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

**Uses of Forecasts**

<table>
<thead>
<tr>
<th>Department</th>
<th>Uses of Forecasts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accounting</td>
<td>Cost/profit estimates</td>
</tr>
<tr>
<td>Finance</td>
<td>Cash flow and funding</td>
</tr>
<tr>
<td>Human Resources</td>
<td>Hiring/recruiting/training</td>
</tr>
<tr>
<td>Marketing</td>
<td>Pricing, promotion, strategy</td>
</tr>
<tr>
<td>MIS</td>
<td>IT/IS systems, services</td>
</tr>
<tr>
<td>Operations</td>
<td>Schedules, MRP, workloads</td>
</tr>
<tr>
<td>Product/service design</td>
<td>New products and services</td>
</tr>
</tbody>
</table>
3-5 Forecasting

- Assumes causal system
  \[ \text{past} \rightarrow \text{future} \]
- Forecasts rarely perfect because of randomness
- Forecasts more accurate for groups vs. individuals
- Forecast accuracy decreases as time horizon increases

I see that you will get an A this semester.

3-6 Forecasting

Elements of a Good Forecast

- **Timely**
- **Reliable**
- **Accurate**
- **Meaningful**
- **Written**
- **Easy to use**

3-7 Forecasting

Steps in the Forecasting Process

1. Determine purpose of forecast
2. Establish a time horizon
3. Select a forecasting technique
4. Gather and analyze data
5. Prepare the forecast
6. Monitor the forecast

"The forecast"

3-8 Forecasting

Types of Forecasts

- **Judgmental** - uses subjective inputs
- **Time series** - uses historical data assuming the future will be like the past
- **Associative models** - uses explanatory variables to predict the future
### Judgmental Forecasts
- Executive opinions
- Sales force opinions
- Consumer surveys
- Outside opinion
- Delphi method
  - Opinions of managers and staff
  - Achieves a consensus forecast

### Time Series Forecasts
- **Trend** - long-term movement in data
- **Seasonality** - short-term regular variations in data
- **Cycle** – wavelike variations of more than one year’s duration
- **Irregular variations** - caused by unusual circumstances
- **Random variations** - caused by chance

### Forecast Variations
- Irregular variation
- Seasonal variations

### Naive Forecasts
Uh, give me a minute....

We sold 250 wheels last week.... Now, next week we should sell....

The forecast for any period equals the previous period’s actual value.
### Naïve Forecasts

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

### Uses for Naïve Forecasts

- Stable time series data
  - \( F(t) = A(t-1) \)
    - Future = past
- Seasonal variations
  - \( F(t) = A(t-n) \)
    - Future = past season
- Data with trends
  - \( F(t) = A(t-1) + (A(t-1) - A(t-2)) \)
    - Future = past + difference from 2 time periods ago

### Techniques for Averaging

- Moving average
- Weighted moving average
- Exponential smoothing

### Moving Averages

- **Moving average** – A technique that averages a number of recent actual values, updated as new values become available.
  \[
  MA_n = \frac{\sum_{i=1}^{n} A_i}{n}
  \]
- **Weighted moving average** – More recent values in a series are given more weight in computing the forecast.
### Simple Moving Average

Simple Moving Average (SMA) is a method for smoothing time series data by creating a series of averages of different subsets of the full data set. The formula for SMA is:

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

### Exponential Smoothing

Exponential Smoothing is a weighted averaging method based on previous forecast plus a percentage of the forecast error. The formula is:

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

- **Premise:** The most recent observations might have the highest predictive value.
- Therefore, we should give more weight to the more recent time periods when forecasting.

### Example 3 - Exponential Smoothing

<table>
<thead>
<tr>
<th>Period</th>
<th>Actual</th>
<th>Alpha = 0.1 Error</th>
<th>Alpha = 0.4 Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42</td>
<td>42 -2.00</td>
<td>42 -2</td>
</tr>
<tr>
<td>2</td>
<td>40</td>
<td>42 -2.00</td>
<td>42 -2</td>
</tr>
<tr>
<td>3</td>
<td>43</td>
<td>41.8 1.20</td>
<td>41.2 1.8</td>
</tr>
<tr>
<td>4</td>
<td>40</td>
<td>41.92 -1.92</td>
<td>41.92 -1.92</td>
</tr>
<tr>
<td>5</td>
<td>41</td>
<td>41.73 -0.73</td>
<td>41.15 -0.15</td>
</tr>
<tr>
<td>6</td>
<td>39</td>
<td>41.66 -2.66</td>
<td>41.09 -2.09</td>
</tr>
<tr>
<td>7</td>
<td>46</td>
<td>41.39 4.61</td>
<td>40.25 5.75</td>
</tr>
<tr>
<td>8</td>
<td>44</td>
<td>41.85 2.15</td>
<td>42.55 1.45</td>
</tr>
<tr>
<td>9</td>
<td>45</td>
<td>42.07 2.93</td>
<td>43.13 1.87</td>
</tr>
<tr>
<td>10</td>
<td>38</td>
<td>42.36 -4.36</td>
<td>43.88 -5.88</td>
</tr>
<tr>
<td>11</td>
<td>40</td>
<td>41.92 -1.92</td>
<td>41.53 -1.53</td>
</tr>
<tr>
<td>12</td>
<td>41.73</td>
<td>40.92 -1.53</td>
<td></td>
</tr>
</tbody>
</table>
**Picking a Smoothing Constant**

- \( \alpha = 0.1 \)
- \( \alpha = 0.4 \)

**Common Nonlinear Trends**

- Parabolic
- Exponential
- Growth

**Linear Trend Equation**

\[
F_t = a + bt
\]

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

**Calculating \( a \) and \( b \)**

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

\[
a = \frac{\sum y - b \sum t}{n}
\]
### Linear Trend Equation Example

<table>
<thead>
<tr>
<th>t</th>
<th>Week</th>
<th>( t^2 )</th>
<th>Sales</th>
<th>( ty )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>150</td>
<td>150</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>157</td>
<td>314</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>166</td>
<td>664</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>16</td>
<td>177</td>
<td>885</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>25</td>
<td>812</td>
<td>2499</td>
<td></td>
</tr>
</tbody>
</table>

\[ \Sigma t = 15 \]
\[ \Sigma t^2 = 55 \]
\[ \Sigma y = 812 \]
\[ \Sigma ty = 2499 \]

### Linear Trend Calculation

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

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

\[ y = 143.5 + 6.3t \]

### Associative Forecasting

- **Predictor variables** - used to predict values of variable interest
- **Regression** - technique for fitting a line to a set of points
- **Least squares line** - minimizes sum of squared deviations around the line

### Linear Model Seems Reasonable

![Computed relationship](image.png)

A straight line is fitted to a set of sample points.
**Forecast Accuracy**

- Error - difference between actual value and predicted value
- Mean Absolute Deviation (MAD)
  - Average absolute error
- Mean Squared Error (MSE)
  - Average of squared error
- Mean Absolute Percent Error (MAPE)
  - Average absolute percent error

**MAD, MSE, and MAPE**

\[
\text{MAD} = \frac{\sum |\text{Actual} - \text{Forecast}|}{n}
\]

\[
\text{MSE} = \frac{\sum (\text{Actual} - \text{Forecast})^2}{n-1}
\]

\[
\text{MAPE} = \frac{\sum \left|\frac{\text{Actual} - \text{Forecast}}{\text{Actual}}\right| \times 100}{n}
\]

**Example 10**

| Period | Actual | Forecast | (A-F) | |\text{A-F}| | (A-F)^2 | (|A-F|/Actual)*100 |
|--------|--------|----------|-------|-------|----------------|-------|-----------------|
| 1      | 217    | 215      | 2     | 2     | 4              | 0.92  |
| 2      | 212    | 210      | -3    | -3    | 9              | 1.41  |
| 3      | 216    | 215      | 1     | 1     | 1              | 0.46  |
| 4      | 210    | 214      | -4    | -4    | 16             | 1.90  |
| 5      | 213    | 211      | 2     | 2     | 4              | 0.94  |
| 6      | 219    | 214      | 5     | 5     | 25             | 2.38  |
| 7      | 216    | 217      | -1    | -1    | 1              | 0.46  |
| 8      | 212    | 216      | -4    | -4    | 16             | 1.89  |
| 9      | 213    | 214      | -1    | -1    | 1              | 0.46  |
| 10     | 216    | 217      | -1    | -1    | 1              | 0.46  |

\[
\text{MAD} = 2.75
\]

\[
\text{MSE} = 10.86
\]

\[
\text{MAPE} = 1.28
\]

**Controlling the Forecast**

- Control chart
  - A visual tool for monitoring forecast errors
  - Used to detect non-randomness in errors
- Forecasting errors are in control if
  - All errors are within the control limits
  - No patterns, such as trends or cycles, are present
**Sources of Forecast errors**

- Model may be inadequate
- Irregular variations
- Incorrect use of forecasting technique

**Tracking Signal**

- Tracking signal
  - Ratio of cumulative error to MAD

\[
\text{Tracking signal} = \frac{\sum (\text{Actual} - \text{forecast})}{\text{MAD}}
\]

Bias – Persistent tendency for forecasts to be greater or less than actual values.

**Choosing a Forecasting Technique**

- No single technique works in every situation
- Two most important factors
  - Cost
  - Accuracy
- Other factors include the availability of:
  - Historical data
  - Computers
  - Time needed to gather and analyze the data
  - Forecast horizon

**Exponential Smoothing**

![Exponential Smoothing Chart]
### Linear Trend Equation

<table>
<thead>
<tr>
<th></th>
<th>Actual</th>
<th>Forecast</th>
<th>Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>42</td>
<td>41.627222</td>
<td>0.627222</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
<td>52.472222</td>
<td>52.472222</td>
</tr>
<tr>
<td>3</td>
<td>60</td>
<td>61.127222</td>
<td>61.127222</td>
</tr>
<tr>
<td>4</td>
<td>54</td>
<td>53.472222</td>
<td>3.472222</td>
</tr>
<tr>
<td>5</td>
<td>55</td>
<td>54.722222</td>
<td>0.722222</td>
</tr>
<tr>
<td>6</td>
<td>65</td>
<td>65.072222</td>
<td>0.072222</td>
</tr>
<tr>
<td>7</td>
<td>60</td>
<td>59.472222</td>
<td>0.527778</td>
</tr>
<tr>
<td>8</td>
<td>56</td>
<td>56.722222</td>
<td>0.277778</td>
</tr>
<tr>
<td>9</td>
<td>42</td>
<td>42.472222</td>
<td>0.527778</td>
</tr>
</tbody>
</table>

**Slope:** 0.72
**Intercept:** 45.472222
**MAE:** 1.66
**MSE:** 5.28

### Simple Linear Regression

<table>
<thead>
<tr>
<th></th>
<th>x</th>
<th>y</th>
<th>x̄</th>
<th>ȳ</th>
<th>x-x̄</th>
<th>y-ȳ</th>
<th>x,x̄</th>
<th>y,ȳ</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>15</td>
<td>4.67</td>
<td>9.27</td>
<td>-3.67</td>
<td>-1.27</td>
<td>3.67</td>
<td>2.67</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>20</td>
<td>4.67</td>
<td>9.27</td>
<td>0.33</td>
<td>0.73</td>
<td>0.33</td>
<td>0.73</td>
</tr>
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<td>1</td>
<td>30</td>
<td>4.67</td>
<td>9.27</td>
<td>-3.67</td>
<td>8.73</td>
<td>3.67</td>
<td>8.73</td>
</tr>
<tr>
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<td>20</td>
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<td>9.27</td>
<td>0.33</td>
<td>0.73</td>
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<td>0.73</td>
</tr>
<tr>
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<td>1</td>
<td>40</td>
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<td>9.27</td>
<td>-3.67</td>
<td>9.73</td>
<td>3.67</td>
<td>9.73</td>
</tr>
</tbody>
</table>

**R²:** 0.99