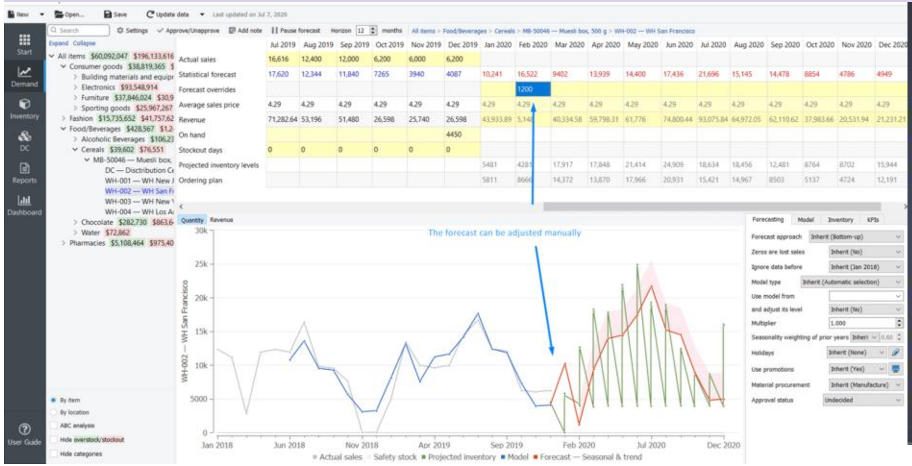
Chapter 4

Forecasting



Learning Objectives

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

1. **Explain** forecasting, the three time horizons and types of forecasts
2. **Explain** when to use each of the four qualitative models
3. **Apply** the naive, moving average, exponential smoothing, and trend methods
4. **Compute** three measures of forecast accuracy

- Disney generates daily, weekly, monthly, annual, and 5-year forecasts
- Forecast used by labor management, maintenance, operations, finance, and park scheduling
- Forecast used to adjust opening times, rides, shows, staffing levels, and guests admitted
- Use judgmental, economic models, moving-averages model, regression analysis

CHAPTER 4

GLOBAL COMPANY PROFILE
Walt Disney Parks & Resorts

Forecasting Provides a Competitive Advantage for Disney

When it comes to the world's most respected global brands, Walt Disney Parks & Resorts is a visible leader. Although the monarch of this magic kingdom is no man but a mouse—Mickey Mouse—it's CEO Robert Iger who daily manages the entertainment giant.

Disney's global portfolio includes Shanghai Disney (2016), Hong Kong Disneyland (2005), Disneyland Paris (1992), and Tokyo Disneyland (1983). But it is Walt Disney World Resort (in Florida) and Disneyland Resort (in California) that drive profits in this $50 billion corporation, which is ranked in the top 100 in both the *Fortune* 500 and *Financial Times* Global 500.

Revenues at Disney are all about people—how many visit the parks and how they spend money while there. When Iger receives a daily report from his four theme parks and two water parks near Orlando, the report contains only two numbers: the *forecast* of yesterday's attendance at the parks (Magic Kingdom, Epcot, Disney's Animal Kingdom, Disney-Hollywood Studios, Typhoon Lagoon, and Blizzard Beach) and the *actual* attendance. An error close to zero is expected. Iger takes his forecasts very seriously.

The forecasting team at Walt Disney World Resort doesn't just do a daily prediction, however, and Iger is not its only customer. The team also provides daily, weekly, monthly, annual, and 5-year forecasts to the labor management, maintenance, operations, finance, and park scheduling departments. Forecasters use judgmental models, econometric models, moving-average models, and regression analysis.

Travelshots/Peter Phipp/Travelshots.com/Alamy

Donald Duck, Goofy, and Mickey Mouse provide the public image of Disney to the world. Forecasts drive the work schedules of 72,000 cast members working at Walt Disney World Resort near Orlando.

Forecasting

What is forecasting?

Art and science of predicting future event

May involve historical data (example past sales) and projecting into the future with a mathematical model

What is the uses of prediction (example future demand)

Basis of all business decisions -

1. **Production Quantity**
2. **Inventory**
3. **Personnel**
4. **Capacity /Facilties**
5. **etc.**

Forecasting Time Horizons

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

Types of Forecasts

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

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 needed to make the forecast
6. Make the forecast
7. Validate and implement results

Forecasting Issues

- Forecast not perfect, unpredictable outside factors may impact the forecast numbers
- Most techniques assume an underlying stability in the system
- Product family and aggregated forecasts are more accurate than individual product forecasts

Forecasting Approaches / Methods

Quantitative methods	Uses **mathematical models** to forecast demand [Data available - past sales, or variables associated]
Qualitative methods	Uses factors such as **intuition, emotions, opinions personal experience and value** system [situation is vague and little information available]

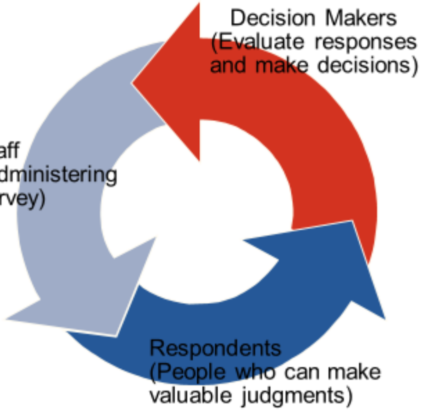
Four Qualitative Methods

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

Delphi Method

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



Four Qualitative Methods

Sales Force Composite

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

Market Survey

- Ask customers about purchasing plans
- Useful for demand and product design and planning
- What consumers say, and what they actually do may be different
- May be overly optimistic

Five Quantitative Methods for Forecasting

ALL USES DATA - Past demand data, or some dependent variables data

Time -series models

Technique that uses a series of past data

1. Naive approach
2. Moving Averages
3. Exponential Smoothing
4. Trend Projection

Associative Models

Incorporates variables that might influence the quantity forecasted

5. Regression Models

Time Series Forecasting

Trend - upward or downward movement

Season - day of week, month, quarter, etc

Cycles - affecting by environment - political, etc

Random - blips in data caused by chance or unknown reasons

Components of Demand

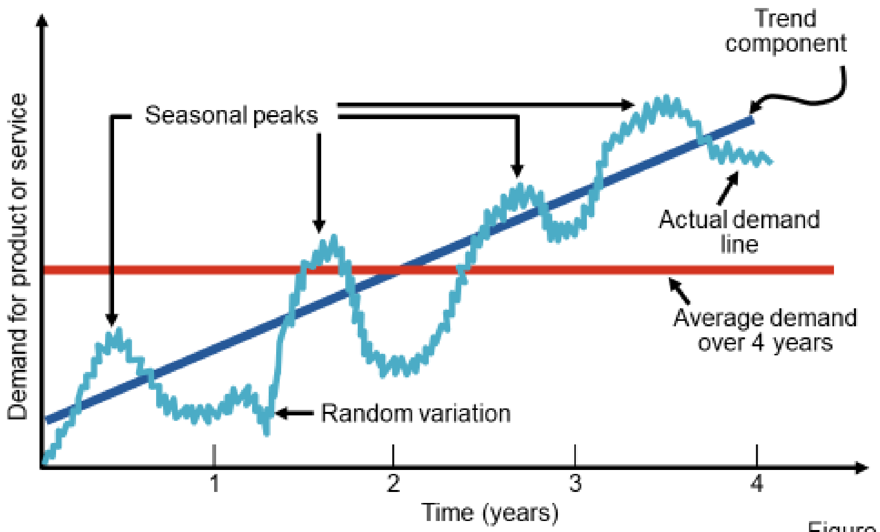


Figure 4.1

Naive Approach

- Techniques that 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

What is the forecast for week 5, 6, 8 ?

Week	Sales (in $1000)	Forecast
1	9	-
2	8	-
3	9	-
4	12	
5	9	
6	12	
7	11	
8	9	

Moving Average Method

A forecasting technique that uses the average of the n most recent periods of data to forecast the next period

Used if little or no trend

Used often for smoothing

Provides overall impression of data over time

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

n = no of periods , example 4, 5, 6, … months

Exercise : Moving Average

Week	**Sales**	**3- Week Moving Average**
1	15	-
2	20	-
3	10	-
4	18	
5	14	

Calculate Forecast value for Week 4 and Week 5

Moving Average Example

Example 1:

Donna's Garden Supply wants a 3-month moving average forecast

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	$(16 + 19 + 23)/3 = 19\,^{1}/_{3}$
August	30	$(19 + 23 + 26)/3 = 22\,^{2}/_{3}$
September	28	$(23 + 26 + 30)/3 = 26\,^{1}/_{3}$
October	18	$(29 + 30 + 28)/3 = 28$
November	16	$(30 + 28 + 18)/3 = 25\,^{1}/_{3}$
December	14	$(28 + 18 + 16)/3 = 20\,^{2}/_{3}$

Question
What is the forecast for next year January?

Weighted Moving Average

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

$$\text{Weighted moving average} = \frac{\sum\left(\left(\text{Weight for period } n\right)\left(\text{Demand in period } n\right)\right)}{\sum \text{Weights}}$$

Assign more weight to recent data

WEIGHTS APPLIED	PERIOD
3	Last month
2	Two months ago
1	Three months ago
6	Sum of the weights

Forecast for this month =

$$\frac{3 \times \text{Sales last mo.} + 2 \times \text{Sales 2 mos. ago} + 1 \times \text{Sales 3 mos. ago}}{\text{Sum of the weights}}$$

SOLUTION ▶ The results of this weighted-average forecast are as follows:

MONTH	ACTUAL SHED SALES	3-MONTH WEIGHTED MOVING AVERAGE
January	10	
February	12	
March	13	
April	16	$[(3 \times 13) + (2 \times 12) + (10)]/6 = 12\frac{1}{6}$
May	19	$[(3 \times 16) + (2 \times 13) + (12)]/6 = 14\frac{1}{3}$
June	23	$[(3 \times 19) + (2 \times 16) + (13)]/6 = 17$
July	26	$[(3 \times 23) + (2 \times 19) + (16)]/6 = 20\frac{1}{2}$
August	30	$[(3 \times 26) + (2 \times 23) + (19)]/6 = 23\frac{5}{6}$
September	28	$[(3 \times 30) + (2 \times 26) + (23)]/6 = 27\frac{1}{2}$
October	18	$[(3 \times 28) + (2 \times 30) + (26)]/6 = 28\frac{1}{3}$
November	16	$[(3 \times 18) + (2 \times 28) + (30)]/6 = 23\frac{1}{3}$
December	14	$[(3 \times 16) + (2 \times 18) + (28)]/6 = 18\frac{2}{3}$

The forecast for January is $15\frac{1}{3}$. Do you see how this number is computed?

INSIGHT ▶ In this particular forecasting situation, you can see that more heavily weighting the latest month provides a more accurate projection.

LEARNING EXERCISE ▶ If the assigned weights were 0.50, 0.33, and 0.17 (instead of 3, 2, and 1), what is the forecast for January's weighted moving average? Why? [Answer: There is no change. These are the same *relative* weights. Note that $\sum$ weights = 1 now, so there is no need for a denominator. When the weights sum to 1, calculations tend to be simpler.]

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 period's forecast
α = smoothing (or weighting) constant ($0 \le \alpha \le 1$)
A_{t-1} = previous period's actual demand

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

New forecast = 142 + .2(153 – 142)
= 142 + 2.2
= 144.2 ≈ 144 cars

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How we know our forecasting model is accurate?

Compare the forecast values with the actual value

Need to calculate forecast error

Forecast error = Actual demand – Forecast value

$$= A_t - F_t$$

Common Measures of Forecasting Error

Mean Absolute Deviation (MAD)

$$\text{MAD} = \frac{\sum \left| \text{Actual - Forecast} \right|}{n}$$

Mean Squared Error (MSE)

$$\text{MSE} = \frac{\sum \left(\text{Forecast errors} \right)^2}{n}$$

Mean Absolute Percent Error (MAPE)

$$\text{MAPE} = \frac{\sum_{i=1}^{n} 100 \left| \text{Actual}_i - \text{Forecast}_i \right| / \text{Actual}_i}{n}$$

Example : Mean Absolute Deviation (MAD)

DETERMINING THE MEAN ABSOLUTE DEVIATION (MAD)

During the past 8 quarters, the Port of Baltimore has unloaded large quantities of grain from ships. The port's operations manager wants to test the use of exponential smoothing to see how well the technique works in predicting tonnage unloaded. He guesses that the forecast of grain unloaded in the first quarter was 175 tons. Two values of α are to be examined: $\alpha = .10$ and $\alpha = .50$.

APPROACH ▶ Compare the actual data with the data we forecast (using each of the two α values) and then find the absolute deviation and MADs.

SOLUTION ▶ The following table shows the *detailed* calculations for $\alpha = .10$ only:

QUARTER	ACTUAL TONNAGE UNLOADED	FORECAST WITH $\alpha = .10$	FORECAST WITH $\alpha = .50$
1	180	175	175
2	168	175.50 = 175.00 + .10(180 − 175)	177.50
3	159	174.75 = 175.50 + .10(168 − 175.50)	172.75
4	175	173.18 = 174.75 + .10(159 − 174.75)	165.88
5	190	173.36 = 173.18 + .10(175 − 173.18)	170.44
6	205	175.02 = 173.36 + .10(190 − 173.36)	180.22
7	180	178.02 = 175.02 + .10(205 − 175.02)	192.61
8	182	178.22 = 178.02 + .10(180 − 178.02)	186.30
9	?	178.59 = 178.22 + .10(182 − 178.22)	184.15

To evaluate the accuracy of each smoothing constant, we can compute forecast errors in terms of absolute deviations and MADs:

QUARTER	ACTUAL TONNAGE UNLOADED	FORECAST WITH $\alpha = .10$	ABSOLUTE DEVIATION FOR $\alpha = .10$	FORECAST WITH $\alpha = .50$	ABSOLUTE DEVIATION FOR $\alpha = .50$
1	180	175	5.00	175	5.00
2	168	175.50	7.50	177.50	9.50
3	159	174.75	15.75	172.75	13.75
4	175	173.18	1.82	165.88	9.12
5	190	173.36	16.64	170.44	19.56
6	205	175.02	29.98	180.22	24.78
7	180	178.02	1.98	192.61	12.61
8	182	178.22	3.78	186.30	4.30
Sum of absolute deviations:			82.45		98.62
$\text{MAD} = \frac{\sum\lvert\text{Deviations}\rvert}{n}$			10.31		12.33

Example : Mean Squared Error (MSE)

DETERMINING THE MEAN SQUARED ERROR (MSE)

The operations manager for the Port of Baltimore now wants to compute MSE for $\alpha = .10$.

APPROACH ▶ Using the same forecast data for $\alpha = .10$ from Example 4, compute the MSE with Equation (4-6).

SOLUTION ▶

QUARTER	ACTUAL TONNAGE UNLOADED	FORECAST FOR $\alpha = .10$	$(\text{ERROR})^2$
1	180	175	$5^2 = 25$
2	168	175.50	$(-7.5)^2 = 56.25$
3	159	174.75	$(-15.75)^2 = 248.06$
4	175	173.18	$(1.82)^2 = 3.31$
5	190	173.36	$(16.64)^2 = 276.89$
6	205	175.02	$(29.98)^2 = 898.80$
7	180	178.02	$(1.98)^2 = 3.92$
8	182	178.22	$(3.78)^2 = 14.29$
			Sum of errors squared = 1,526.52

$$\text{MSE} = \frac{\sum(\text{Forecast errors})^2}{n} = 1{,}526.52/8 = 190.8$$

INSIGHT ▶ Is this MSE = 190.8 good or bad? It all depends on the MSEs for other forecasting approaches. A low MSE is better because we want to minimize MSE. MSE exaggerates errors because

Mean Absolute Percent Error (MAPE)

DETERMINING THE MEAN ABSOLUTE PERCENT ERROR (MAPE)

The Port of Baltimore wants to now calculate the MAPE when $\alpha = .10$.

APPROACH ▶ Equation (4-7) is applied to the forecast data computed in Example 4.

SOLUTION ▶

QUARTER	ACTUAL TONNAGE UNLOADED	FORECAST FOR $\alpha = .10$	ABSOLUTE PERCENT ERROR 100 (|ERROR|/ACTUAL)
1	180	175.00	100(5/180) = 2.78%
2	168	175.50	100(7.5/168) = 4.46%
3	159	174.75	100(15.75/159) = 9.90%
4	175	173.18	100(1.82/175) = 1.05%
5	190	173.36	100(16.64/190) = 8.76%
6	205	175.02	100(29.98/205) = 14.62%
7	180	178.02	100(1.98/180) = 1.10%
8	182	178.22	100(3.78/182) = 2.08%
			Sum of % errors = 44.75%

$$\text{MAPE} = \frac{\sum \text{absolute percent error}}{n} = \frac{44.75\%}{8} = 5.59\%$$

INSIGHT ▶ MAPE expresses the error as a percent of the actual values, undistorted by a single large value.

LEARNING EXERCISE ▶ What is MAPE when α is .50? [Answer: MAPE = 6.75%. As was the case with MAD and MSE, the $\alpha = .1$ was preferable for this series of data.]

Comparison of Forecast Error

Quarter	Actual Tonnage Unloaded	Rounded Forecast with $\alpha = .10$	Absolute Deviation for $\alpha = .10$	Rounded Forecast with $\alpha = .50$	Absolute Deviation for $\alpha = .50$
1	180	175	5.00	175	5.00
2	168	175.5	7.50	177.50	9.50
3	159	174.75	15.75	172.75	13.75
4	175	173.18	1.82	165.88	9.12
5	190	173.36	16.64	170.44	19.56
6	205	175.02	29.98	180.22	24.78
7	180	178.02	1.98	192.61	12.61
8	182	178.22	3.78	186.30	4.30
			82.45		98.62
		MAD	10.31		12.33
		MSE	190.82		195.24
		MAPE	5.59%		6.76%

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 $\hat{y}$ = value of the dependent variable (in our example, sales)

a = y-axis intercept

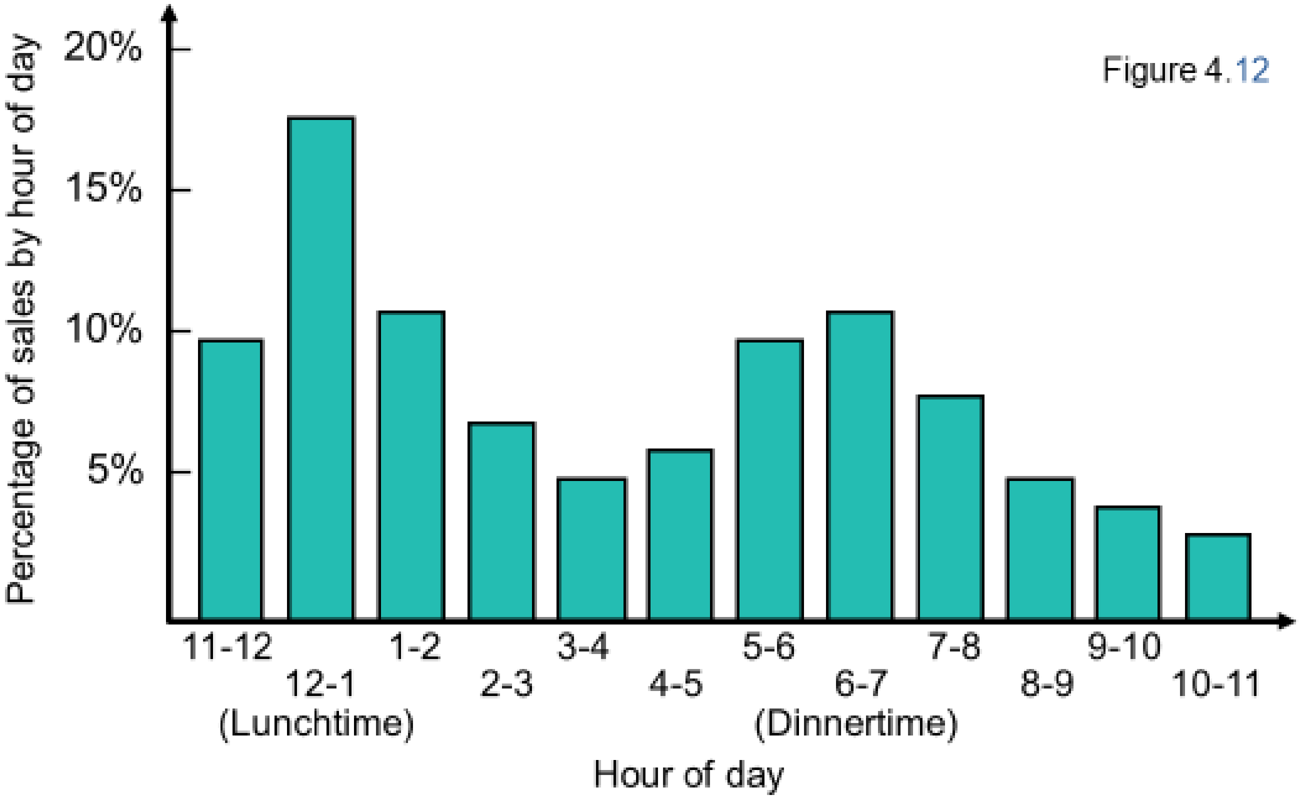
b = slope of the regression line

x = the independent variable

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



FedEx Call Center Forecast