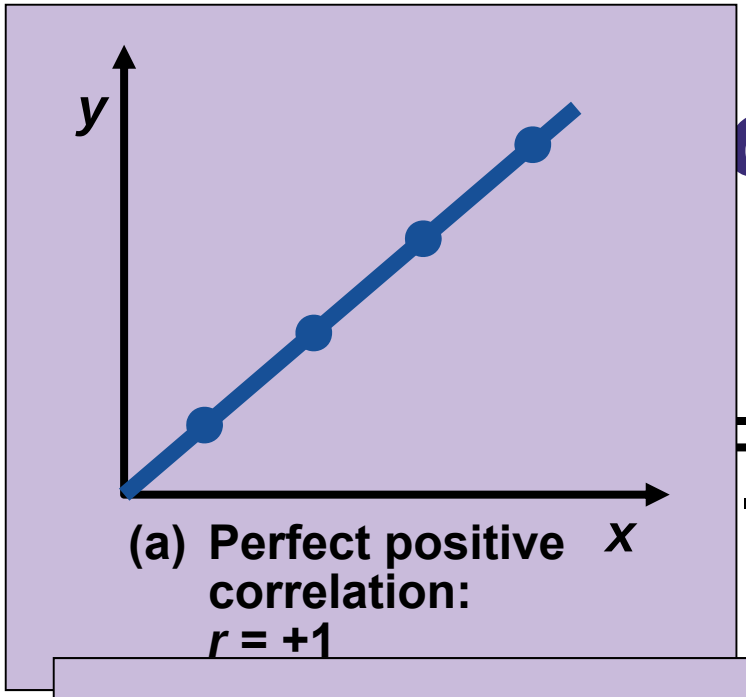
- How strong is the linear relationship between the variables?
- Correlation does not necessarily imply causality!
- Coefficient of correlation, *r*, measures degree of association
  - Values range from -1 to +1

Correlation Coefficient

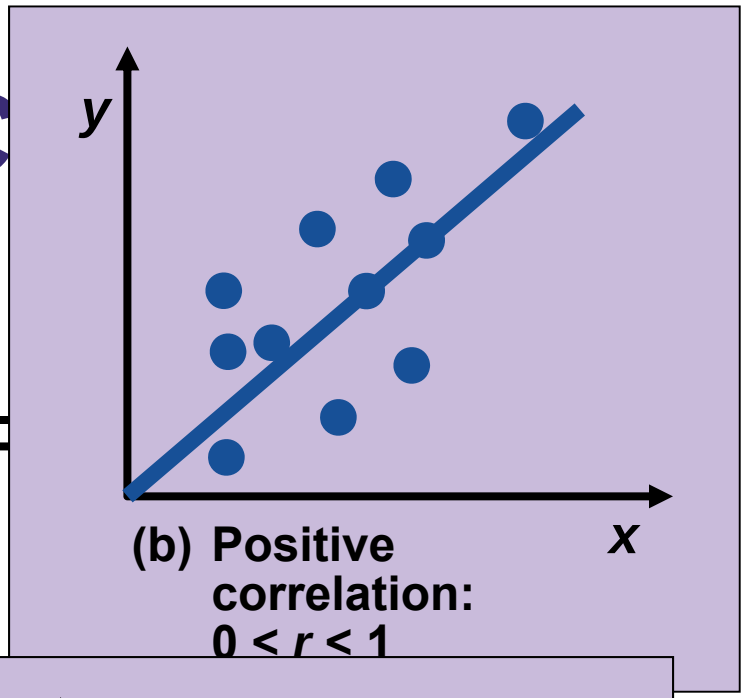
$$r = \frac{n\Sigma xy - \Sigma x \Sigma y}{\sqrt{[n\Sigma x^2 - (\Sigma x)^2][n\Sigma y^2 - (\Sigma y)^2]}}$$

on C

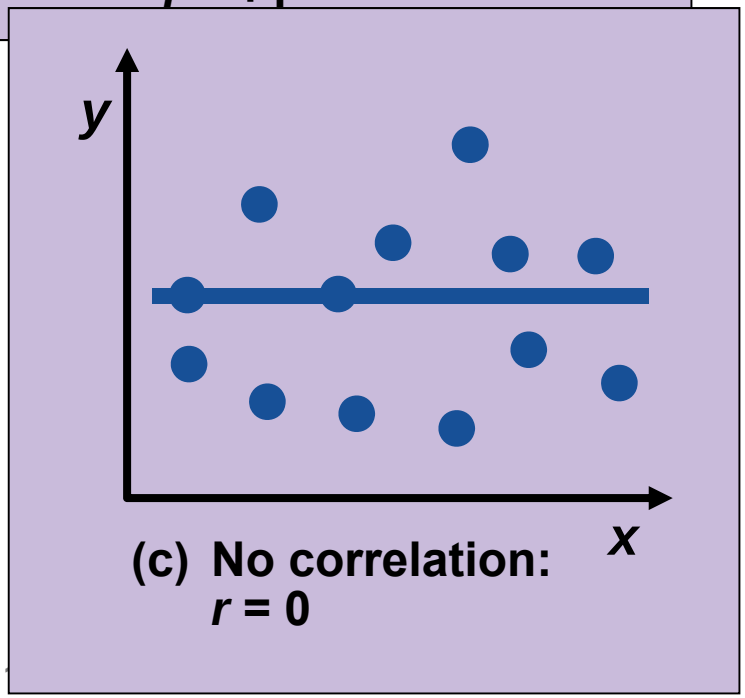
$$\frac{n\Sigma xy - }{- (\Sigma x)^2]}$$



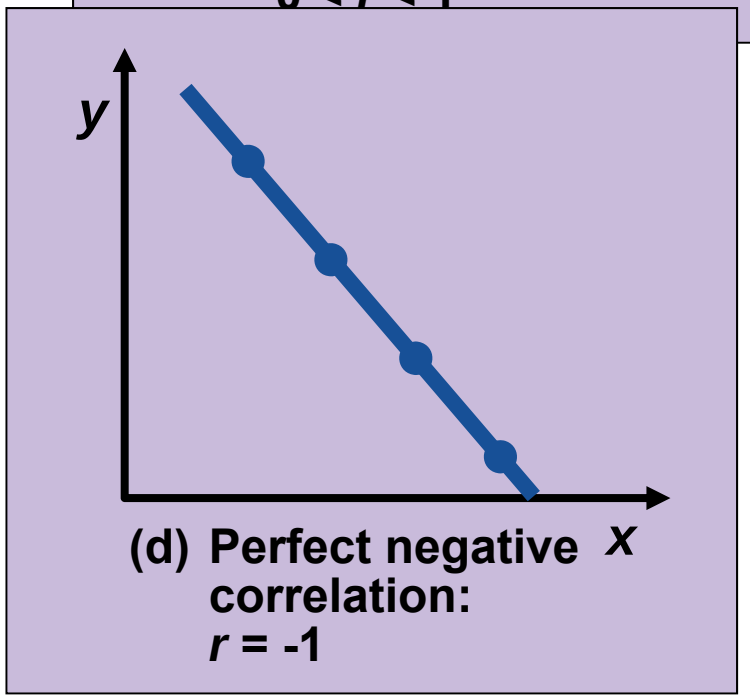
(a) Perfect positive correlation: $r = +1$



(b) Positive correlation: $0 < r < 1$



(c) No correlation: $r = 0$



(d) Perfect negative correlation: $r = -1$

Correlation

- **Coefficient of Determination, r^2, measures the percent of change in *y* predicted by the change in *x***
  - **Values range from 0 to 1**
  - **Easy to interpret**

For the Nodel Construction example:

$$r = .901$$

$$r^2 = .81$$

Adaptive Forecasting

- It's possible to use the computer to continually monitor forecast error and adjust the values of the α and β coefficients used in exponential smoothing to continually minimize forecast error
- This technique is called adaptive smoothing

Focus Forecasting

- **Developed at American Hardware Supply, based on two principles:**
  1. **Sophisticated forecasting models are not always better than simple ones**
  2. **There is no single technique that should be used for all products or services**
- **This approach uses historical data to test multiple forecasting models for individual items**
- **The forecasting model with the lowest error is then used to forecast the next demand**

Forecasting in the Service Sector

- **Presents unusual challenges**
  - **Special need for short term records**
  - **Needs differ greatly as function of industry and product**
  - **Holidays and other calendar events**
  - **Unusual events**

Fast Food Restaurant Forecast

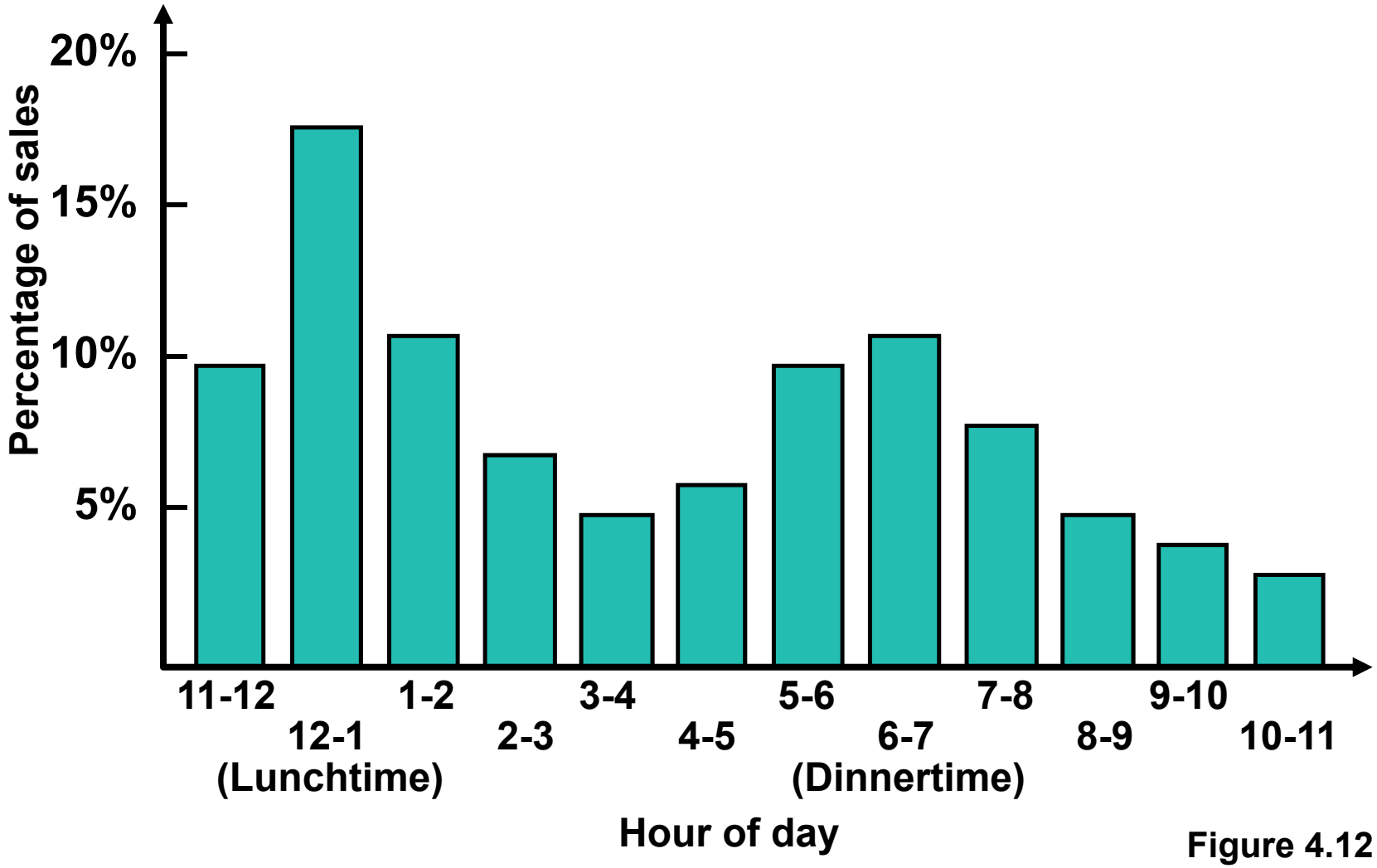


Figure 4.12

FedEx Call Center Forecast

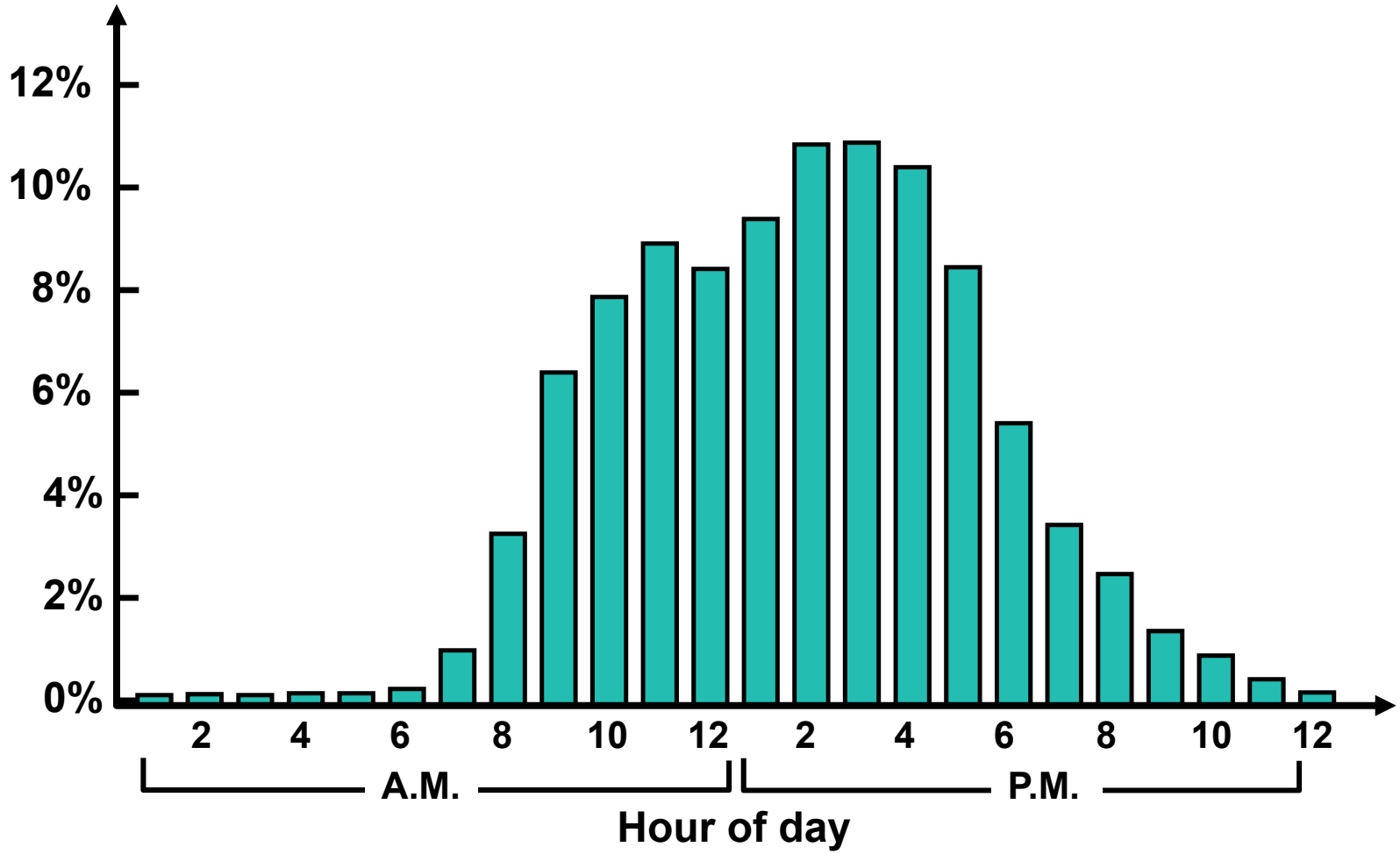


Figure 4.12