Demand Forecasting

- When a product is produced for a market, the demand occurs in the future.
- The production planning cannot be accomplished unless the volume of the demand known.
- The success of the business in supplying the demand in the most efficient & profitable way will then depend on the accuracy of the forecasting process in predicting the future demand.

Some Reasons Why Forecasting Is Essential in POM

1. **New Facility Planning.** It can take as long as five years to design and build a new factory or design and implement a new production process. Such strategic activities in POM require long-range forecasts of demand for existing and new products so that operations managers can have the necessary lead time to build factories and install processes to produce the products and services when needed.
2. **Production Planning.** Demands for products and services vary from month to month. Production rates must be scaled up or down to meet these demands. It can take several months to change the capacities of production processes. Operations managers need medium-range forecasts so that they can have the lead time necessary to provide the production capacity to produce these variable monthly demands.
3. **Work Force Scheduling.** Demands for products and services vary from week to week. The work force must be scaled up or down to meet these demands by using reassignment, overtime, layoffs, or hiring. Operations managers need short-range forecasts so that they can have the lead time necessary to provide work force changes to produce the weekly demands.

Some Examples of Things That Must Be Forecasted in POM

Forecast Horizon	Time Span	Examples of Things That Must Be Forecasted	Some Typical Units of Forecasts
Long-range	Years	New product lines	Dollars
		Old product lines	Dollars
		Factory capacities	Gallons, hours, pounds, units, or customers per time period
		Capital funds	Dollars
		Facility needs	Space, volume
Medium-range	Months	Product groups	Units
		Departmental capacities	Hours, strokes, pounds, gallons, units, or customers per time period
		Work force	Workers, hours
		Purchased materials	Units, pounds, gallons
		Inventories	Units, dollars
Short-range	Weeks	Specific products	Units
		Labor-skill classes	Workers, hours
		Machine capacities	Units, hours, gallons, strokes, pounds, or customers per time period
		Cash	Dollars
		Inventories	Units, dollars

1   Forecasting as an Integral Part of Business Planning
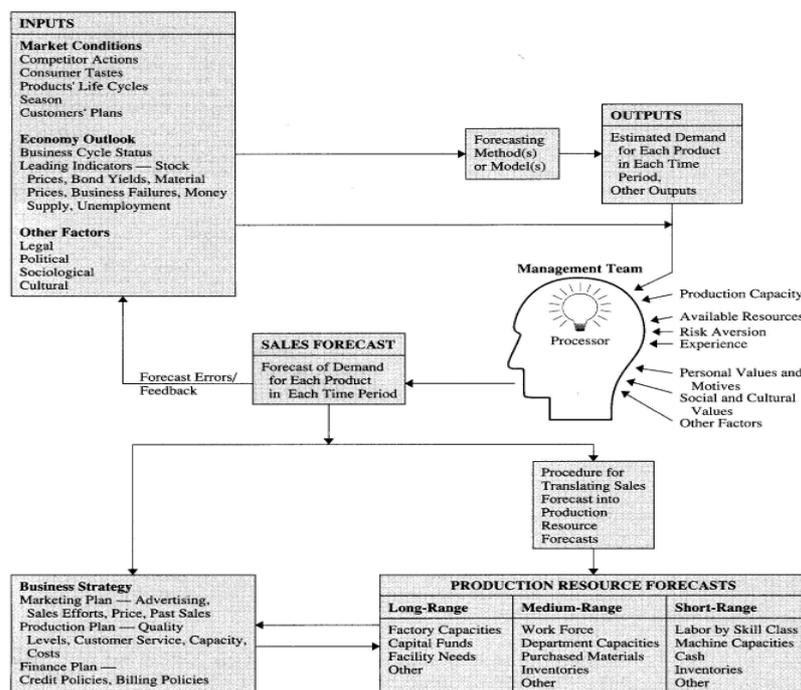
Qualitative Forecasting Methods

1. **Executive Committee Consensus.** Knowledgeable executives from various departments within the organization form a committee charged with the responsibility of developing a sales forecast. The committee may use many inputs from all parts of the organization and may have staff analysts provide analyses as needed. Such forecasts tend to be compromise forecasts, not reflecting the extremes that could be present had they been prepared by individuals. This method is the most common forecasting method.

2. **Delphi Method.** This method is used to achieve consensus within a committee. In this method executives anonymously answer a series of questions on successive rounds. Each response is fed back to all participants on each round, and the process is then repeated. As many as six rounds may be required before consensus is reached on the forecast. This method can result in forecasts that most participants have ultimately agreed to in spite of their initial disagreement.

3. **Survey of Sales Force.** Estimates of future regional sales are obtained from individual members of the sales force. These estimates are combined to form an estimate of sales for all regions. Managers must then transform this estimate into a sales forecast to ensure realistic estimates. This is a popular forecasting method for companies that have a good communication system in place and that have salespersons who sell directly to customers.

4. **Survey of Customers.** Estimates of future sales are obtained directly from customers. Individual customers are surveyed to determine what quantities of the firm's products they intend to purchase in each future time period. A sales forecast is determined by combining individual customers' responses. This method may be preferred by companies that have relatively few customers.

5. **Historical Analogy.** This method ties the estimate of future sales of a product to knowledge of a similar product's sales. Knowledge of one product's sales during various stages of its product life cycle is applied to the estimate of sales for a similar product. This method may be particularly useful in forecasting sales of new products.

6. **Market Research.** In *market surveys,* mail questionnaires, telephone interviews, or field interviews form the basis for testing hypotheses about real markets. In *market tests,* products marketed in target regions or outlets are statistically extrapolated to total markets. These methods are ordinarily preferred for new products or for existing products to be introduced into new market segments.

Technique for Demand Forecasting
1. Naïve techniques - adding a certain percentage to the demand for next year.
2. Opinion sampling - collecting opinions from sales, customers etc.
3. Qualitative methods
4. Quantitative methods - based on statistical and mathematical concepts.
   a. Time series - the variable to be forecast has behaved according to a specific pattern in the past and that this pattern will continue in the future.
   b. Causal - there is a causal relationship between the variable to be forecast and another variable or a series of variables.

Quantitative Methods of Forecasting
1. Causal – There is a causal relationship between the variable to be forecast and another variable or a series of variables. (Demand is based on the policy, e.g. cement, and build material.
2. Time series – The variable to be forecast has behaved according to a specific pattern in the past and that this pattern will continue in the future.

Causal:
Demand for next period

$= f$ (number *of permits, number of loan application....*)

Time series:
1. $D = F (t)$

Where D is the variable to be forecast and $f(t)$ is a function whose exact form can be estimated from the past data available on the variable.

2. The value of the variable for the future as a function of its values in the past.

$D_{t+1} = f (D_t, D_{t-1}, D_{t-2}, ...)$

- There exists a function whose form must be estimated using the available data..
- The most common technique for estimation of equation is regression analysis.

Regression Analysis: is not limited to locating the straight line of best fit.

Example A: Following data on the demand for sewing machines manufactured by Taylor and Son Co. have been compiled for the past 10 years.

year	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980
Demand in (1000 units)	58	65	73	76	78	87	88	93	99	106
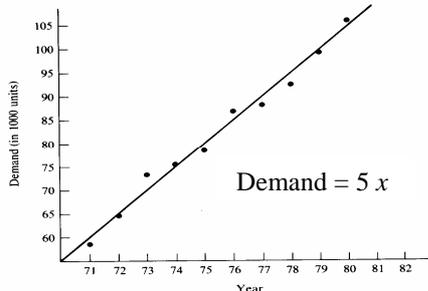
1. *Single variable linear regression*

Year $= x$ where $x = 1, 2, 3,...., 10$
  Demand $= y$
  $D = y + \varepsilon$ Where D is actual demand
  $\varepsilon = D - y$
To find out whether this is the line of best fitted to be sure that this sum of squares is a min.

Determination of the regression line
In general form
$y = a + bx$
Where y is dependent variable, and x is independent data variable.
When a and b specified this line will be specified.

$\varepsilon_1 = y_1 - y(x_1) = y_1 - a - bx_1$
$\varepsilon_2 = y_2 - y(x_2) = y_2 - a - bx_2$
.
$\varepsilon_n = y_n - y(x_n) = y_n - a - bx_n$

The sum of square of error (SSE)
$$SSE = \sum \varepsilon^2 = \varepsilon_1^2 + \varepsilon_2^2 + ... + \varepsilon_n^2$$
$$= (y_1 - a - bx_1)^2 + ... + (y_n - a - bx_n)^2$$

To minimize SSE, its partial derivatives with respect to a and b may be equated to zero and solve a and b

$$\frac{\partial SSE}{\partial a} = -2(y_1 - a - bx_1) - 2(y_2 - a - bx_2) \cdots$$
$$- 2(y_n - a - bx_n) = 0$$

$$\frac{\partial SSE}{\partial b} = -2x_1(y_1 - a - bx_1) - 2x_2(y_2 - a - bx_2) \cdots$$
$$- 2x_n(y_2 - a - bx_n) = 0$$

or

$$-2(y_1 + y_2 \cdots y_n) + 2(a + a + \cdots a)$$
$$+ 2b(x_1 + x_2 \cdot \cdots x_n) = 0$$

and

$$-2(x_1y_1 + x_2y_2 + \cdots x_ny_n) + 2a(x_1 + x_2 + \cdots x_n)$$
$$+ 2b(x_1^2 + x_2^2 + \cdots x_n^2) = 0$$

$$a = \frac{\Sigma x^2 \Sigma y - \Sigma x \Sigma xy}{n\Sigma x^2 - (\Sigma x)^2}$$

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

or

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

$$a = \frac{\Sigma y - b\Sigma x}{n}$$

Coefficient of correlation

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

Where $-1 \leq r \leq 1$

*Perfect interdependence between variables when ± 1

2. *Exponential*: sometimes a smooth curve provides a better fit for data points than does a straight line $\quad y = ab^x \quad$ indicates that y changes in each period at the constant rate b.
Determine the value for *a* and *b* by the least squares method:
$\quad \log y = \log a + x \log b$
The logarithmic version plots as a straight line on semi-logarithmic paper: the Y scale is logarithmic and the X scale arithmetic.

$$\sum (\log Y) = N(\log a) + \sum X(\log b)$$

$$\sum (X \log Y) = \sum X(\log a) + \sum X^2 (\log b)$$

$$\log a = \frac{\sum (\log Y)}{N}$$

and

$$\log b = \frac{\sum (X \log Y)}{\sum X^2}$$

- If the curved line from the exponential equation does not represent the data adequately, forecasting equation can be based on algebraic series such as,
  $Y = a + b_1 X + b_2 X^2 + \dots + b_n X^n$
- Or trigonometric functions such as
  $Y = a + b_1 sin(2\pi X/b_2) + b_3 cos(2\pi X/b_4)$

3. *Regression time series forecasting*
Demand = Trend + Error
The error part is decomposed to
(a). Seasonal
(b). Cyclical – Similar to seasonal variations except for the fact that the cycle has long period.
(c). Random variations – do not follow any pattern that cannot control or accounted.

Seasonal

Regression time series forecasting without seasonal variation (Same as we had discussed)
Regression time series forecasting with seasonal variation
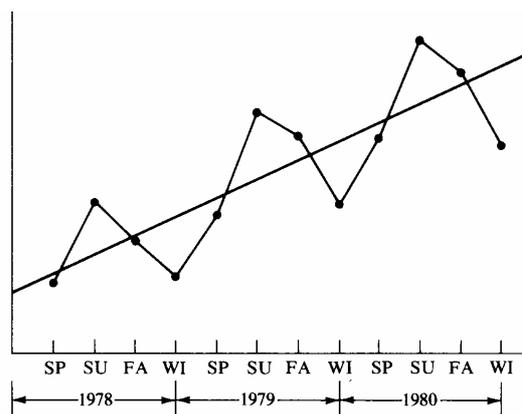
Example:
● Demand for sporting goods for sports, golf, swimming
● Different types of clothing, food, and heating and cooling systems

Example B: The demand for a certain soft drink in the past four years in given in following on a quarterly basis.

Year	Period	Demand (in Million)	Year	Period	Demand (in Million)
1	Spring	15	3	Spring	20
	Summer	25		Summer	30
	Fall	16		Fall	18
	Winter	8		Winter	11
2	Spring	17	4	Spring	18
	Summer	29		Summer	32
	Fall	14		Fall	19
	Winter	10		Winter	12

$$b = \frac{n\Sigma xy - \Sigma x\Sigma y}{n\Sigma x^2 - (\Sigma x)^2} = \frac{16(2,551) - (136)(294)}{16(1,496) - (136)^2} = 0.153$$

$$a = \frac{\Sigma y - b\Sigma x}{n} = \frac{294 - 0.153(136)}{16} = 17.075$$

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

$$= \frac{16(2551) - (136)(294)}{\sqrt{[16(1496) - (136)^2][16(6194) - (294)^2]}}$$

$$r = 0.1002$$

r very small almost indicating that no relation. We may be able to use the trend line by adjusting its forecast value such that it is acceptable.

Seasonal adjustment
i. Additive model: Adjustment is made by adding or deducting a specific amount from the value obtained from the trend line to determine the forecast for the respective season. This is very depended on experiences.
ii. Multiplicative model: This is made by multiplying the value estimated by the trend by a factor of either more or less than one to forecast the demand for the season.

$\tilde{A}_j = SF_j \cdot D$

Where, $\tilde{A}_j$: the adjusted forecast for the season j
And SF_j: the seasonal factor

Example C: Use the example from B finds the seasonal factor.

Take summer as example
For year 1, $t = 2$,
Actual value = 25,
The value of trend line $D = 17.075 + 0.153\,(t) = 17.381$
The seasonal factor = $(SF_2)_1 = 25/17.381 = 1.438$
For year 2, $t = 6$,
Actual value = 29,
The value of trend line $D = 17.075 + 0.153\,(t) = 17.993$

The seasonal factor $= (SF_2)_2 = 25/17.993 = 1.612$

For year 3, $t = 10$,
Actual value $= 30$,
The value of trend line $D = 17.075 + 0.153\ (t) = 18.605$
The seasonal factor $= (SF_2)_3 = 25/18.605 = 1.612$

For year 4, $t = 14$,
Actual value $= 32$,
The value of trend line $D = 17.075 + 0.153\ (t) = 19.217$
The seasonal factor $= (SF_2)_4 = 25/19.217 = 1.665$

Average these four values yield the seasonal adjustment factor for the summer season of any year.

$SF_2 = [(SF_2)_1 + (SF_2)_2 + (SF_2)_3 + (SF_2)_4]/4 = 1.582$

Now to find the forecast for the summer of year 5, i.e. $t = 18$
$$D = 17.075 + 0.153\ (t) = 19.829$$
$$\tilde{A}_j = SF_j \bullet D = 1.582 \bullet 19.829 = 31.369$$

With the same techniques we may find
Spring $SF_2 = 0.963$
Fall $SF_2 = 0.906$
Winter $SF_2 = 0.549$

Forecasting by Time Series Analysis(short-range forecast) - Without using regression analysis

These models are especially helpful when there is no clear upward or downward pattern in the past data to suggest a kind of linear relationship between the demand and time.
In general
$$D_{t+1} = F\ (D_t, D_{t-1}, ..., D_2, D_1)$$
Where D_{t+1} is forecast demand for the next period

(a). Simple moving average forecasting
(b). Exponential smoothing

Simple moving average forecasting
● All past data are given equal weight in estimating.

$D_{t+1} = 1/k \bullet (D_t, + D_{t-1} + ...+ D_2 + D_1)$

Example C. Simple Moving Average Forecasting
The demand for the past 12 years of certain type of automobile alternator is given below

year	Demand (in 10,000 units)	year	Demand (in 10,000 units)
69	32	75	40
70	40	76	25
71	50	77	52
72	28	78	48
73	30	79	40
74	44	80	44

A. Three period moving average forecast for the demand
$$D_{t+1} = 1/3 \bullet (D_t, + D_{t-1} + D_{t-2})$$
B. Five period moving average is given by
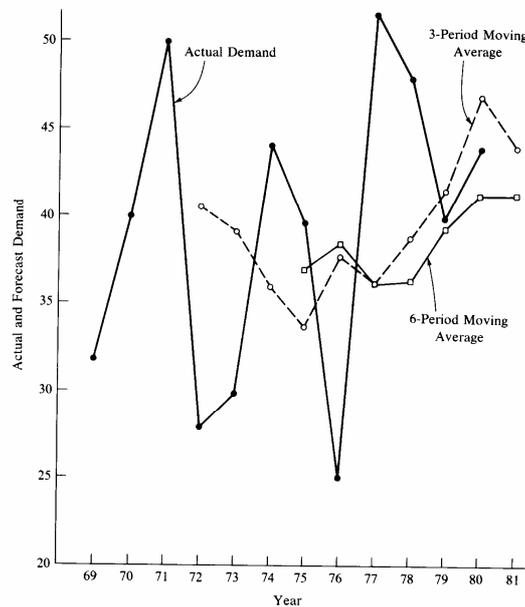$$D_{t+1} = 1/5 \bullet ((D_t, + D_{t-1} + D_{t-2} + D_{t-3} + D_{t-4})$$
For example:

$$D_{81} = 1/3 \bullet (D_{80}, + D_{79} + D_{78}) = 44$$
$$D_{81} = 1/5 \bullet (D_{80}, + D_{79} + D_{78} + D_{77} + D_{76}) = 41.8$$

Results of Applying the Simple Moving Average Forecasting

Year	Demand	3-period	6-period
69	32		
70	40		
71	50		
72	28	40.7	
73	30	39.3	
74	44	36.0	
75	40	34.0	37.3
76	25	38.0	38.7
77	52	36.3	36.2
78	48	39.0	36.5
79	40	41.7	39.8
80	44	46.0	41.5
1981 Forecasting		44	41.5

Conclusions:
1. A large number for k is suitable for data that fluctuate very much.
2. Small values of k are better for data which follow a pattern with less fluctuations.
3. $k = n$ is the most extreme case, in such a case the curve representing the forecast would approximate a horizontal line.
4. If the past data suggest an increasing or decreasing pattern the most recent data provide better estimates of the future values. Thus small k is suggested.

Weighted Moving Average Method

- In some situations, it may be desirable to apply unequal weights to the historical data

	Actual	Weight
72	28	.20
73	30	.30
74	44	.50

Modification of $Forecast_{75}=36.6$

Exponential smoothing

- Exponential smoothing is assumed that the future demand is the same as the forecast made for the present period plus a percentage of the forecasting error made in the past period.

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

Where α is smoothing factor

Example D. Exponential Smoothing

A new product demand for January and February of this year has been 40,000 and 48,000 respectively. New product has no additional information. Forecast the demand for March with $\alpha = 0.4$.

Solution:

$$F_M = F_F + \alpha \ (D_F - F_F)$$

$$F_F = F_J + \alpha \ (D_J - F_J)$$

F_J is unknown, since no additional information is available, we assume

$$F_J = D_J = 40,000 \quad \text{and} \quad F_F = F_J = 40,000$$

$$\Rightarrow \quad F_M = 4,000 + 0.4 \ (48,000 - 40,000) = 43,200$$

- More detail about exponential smoothing (if we know more past).

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

Expand the equation

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

Substitute F_t with F_{t+1}

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

$$\Rightarrow \quad F_{t+1} = \alpha \ D_t + \alpha \ (1- \alpha) \ D_{t-1} + (1- \alpha)^2 \ F_{t-1}$$
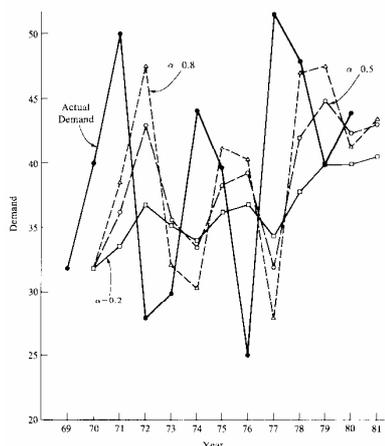
With the same procedure on F_{t-1} and F_{t-2}

The general form can be written as

$$F_{t+1} = \alpha \ D_t + \alpha \ (1- \alpha) \ D_{t-1} + \alpha \ (1- \alpha)^2 \ D_{t-2} + ...+ \alpha \ (1- \alpha)^{t-1} \ D_1 + (1- \alpha)^t \ F_1$$

The effect of α analysis

Example E. let's applied exponential smoothing to previous example C. To study the effect of α, $\alpha = 0.2, 0.5,$ and 0.8

Year	Periods	Actual Demand	$\alpha = 0.2$	$\alpha = 0.5$	$\alpha = 0.8$
1969	1	32	—	—	—
1970	2	40	32	32	32
1971	3	50	33.6	36	38.4
1972	4	28	36.88	43	47.68
1973	5	30	35.10	35.5	31.94
1974	6	44	34.08	32.75	30.39
1975	7	40	36.07	38.38	41.28
1976	8	25	36.85	39.19	40.26
1977	9	52	34.48	32.10	28.05
1978	10	48	37.99	42.05	47.21
1979	11	40	39.99	45.03	47.84
1980	12	44	39.99	42.52	41.57
1981	13	—	—	43.26	43.51

Forecast Values

1. From the graphic with 0.2 is the smoothest of the three, indicating that the smaller values of α have more smoothing effect.
2. The pattern of variations in the forecast in very similar to that of the actual demand except that the forecast curve lags the actual curve by a number of periods.
3. As the smoothing effect is increased (α decreased) this similarity becomes less visible.
4. The small value of α is suitable for data that behave very randomly.
5. The large value of α is suggest for data with less fluctuation and with a recognizable pattern.

$$\mathbf{F_{t+1} = F_t + \alpha\,(\,D_t - F_t\,)}$$

$\alpha \approx 0$ $\rightarrow$Future forecast in very closed to present forecast (Similar to moving average with k large)

$\alpha \approx 1$ Present forecast much be adjusted a great deal to yield future forecast (similar to moving average with k small)

Moving average and exponential smoothing

- An earlier term for exponential smoothing was exponentially weighted moving average. This term reminds us the exponential smoothing, like the moving average and the weighted moving average models, develops forecasts that are averages.
- Exponential smoothing weights data from recent periods heavier than data from more distant periods
- Moving average and exponential smoothing are similar in this regard. The number of period (AP) and a are related by the following expression:

$$\alpha = \frac{2}{AP+1}$$

Exponential Smoothing with Trend

- As we move from short-range forecasts toward medium-range forecasts, however, seasonality and trend become more important.
- Incorporating a trend component into exponentially smoothed forecasts is called double exponential smoothing, because the estimate for the average and the estimate for the trend are both smoothed.
- Both a, the smoothing constant for the average, and b, the smoothing constant for the trend, are used in this model.

Formulas, variable definitions, and procedure for exponential smoothing forecasts with trend

Variable Definitions

S_t	= Smoothed forecast in period t
T_t	= Trend estimate in period t
A_t	= Actual data in period t
t	= The next time period
$t-1$	= The preceding time period
FT_t	= Forecast with trend in period t
α	= Smoothing constant for the average, from 0 to 1
β	= Smoothing constant for the trend, from 0 to 1

Formulas

$FT_t = S_{t-1} + T_{t-1}$

$S_t = FT_t + \alpha(A_t - FT_t)$

$T_t = T_{t-1} + \beta(FT_t - FT_{t-1} - T_{t-1})$

Procedure

If we want to compute the exponential smoothing forecast with trend for Week 7, we would follow this procedure:

1. To begin, we need to know values of α, and β. The values of the smoothing constants α and β are between 0 and 1 and must be estimated or experimentally derived.
2. S_6 and T_6 would have been computed earlier.
3. Compute: $FT_7 = S_6 + T_6$. This is the exponential smoothing forecast with trend for Week 7.
4. In preparation for computing the forecast for next week, we compute S_7 and T_7. Knowing the values of FT_7, FT_6, α, β, and T_6, and after the value of A_7 is known, compute:
   $S_7 = FT_7 + \alpha(A_7 - FT_7)$
   $T_7 = T_6 + \beta(FT_7 - FT_6 - T_6)$

Why Causal Forecasting
- There is no logical link between the demand in the future and what has happened in the past. – statistic
- There are other factors which can be logically linked to the demand

Example 1: There is a strong cause and effect relationship between future demand for doors and windows and the number of construction permits issued at present.

Example 2: The demand for new house or automobile is very much affected by the interest rates changed by banks.

Economic indicators
General form for one: Simple linear regression in causal forecasting

$$F_{t+1} = f(x)_t$$

- This indicates the future demand is a function of the value of the economic indicator at the present time.

Where F_{t+1}: the forecast for the next period

And x is the relevant economic indicator

$$F = a + bx$$

More than one economic indicators: multiple regression analysis in causal forecasting

$$F_{t+1} = f(x_1, x_2, x_3, \ldots\ldots, x_n)_t$$
$$F = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + \ldots\ldots + b_n x_n$$

Multiple regression analysis in causal forecasting
- Sometimes one economic indicator alone does not show a very strong relationship. One way consider the use of combination of economic indicators as a means of forecasting.
- Another way stating as a function of several economic indicators.

$$F = a + b_1 x_1 + b_2 x_2 + b_3 x_3 + \ldots\ldots + b_n x_n$$

- The Determination of these parameters $a, b_1, b_2, b_3, \ldots\ldots b_n$ may use SPSS (Statistical Programs For Social Scientists) or IMSL (International Mathematical and Statistical Library) by computer input the past data.

Example of two economic indicators involved.

$$y = a + b_1 x_1 + b_2 x_2$$

Using the criterion of the least squared error

$$\Sigma y = na + b_1 \Sigma x_1 + b_2 \Sigma x_2$$
$$\Sigma x_1 y = a \Sigma x_1 + b_1 \Sigma x_1{}^2 + b_2 \Sigma x_1 x_2$$
$$\Sigma x_2 y = a \Sigma x_2 + b_1 \Sigma x_1 x_2 + b_2 \Sigma x_2{}^2$$

$$R = \sqrt{\frac{r_{01}{}^2 + r_{02}{}^2 - 2 r_{01} r_{02} r_{12}}{1 - r_{12}{}^2}}$$

Where

$$r_{01} = \frac{n \Sigma x_1 y - \Sigma x_1 \Sigma y}{\sqrt{[n \Sigma x_1{}^2 - (\Sigma x_1)^2][n \Sigma y^2 - (\Sigma y)^2]}}$$

$$r_{02} = \frac{n \Sigma x_2 y - \Sigma x_2 \Sigma y}{\sqrt{[n \Sigma x_2{}^2 - (\Sigma x_2)^2][n \Sigma y^2 - (\Sigma y)^2]}}$$

$$r_{12} = \frac{n \Sigma x_1 x_2 - \Sigma x_1 \Sigma x_2}{\sqrt{[n \Sigma x_1{}^2 - (\Sigma x_1)^2][n \Sigma x_2{}^2 - (\Sigma x_2)^2]}}$$

Market Share
● Since most of the time the producer is not the sole supplier of the product to the market.
a. The market share has remained fairly constant.
$$D = MS \bullet D_{total}$$

$$MS = \Sigma(MS)_i / n$$

| Year	Total D	Amount Sold by A	Market Share
1	125	43	0.344
2	140	47	0.336
3	160	54	0.338
4	130	44	0.338
5	200	68	0.340
6	175	60	0.343

b. The market share is not fixed.

   i. Market share is increasing every year, then linear regression
   ii. Use the methods discussed previously.

Selection of a forecasting method

- A single organization may use several different forecasting methods to anticipate the future of its various actives. It also will likely use different methods during the life cycle of a single product. The selection may depend on any or all of the following factors:
    1. Availability and accuracy of historical data.
    2. Degree of accuracy expected from the prediction.
    3. Cost of developing the forecasting.
    4. Length of the prediction period.
    5. Time available to make the analysis.
    6. Complexity of factors affecting future operations.

- Comparison of forecasting costs for different forecasting methods ad the cost of inaccuracy. For example, qualitative techniques range from the expensive and accurate market research method to the less costly but also usually less reliable method of relying on one individual's prophecy.
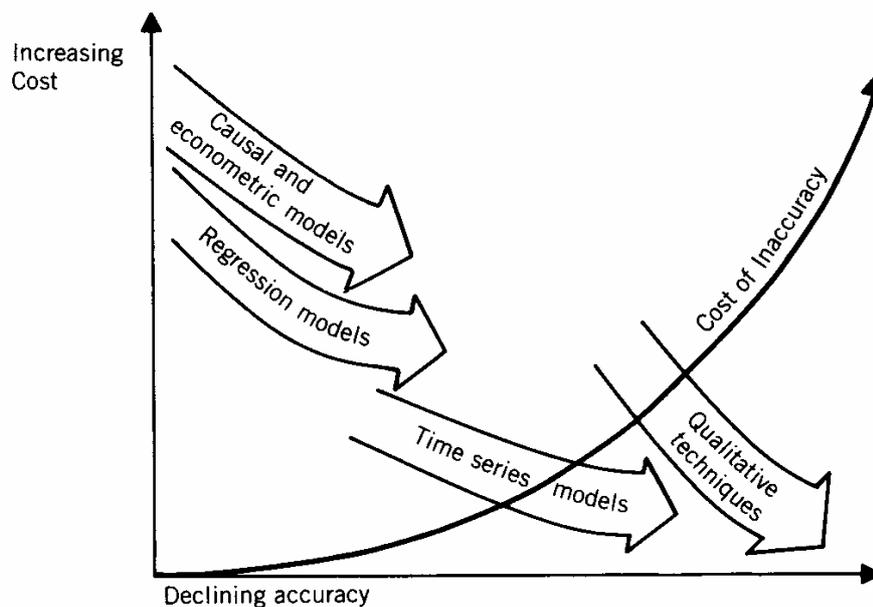
Evaluating Forecasting Model Performance
- Impulse response: respond very fast to changes in historical data are described as having a high impulse response.
- Noise dampening ability: forecasts that reflect every little happenstance fluctuation in the past data are said to include random variation, or noise.
- Measure of forecast accuracy: the accuracy of a forecasting model refers to how close actual data follow forecasts
- The larger the number of period, the greater is the noise-dampening ability and the lower impulse response of the forecast and vice versa.

Three measures of forecast accuracy are commonly used
- Standard error of forecast or standard deviation of the forecast s_{yx}

$$S_{yx} = \sqrt{\frac{\sum y^2 - a\sum y - b\sum xy}{n-2}}$$

- Mean squared error (MSE), $(s_{yx})^2$
- Mean absolute deviation (MAD)

$$MAD = \frac{\sum_{i=1}^{n} |Actual demand - Forecast demand|}{n}$$

How to Select a Forecasting Method (how to have a successful forecasting system)
- Several factors should be considered:
1. Cost
2. Accuracy
3. Data available
4. Time span
5. Nature of products and services
6. Impulse response and noise dampening
There may be a trade-off between cost and accuracy.