Adeng Pustikaningsih, M.Si.
Dosen Jurusan Pendidikan Akuntansi
Fakultas Ekonomi
Universitas Negeri Yogyakarta

CP: 08 222 180 1695
Email : adengpustikaningsih@uny.ac.id
Operations Management

Forecasting

Chapter 4
What is Forecasting?

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

Sales will be $200 Million!
Types of Forecasts

- **Economic forecasts**
  - Address business cycle, e.g., inflation rate, money supply etc.

- **Technological forecasts**
  - Predict rate of technological progress
  - Predict acceptance of *new* product

- **Demand forecasts**
  - Predict sales of *existing* product
Types of Forecasts by Time Horizon

- **Short-range forecast**
  - Up to 1 year; usually less than 3 months
  - Job scheduling, worker assignments

- **Medium-range forecast**
  - 3 months to 3 years
  - Sales & production planning, purchasing, budgeting

- **Long-range forecast**
  - 3+ years
  - New product planning, facility location
What Do We Forecast - Aggregation

Clustering goods or services that have similar demand requirements and common processing, labor, and materials requirements:

Red shirts
White shirts
Blue shirts

Big Mac
Quarter Pounder
Regular Hamburger

Shirts $
Pounds of Beef $
Realities of Forecasting

- Forecasts are seldom perfect
- Most forecasting methods assume that there is some underlying stability in the system
- Both product family and aggregated product forecasts are more accurate than individual product forecasts
Trend Component

- Persistent, overall upward or downward pattern
- Due to population, technology etc.
- Several years duration
Seasonal Component

- Regular pattern of up & down fluctuations
- Due to weather, customs etc.

![Seasonal Component Graph]

- Summer
Cyclical Component

- Repeating up & down movements
- Due to interactions of factors influencing the economy
- Usually 2-10 years duration
Product Demand

- Seasonal peaks
- Trend component
- Actual demand line
- Random variation
- Average demand over four years

Demand for product or service

Year 1 Year 2 Year 3 Year 4

© 2004 by Prentice Hall, Inc., Upper Saddle River, N.J. 07458
Forecasting Approaches

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

Quantitative Methods
- Used when situation is ‘stable’ & historical data exist
  - Existing products
  - Current technology
- Involves mathematical techniques
  - e.g., forecasting sales of color televisions
Overview of Qualitative Methods

- Jury of executive opinion
  - Pool opinions of high-level executives, sometimes augmented by statistical models

- Delphi method
  - Panel of experts, queried iteratively

- Sales force composite
  - Estimates from individual salespersons are reviewed for reasonableness, then aggregated

- Consumer Market Survey
  - Ask the customer
Overview of Quantitative Approaches

- Naïve approach
- Moving averages
- Exponential smoothing
- Trend projection
- Seasonal variation

Time-series Models

- Linear regression

Associative Models
What is a Time Series?

- Set of evenly spaced numerical data
  Observing the response variable at regular time intervals
- Forecast based only on past values
  Assumes that factors influencing the past and present will continue to influence the future
- Example

<table>
<thead>
<tr>
<th>Year</th>
<th>1999</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>78.7</td>
<td>63.5</td>
<td>89.7</td>
<td>93.2</td>
<td>92.1</td>
</tr>
</tbody>
</table>
Naive Approach

- Assumes demand in *next* period is the same as demand in *most recent* period
  - e.g., If May sales were 48, then June sales will be 48

- Sometimes cost effective & efficient
Simple Moving Average

\[
\text{Forecast} = \frac{\sum \text{Demand in Previous } n \text{ Periods}}{n}
\]

\[
F_t = \frac{A_{t-1} + A_{t-2} + A_{t-3} + A_{t-4}}{4}
\]

\[
F_t = \frac{A_{t-1} + A_{t-2} + A_{t-3}}{3}
\]
Weighted Moving Average

Forecast = \[ \sum (\text{Weight for period } n) \times (\text{Demand in period } n) \]

\[
F_t = 0.4A_{t-1} + 0.3A_{t-2} + 0.2A_{t-3} + 0.1A_{t-4}
\]

\[
F_t = 0.7A_{t-1} + 0.2A_{t-2} + 0.1A_{t-3}
\]
Exponential Smoothing Method

- Form of weighted moving average
  - Weights decline exponentially
  - Most recent data weighted most
- Requires smoothing constant ($\alpha$)
  - Ranges from 0 to 1
  - Subjectively chosen
- Involves little record keeping of past data
Exponential Smoothing

Forecast \[= \alpha (\text{Demand last period}) + (1 - \alpha ) (\text{Last forecast})\]

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

\[= \alpha A_{t-1} + F_{t-1} - \alpha F_{t-1}\]

\[= F_{t-1} + \alpha (A_{t-1} - F_{t-1})\]

Forecast \[= \text{Last forecast} + \alpha (\text{Last demand} - \text{Last forecast})\]
Exponential Smoothing with Trend Adjustment

Forecast = Exponentially smoothed forecast \( (F_t) \)  
+ Exponentially smoothed trend \( (T_t) \)

\[ T_t = \beta (\text{Forecast this period} - \text{Forecast last period}) \]
\[ + (1- \beta) (\text{Trend estimate last period}) \]

\[ = \beta(F_t - F_{t-1}) + (1- \beta)T_{t-1} \]
## Seasonal Variation

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45</td>
<td>70</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>335</td>
<td>370</td>
<td>585</td>
<td>725</td>
</tr>
<tr>
<td>3</td>
<td>520</td>
<td>590</td>
<td>830</td>
<td>1160</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>170</td>
<td>285</td>
<td>215</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1000</strong></td>
<td><strong>1200</strong></td>
<td><strong>1800</strong></td>
<td><strong>2200</strong></td>
</tr>
<tr>
<td><strong>Average</strong></td>
<td><strong>250</strong></td>
<td><strong>300</strong></td>
<td><strong>450</strong></td>
<td><strong>550</strong></td>
</tr>
</tbody>
</table>

Seasonal Index = \[
\frac{\text{Actual Demand}}{\text{Average Demand}} = \frac{45}{250} = 0.18
\]

Forecast for Year 5 = 2600
**Seasonal Variation**

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>45/250 = 0.18</td>
<td>70/300 = 0.23</td>
<td>100/450 = 0.22</td>
<td>100/550 = 0.18</td>
</tr>
<tr>
<td>2</td>
<td>335/250 = 1.34</td>
<td>370/300 = 1.23</td>
<td>585/450 = 1.30</td>
<td>725/550 = 1.32</td>
</tr>
<tr>
<td>3</td>
<td>520/250 = 2.08</td>
<td>590/300 = 1.97</td>
<td>830/450 = 1.84</td>
<td>1160/550 = 2.11</td>
</tr>
<tr>
<td>4</td>
<td>100/250 = 0.40</td>
<td>170/300 = 0.57</td>
<td>285/450 = 0.63</td>
<td>215/550 = 0.39</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quarter</th>
<th>Average Seasonal Index</th>
<th>Forecast</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(0.18 + 0.23 + 0.22 + 0.18)/4 = 0.20</td>
<td>650(0.20) = 130</td>
</tr>
<tr>
<td>2</td>
<td>(1.34 + 1.23 + 1.30 + 1.32)/4 = 1.30</td>
<td>650(1.30) = 845</td>
</tr>
<tr>
<td>3</td>
<td>(2.08 + 1.97 + 1.84 + 2.11)/4 = 2.00</td>
<td>650(2.00) = 1300</td>
</tr>
<tr>
<td>4</td>
<td>(0.40 + 0.57 + 0.63 + 0.39)/4 = 0.50</td>
<td>650(0.50) = 325</td>
</tr>
</tbody>
</table>
Overview of Quantitative Approaches

- Naïve approach
- Moving averages
- Exponential smoothing
- Trend projection
- Seasonal variation

Time-series Models

- Linear regression

Associative Models
Linear Regression

Factors Associated with Our Sales

- Advertising
- Pricing
- Competitors
- Economy
- Weather

Independent Variables → Dependent Variable

Sales
Scatter Diagram

Sales vs. Payroll

Area Payroll (in $ hundreds of millions)

Sales (in $ hundreds of thousands)

Regression Line

Now What?
Types of Forecasts by Time Horizon

- Short-range forecast
  - Up to 1 year; usually less than 3 months
  - Job scheduling, worker assignments

- Medium-range forecast
  - 3 months to 3 years
  - Sales & production planning, budgeting

- Long-range forecast
  - 3+ years
  - New product planning, facility location
Forecast Error

\[ E_t = A_t - F_t \]
Forecast Error - CFE

CFE – Cumulative sum of Forecast Errors

\[ CFE = \sum E_t \]

• Positive errors offset negative errors

• Useful in assessing bias in a forecast
Forecast Error - MSE

MSE – Mean Squared Error

\[
\text{MSE} = \frac{\sum E_t^2}{n}
\]

Accentuates large deviations
Forecast Error - MAD

MAD – Mean Absolute Deviation

\[ \text{MAD} = \frac{\sum |E_t|}{n} \]

Widely used, well understood measurement of forecast error
Forecast Error - MAPE

MAPE – Mean Absolute Percent Error

\[
\text{MAPE} = \frac{100 \sum |E_t| / A_t}{n}
\]

Relates forecast error to the level of demand
Forecast Error

\[ E_t = A_t - F_t \]

CFE = \[ \sum E_t \]

MSE = \[ \frac{\sum E_t^2}{n} \]

MAD = \[ \frac{\sum |E_t|}{n} \]

MAPE = \[ 100 \frac{\sum |E_t|}{A_t} / n \]
Monitoring & Controlling Forecasts

We need a **TRACKING SIGNAL** to measure how well the forecast is predicting actual values.

\[
TS = \frac{\text{Running sum of forecast errors (CFE)}}{\text{Mean Absolute Deviation (MAD)}}
\]

\[
= \frac{\sum E_t}{\sum |E_t| / n}
\]
Plot of a Tracking Signal

Signal exceeded limit

Upper control limit

Tracking signal CFE / MAD

Acceptable range

Lower control limit

Time
Forecasting in the Service Sector

Presents unusual challenges

- special need for short term records
- needs differ greatly as function of industry and product
- issues of holidays and calendar
- unusual events
Forecast of Sales by Hour for Fast Food Restaurant
Summary

Demand forecasts drive a firm’s plans
- Production
- Capacity
- Scheduling

Need to find the forecasting method(s) that best fit our pattern of demand – no one right tool
- Qualitative methods e.g. customer surveys
- Time series methods (quantitative) rely on historical demand to predict future demand
- Associative models (quantitative) use historical data on independent variables to predict demand e.g. promotional campaign

Track forecast error to determine if forecasting model requires change