



AUM

American University Of The Middle East

Operations Management

MGT 320



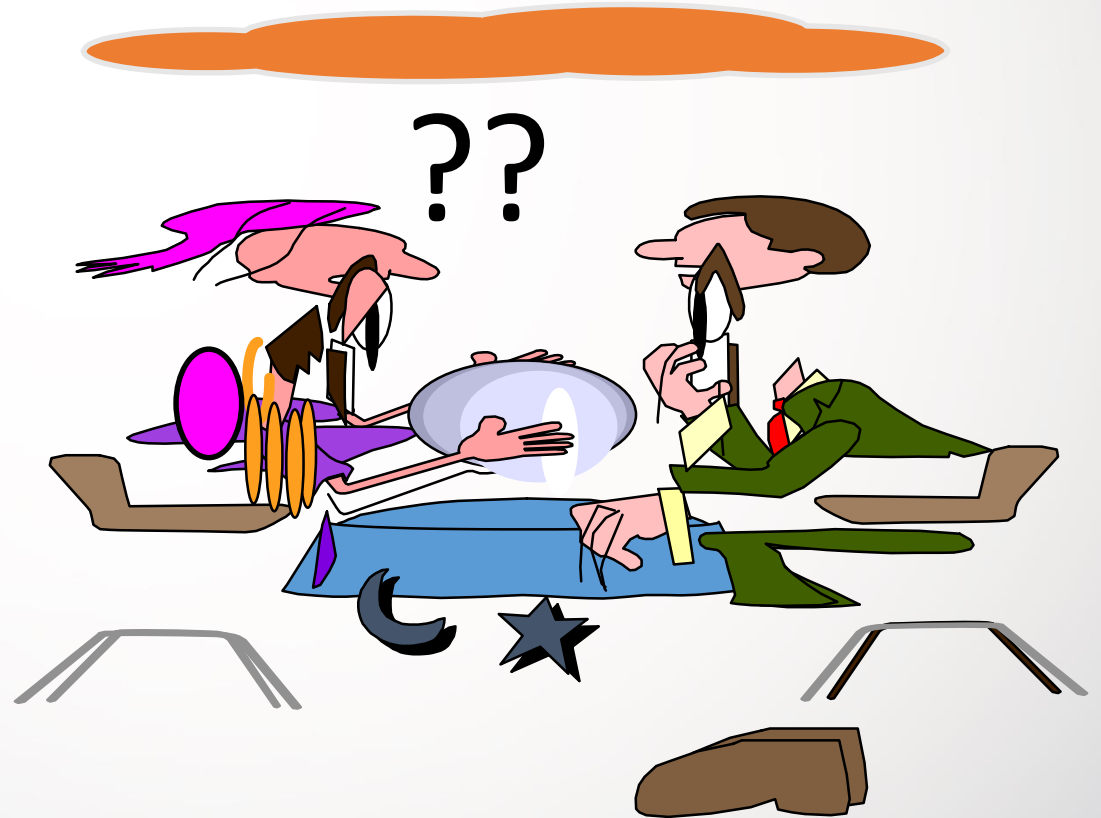
CHAPTER 3

Forecasting

Covers pages 74 to 94 & 110-112

What is Forecasting? (Ref. pg. 75)

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



Strategic Importance of Forecasting (Ref. pg. 76)

- 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 advance

Forecasting Time Horizons (Ref. pg. 76)

- 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, cash budgeting and analyzing operating plans.
- Long-range forecast
 - ☑ 3+ years
 - ☑ New product planning, facility location, research and development

Distinguishing Differences (Ref. pg. 77)

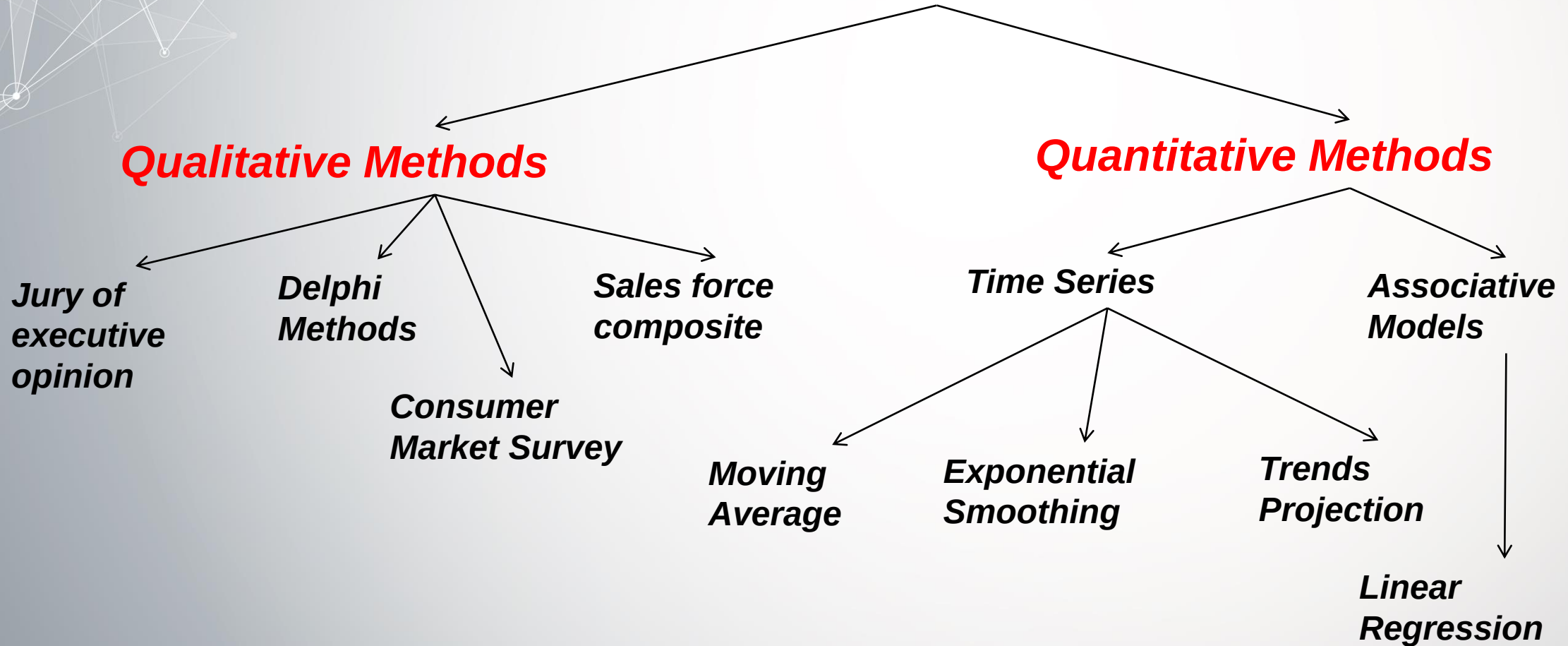
- Medium/long range forecasts deal with more comprehensive issues.
- Short-term
 - ☑ forecasting usually employs different methodologies than longer-term forecasting (using mathematical techniques).
 - ☑ forecasts tend to be more accurate than longer-term forecasts.

Elements of Good Forecasting (Ref. pg. 78)

- Forecast should be **accurate**.
- Forecast should be **timely**.
- Forecast should be **reliable**; it should work consistently.
- Forecast should be expressed by **meaningful units**.
- Forecast should be **cost-effective**; benefits should exceed the cost.

Approaches to Forecasting (Ref. pg. 82)

Forecasting Methods



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

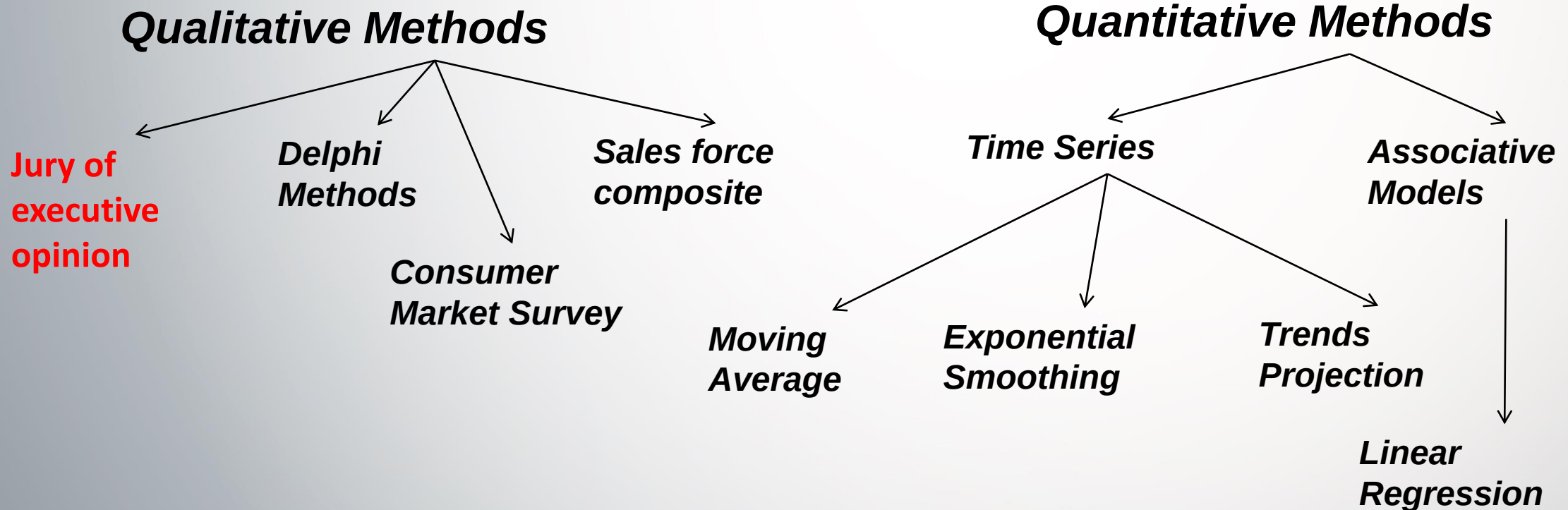
Forecasting Approaches

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

Approaches to Forecasting

Forecasting Methods



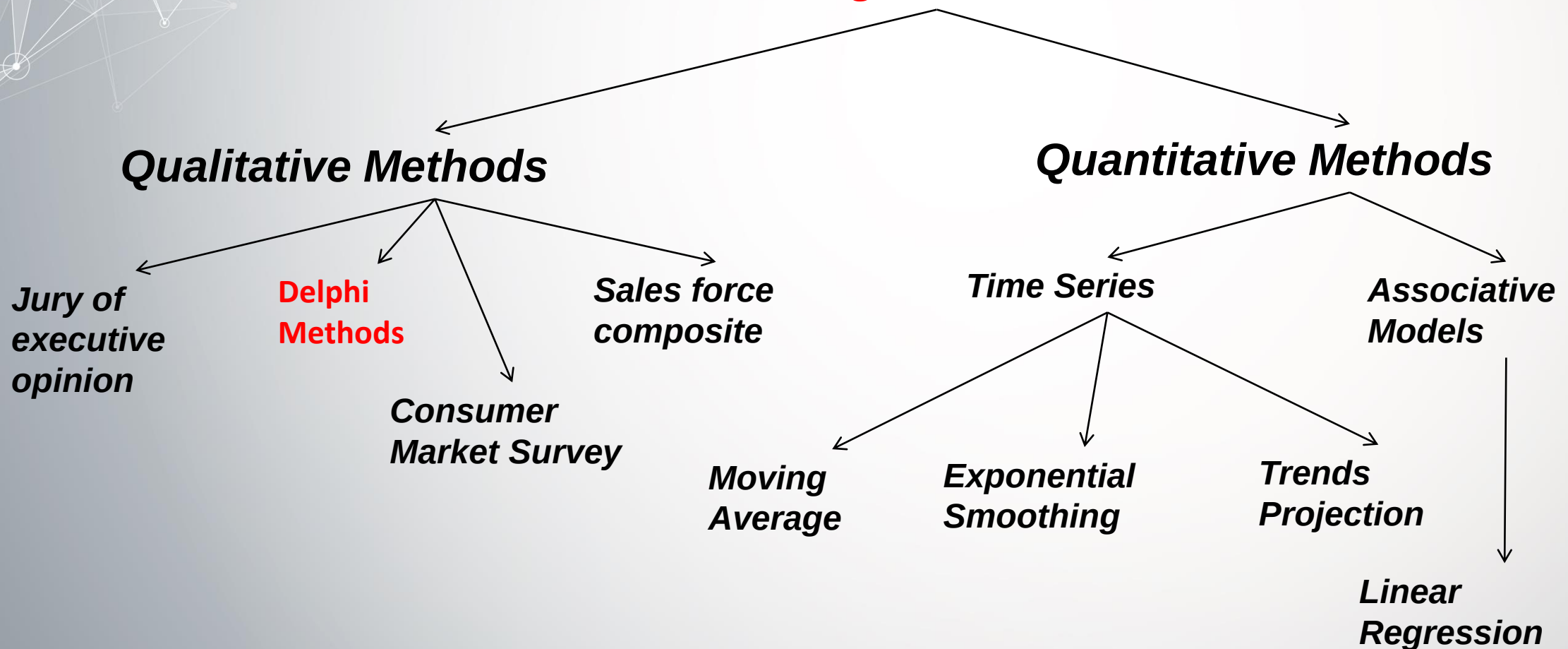
Jury of Executive Opinion (Ref. pg. 83)

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



Approaches to Forecasting

Forecasting Methods



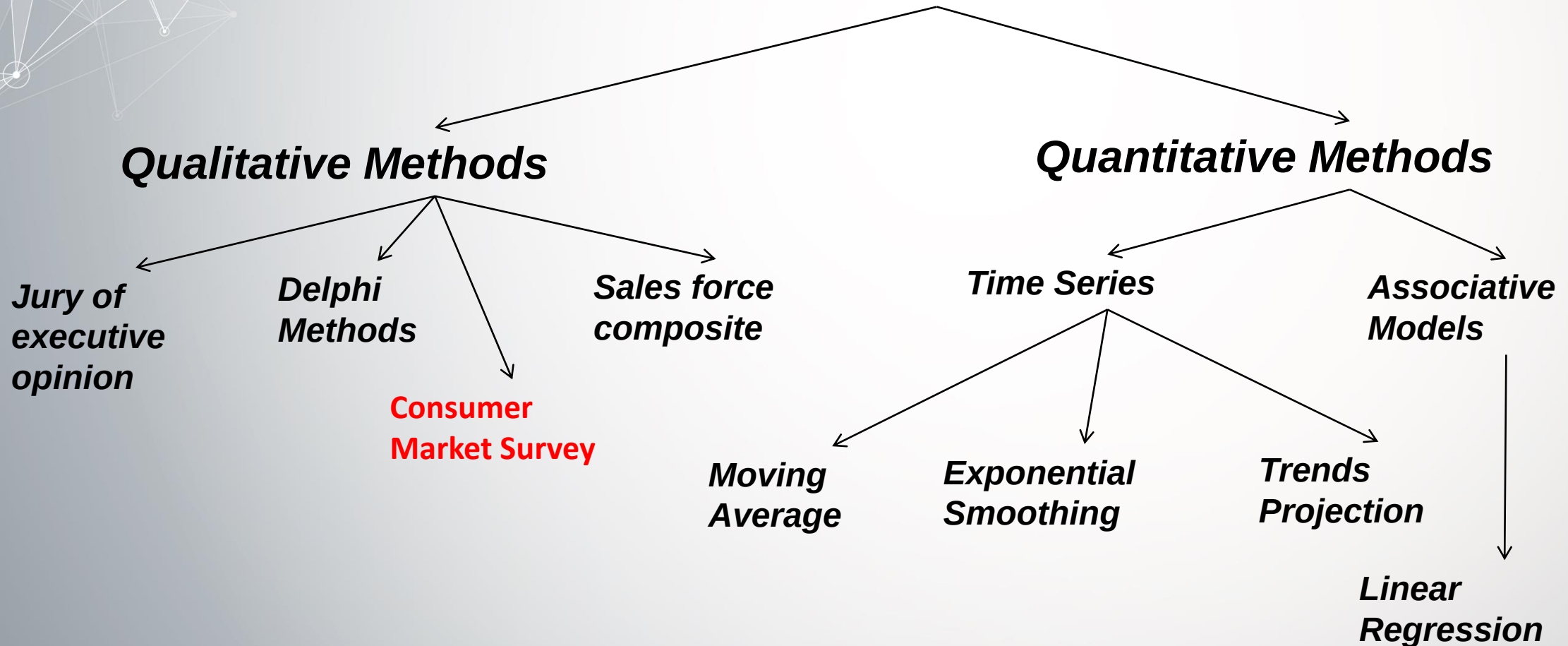
Delphi Method (Ref. pg. 83)

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



Approaches to Forecasting

Forecasting Methods

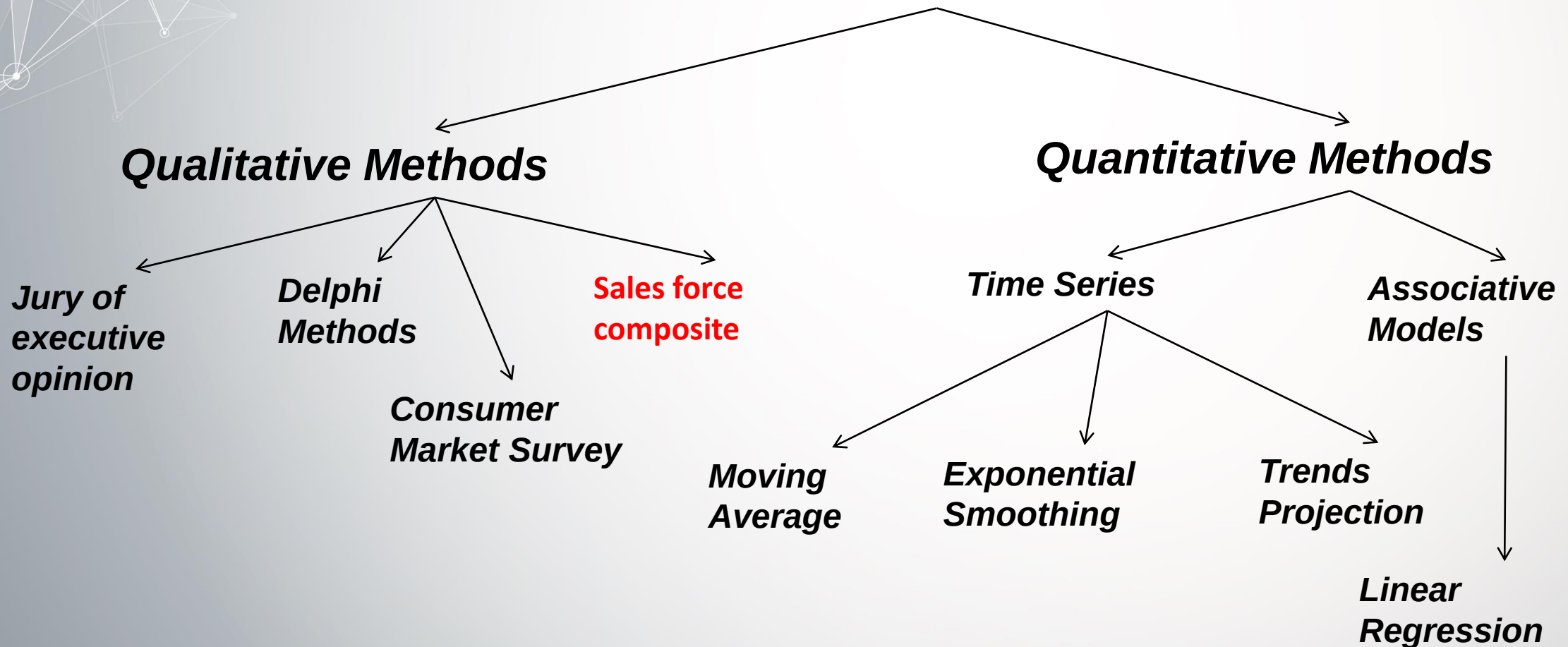


Consumer Market Survey (Ref. pg. 83)

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

Approaches to Forecasting

Forecasting Methods



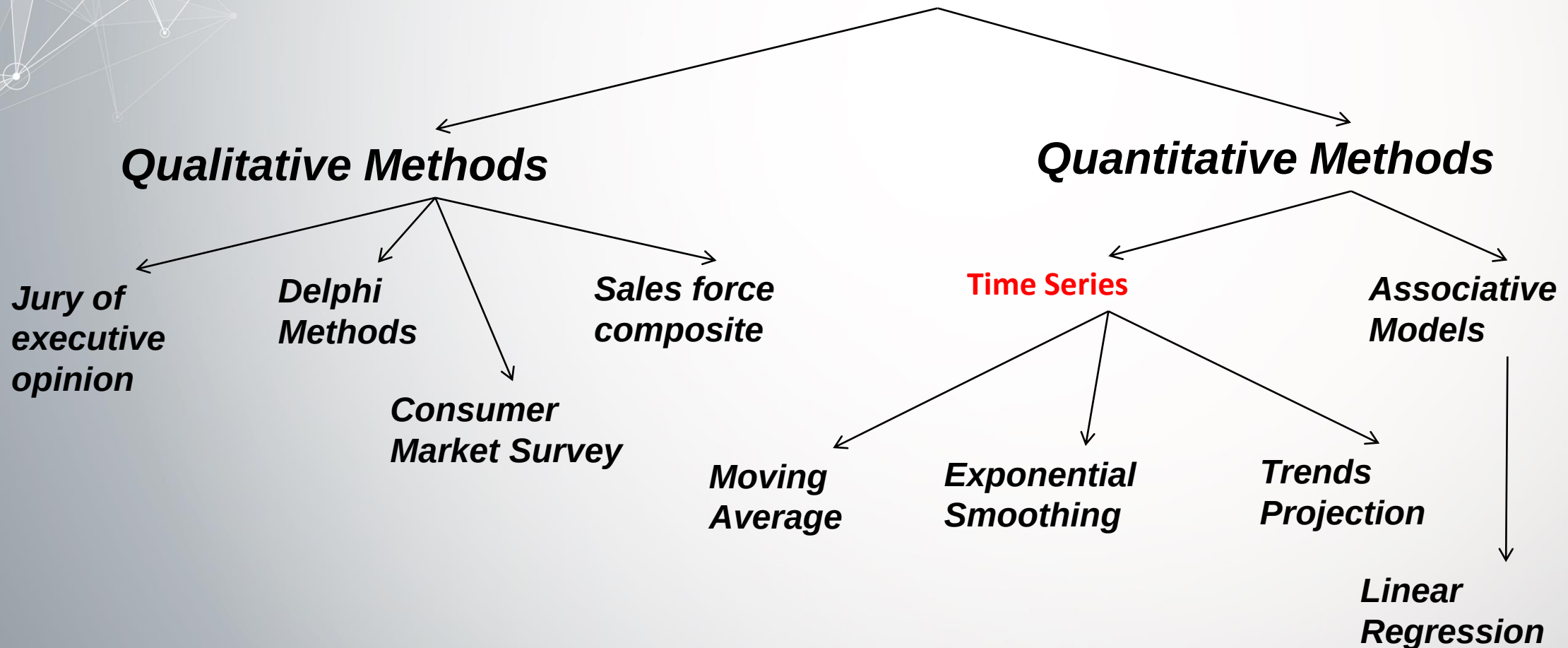


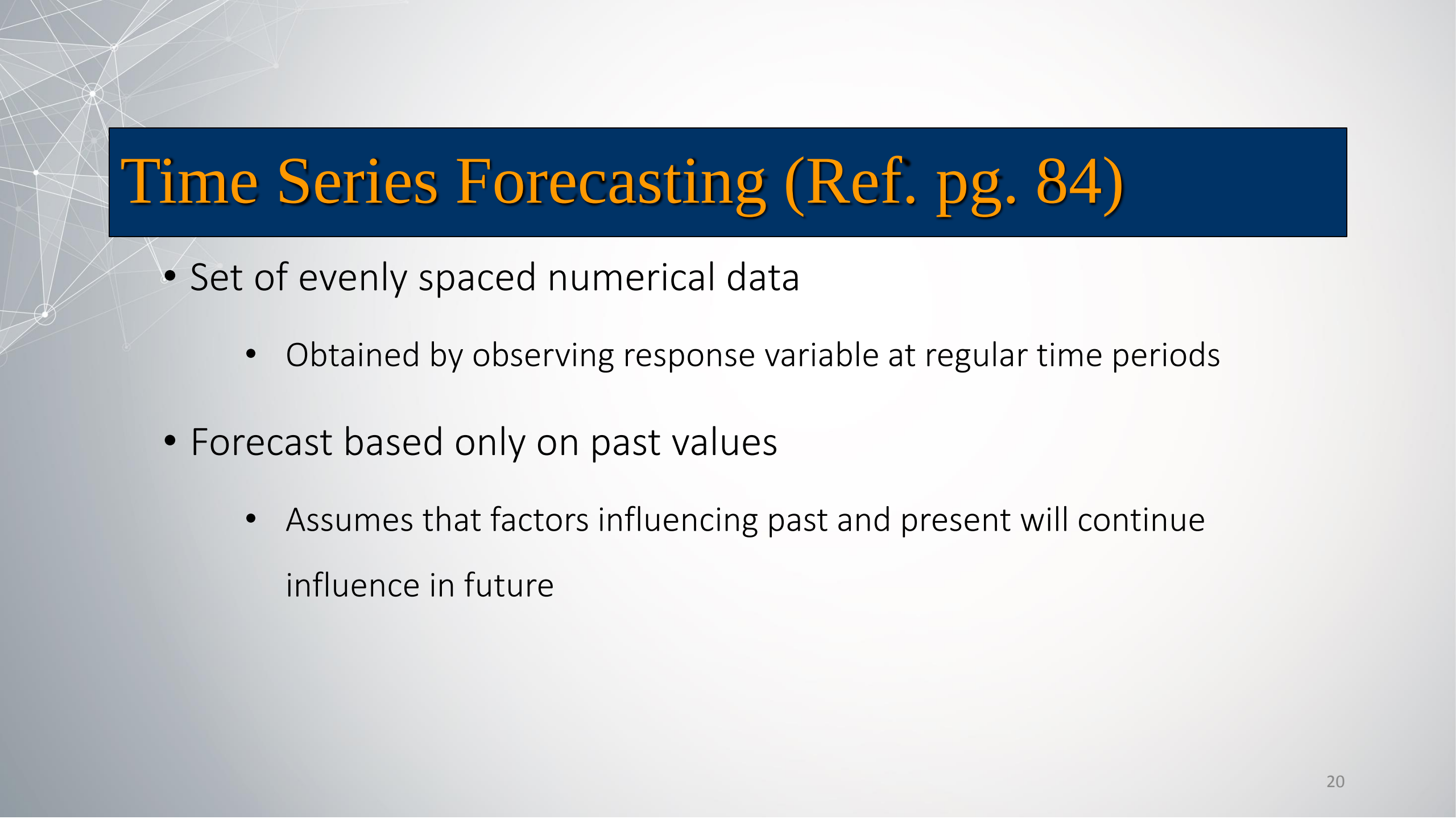
Sales Force Composite (Ref. pg. 83)

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

Approaches to Forecasting

Forecasting Methods

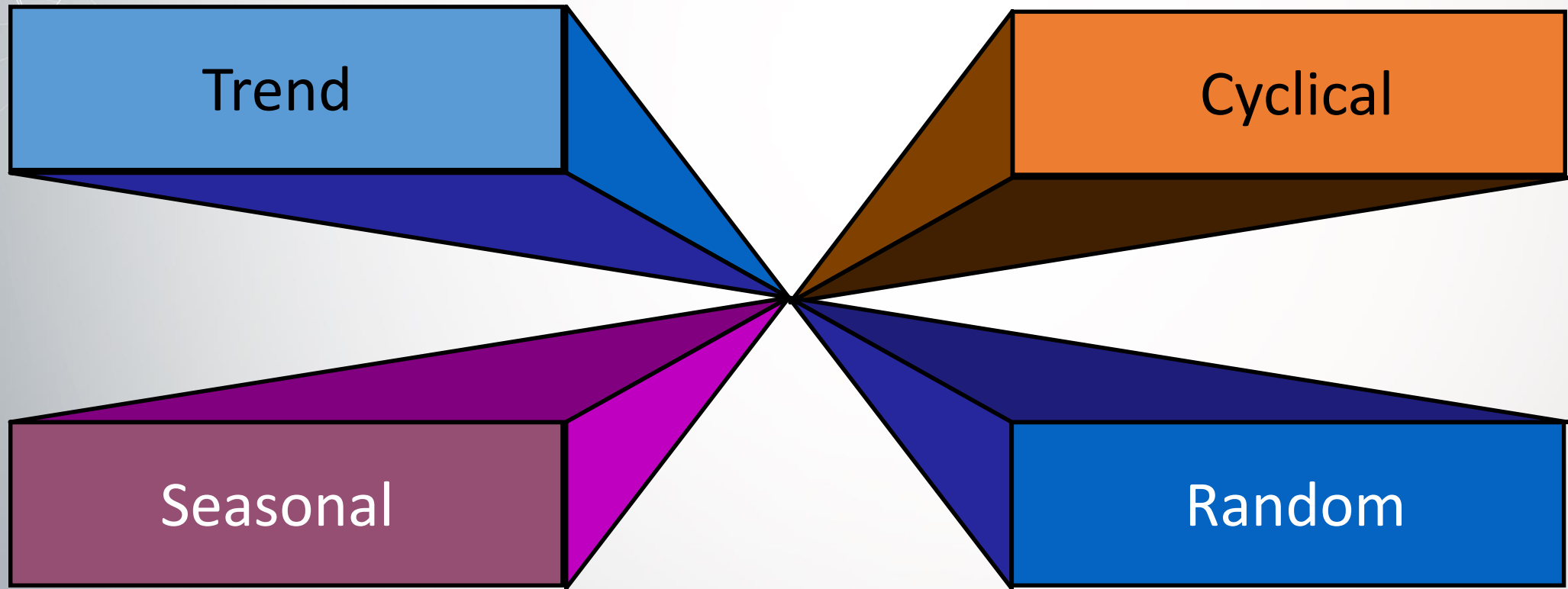




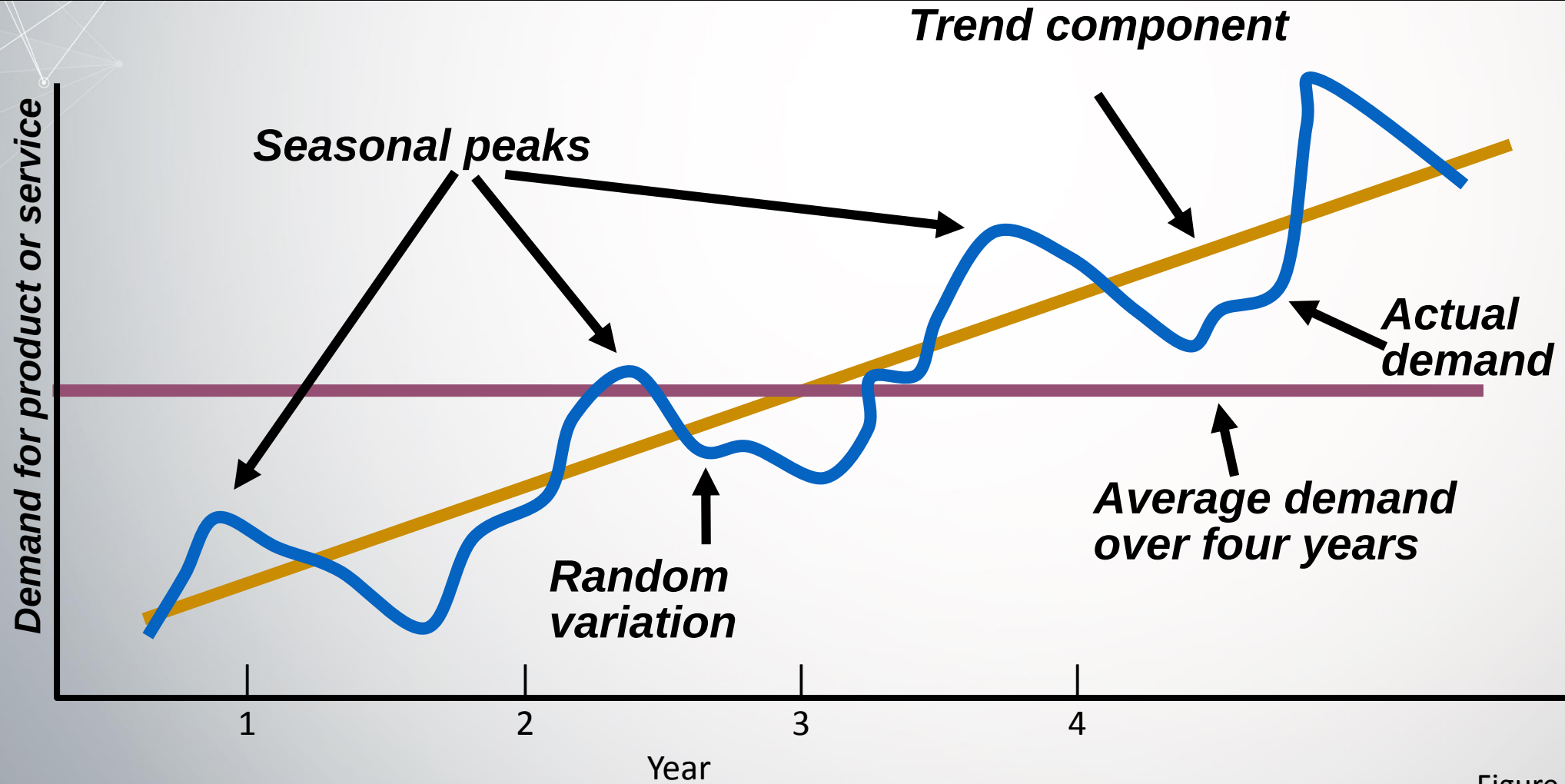
Time Series Forecasting (Ref. pg. 84)

- Set of evenly spaced numerical data
 - Obtained by observing response variable at regular time periods
- Forecast based only on past values
 - Assumes that factors influencing past and present will continue influence in future

Time Series Components (Ref. pg. 84)



Components of Demand



Trend Component

- Gradual upward or downward movement of the data overtime.
- Changes due to population, technology, age, culture, etc.
- Typically several years duration



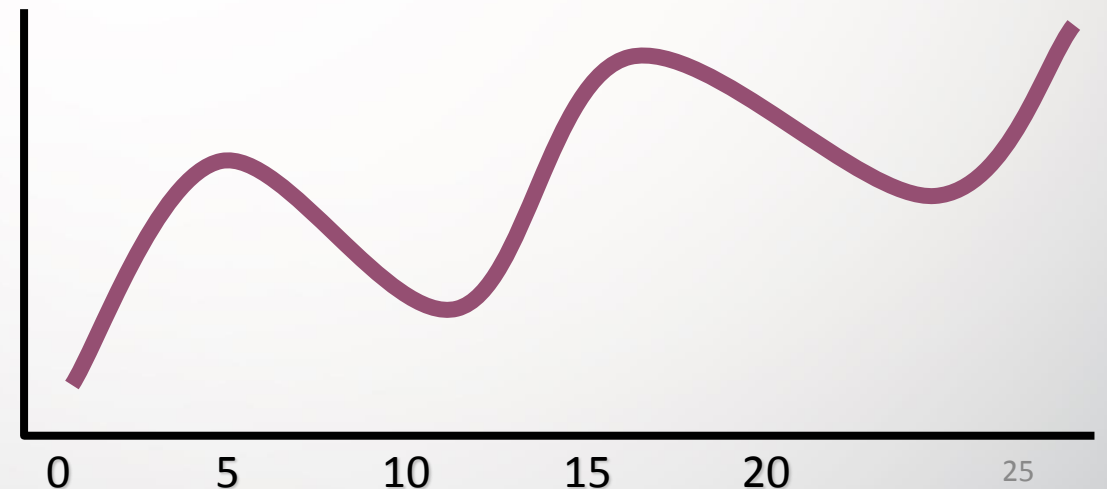
Seasonal Component

- Regular pattern of up and down fluctuations
- Ex. Restaurants, clothing,..
- 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

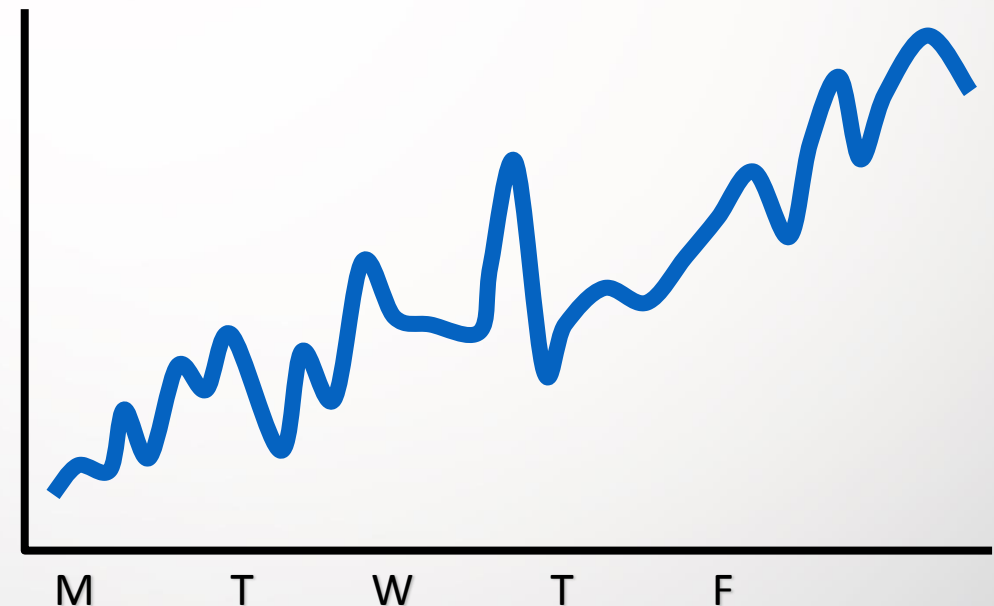
Cyclical Component

- Repeating up and down movements
- Affected by business cycle, political, and economic factors
- Multiple years duration
- Ex. Effects of government changes.



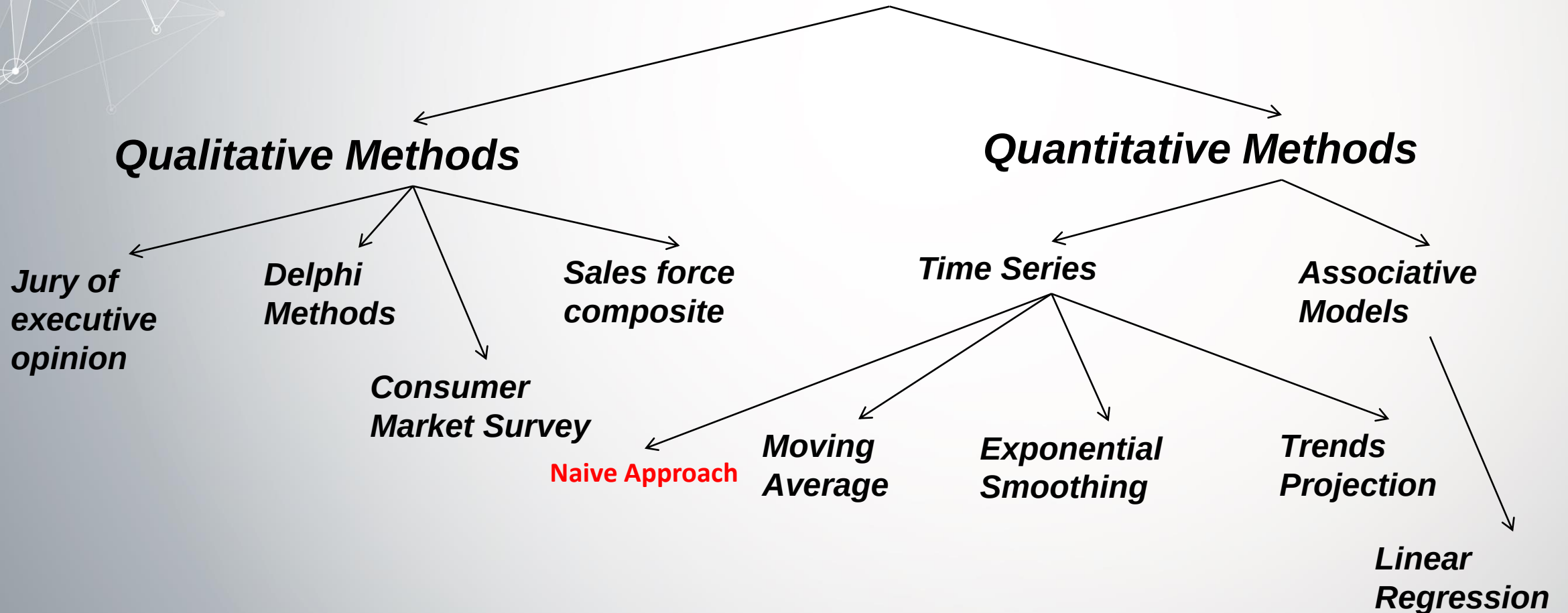
Random Component

- Erratic, unsystematic, 'residual' fluctuations
- Due to random variation or unforeseen events
- Short duration and nonrepeating



Approaches to Forecasting

Forecasting Methods

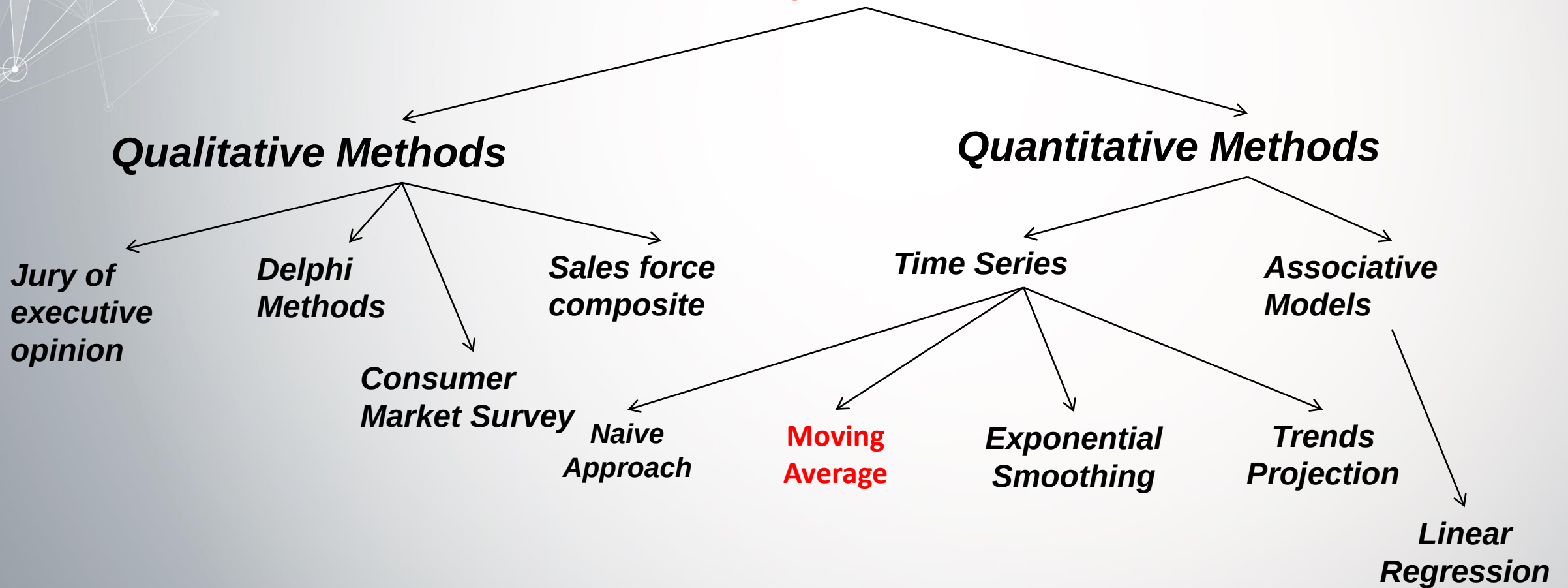


Naive Approach (Ref. pg. 84)

- 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 and efficient

Approaches to Forecasting

Forecasting Methods

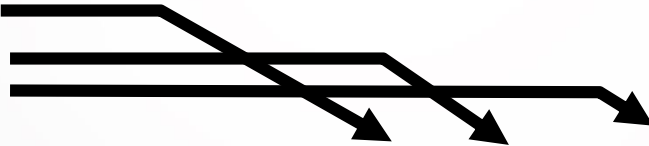


Moving Average Method (Ref. pg. 86)

- MA is a series of arithmetic means
- Used if we can assume that demand will stay steady over time.
- 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	$(10 + 12 + 13)/3 = 11 \frac{2}{3}$
May	19	$(12 + 13 + 16)/3 = 13 \frac{2}{3}$
June	23	$(13 + 16 + 19)/3 = 16$
July	26	$(16 + 19 + 23)/3 = 19 \frac{1}{3}$

Graph of Moving Average



Weighted Moving Average (Ref. pg. 88)

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

Weighted
moving average

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

Weighted Moving Average

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	$[(3 \times 13) + (2 \times 12) + (10)]/6 = 12\frac{1}{6}$
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	$[(3 \times 23) + (2 \times 19) + (16)]/6 = 20\frac{1}{2}$

Moving Average And Weighted Moving Average

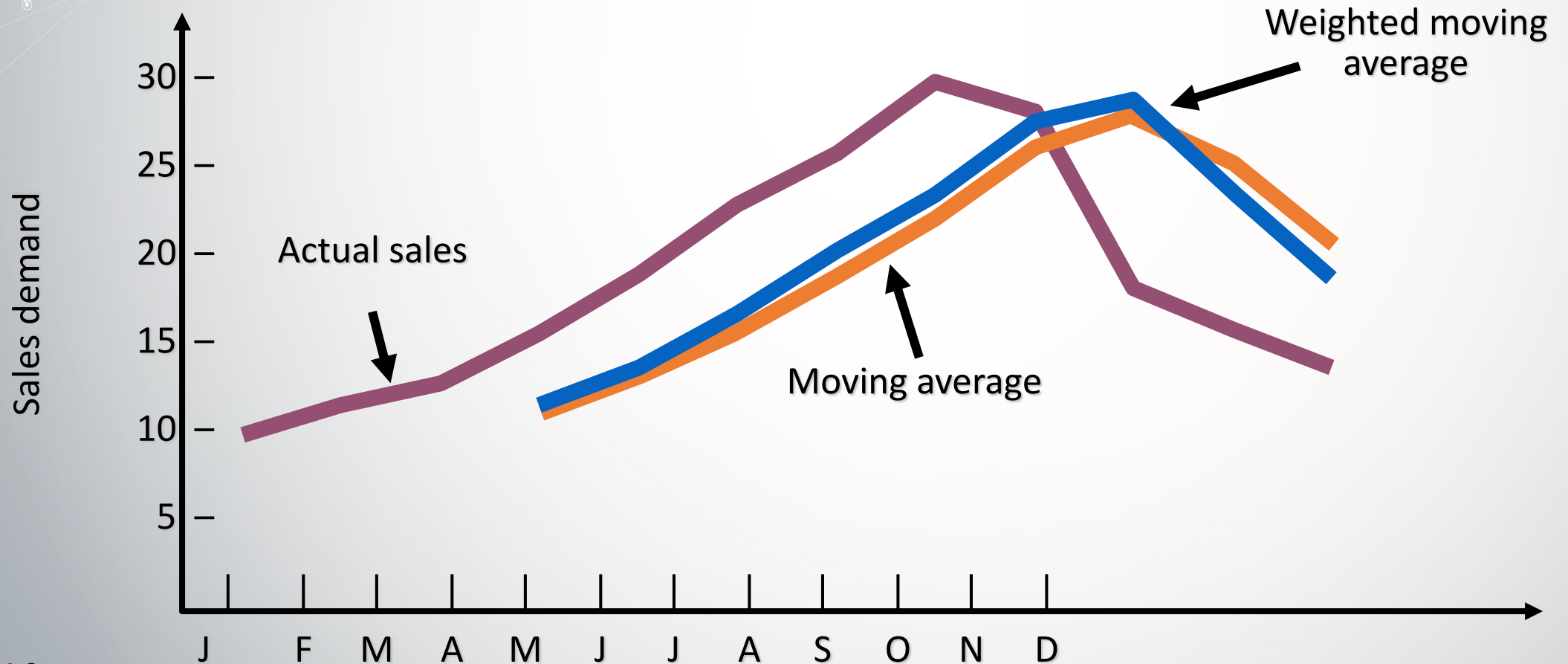


Figure 4.2

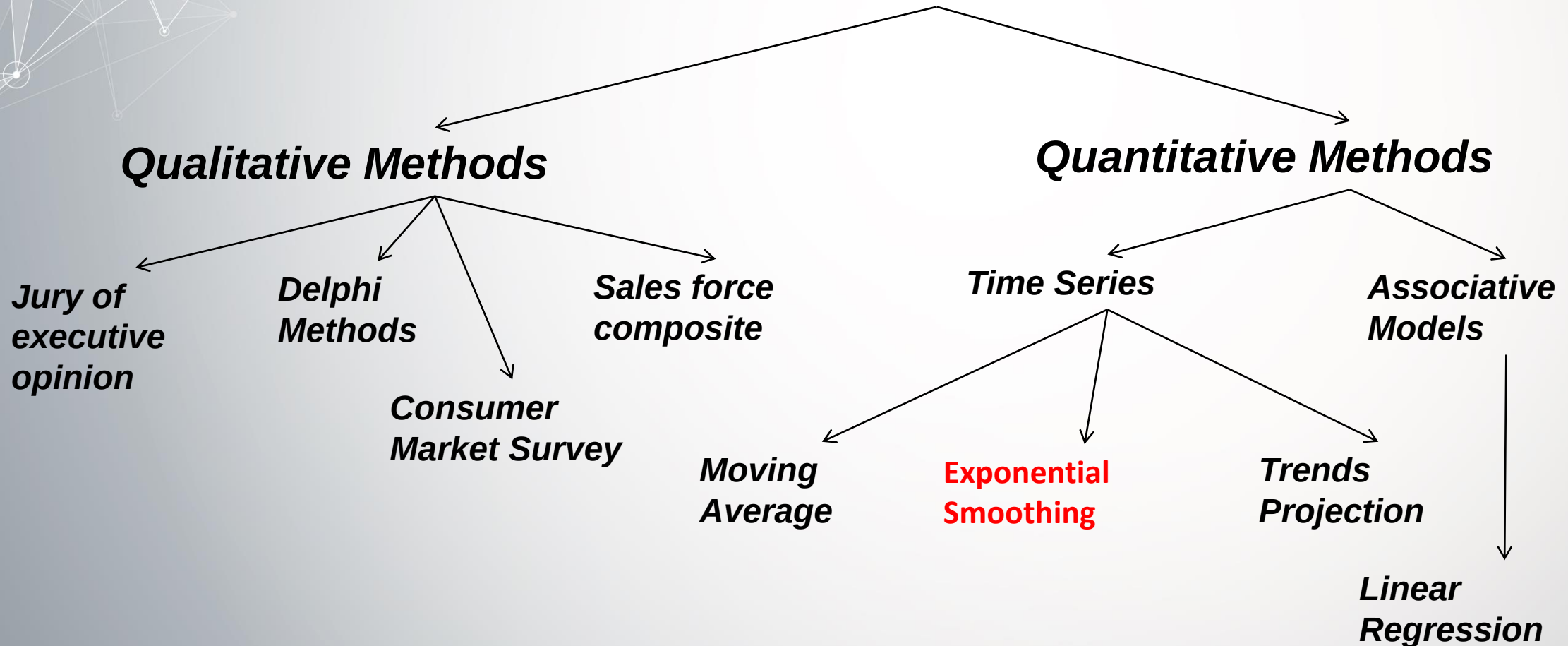


Potential Problems With Moving Average

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

Approaches to Forecasting

Forecasting Methods



Exponential Smoothing (Ref. pg. 89)

- Form of weighted moving average
 - Weights decline exponentially
 - Most recent data weighted most
- 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 ($0 \leq \alpha \leq 1$)

A decorative graphic in the top-left corner consisting of a network of white lines and dots on a light gray background, resembling a molecular or web structure.

Exponential Smoothing Example

Predicted demand = 142 Ford Mustangs

Actual demand = 153

Smoothing constant $\alpha = .20$

Exponential Smoothing Example

Predicted demand = 142 Ford Mustangs

Actual demand = 153

Smoothing constant $\alpha = .20$

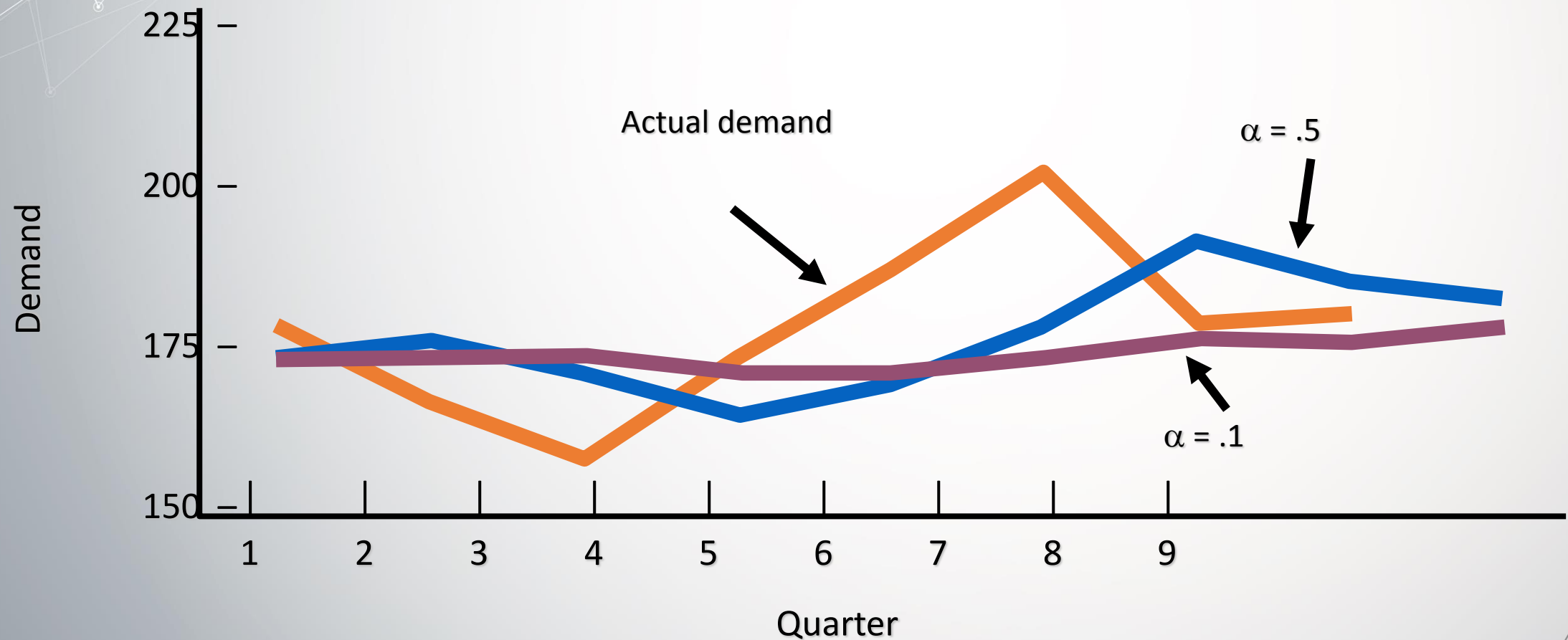
$$\begin{aligned}\text{New forecast} &= 142 + .2(153 - 142) \\ &= 142 + 2.2 \\ &= 144.2 \approx 144 \text{ cars}\end{aligned}$$

Effect of Smoothing Constants

- (α is high) mean that more weight are given to the recent data.
- (α is Low) mean that more weight are given to the past data.
- If $\alpha = 1$, then $F_t = 1 A_{t-1}$

α can make the difference between accurate and inaccurate forecasting.

Impact of Different α (Ref. pg. 90)



Choosing α

The objective is to obtain the most accurate forecast no matter the technique

We generally do this by selecting the model that gives us the lowest forecast error

$$\begin{aligned}\text{Forecast error} &= \text{Actual demand} - \text{Forecast value} \\ &= A_t - F_t\end{aligned}$$

Common Measures of Error (Ref. pg. 81)

Mean Absolute Deviation (MAD)

$$\text{MAD} = \frac{\sum |\text{actual} - \text{forecast}|}{n}$$

Mean Squared Error (MSE)

$$\text{MSE} = \frac{\sum (\text{forecast errors})^2}{n-1}$$

Common Measures of Error

Mean Absolute Percent Error (MAPE)

$$\text{MAPE} = \frac{100 \sum_{i=1}^n |\text{actual}_i - \text{forecast}_i| / \text{actual}_i}{n} \times 100\%$$

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	175	5
2	168	176	8	178	10
3	159	175	16	173	14
4	175	173	2	166	9
5	190	173	17	170	20
6	205	175	30	180	25
7	180	178	2	193	13
8	182	178	4	186	4
			84		100

Comparison of Forecast Error

Quarter	Actual Tonage 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	175	5
2	168	176	8	178	10
3	159	175	16	173	14
4	175	173	2	166	9
5	190	173	17	170	20
6	205	175	30	180	25
7	180	178	2	193	13
8	182	178	4	186	4
			84		100

$$\text{MAD} = \frac{\sum |\text{deviations}|}{n}$$

For $\alpha = .10$

$$= 84/8 = 10.50$$

For $\alpha = .50$

$$= 100/8 = 12.50$$

Comparison of Forecast Error

Quarter	Actual Tonage Unloaded	Rounded Forecast with $\alpha = .10$	Sq of Absolute Deviation for $\alpha = .10$	Rounded Forecast with $\alpha = .50$	Sq of Absolute Deviation for $\alpha = .50$
1	180	175	25	175	25
2	168	176	64	178	100
3	159	175	256	173	196
4	175	173	4	166	81
5	190	173	289	170	400
6	205	175	900	180	625
7	180	178	4	193	169
8	182	178	16	186	16
			<u>1,558</u>		<u>1,612</u>
MAD			10.50		12.50

$$\text{MSE} = \frac{\sum (\text{Forecast Deviation})^2}{n-1}$$

For $\alpha = .10$

$$= 1,558/7 = 222.57$$

For $\alpha = .50$

$$= 1,612/7 = 230.28$$

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	175	5
2	168	176	8	178	10
3	159	175	16	173	14
4	175	173	2	166	9
5	190	173	17	170	20
6	205	175	30	180	25
7	180	178	2	193	13
8	182	178	4	186	4
			84		100
		MAD	10.50		12.50
		MSE	222.57		230.28

$$\text{MAPE} = \frac{100 \sum_{i=1}^n |\text{deviation}_i| / \text{actual}_i}{n}$$

For $\alpha = .10$
 $= 45.62/8 = 5.70\%$

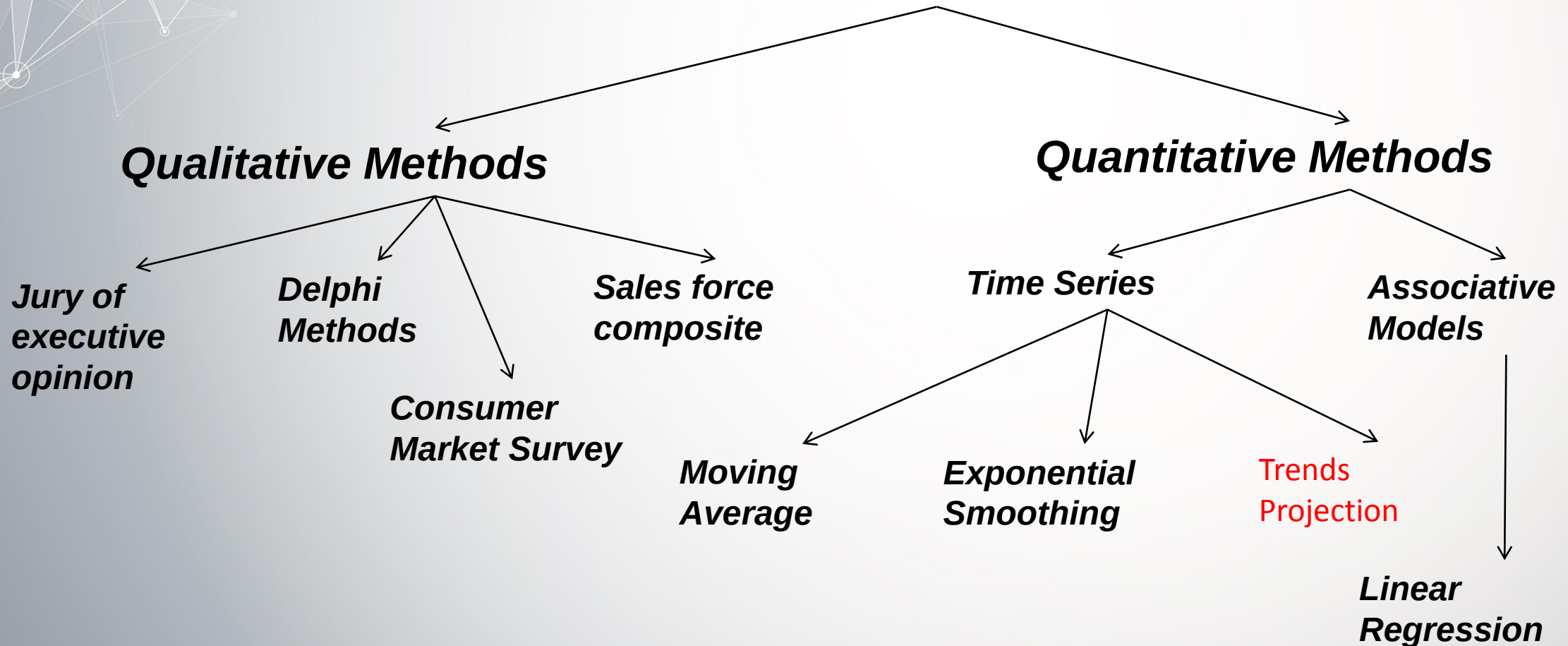
For $\alpha = .50$
 $= 54.8/8 = 6.85\%$

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	175	5
2	168	176	8	178	10
3	159	175	16	173	14
4	175	173	2	166	9
5	190	173	17	170	20
6	205	175	30	180	25
7	180	178	2	193	13
8	182	178	4	186	4
			<u>84</u>		
MAD			10.50	12.50	
MSE			222.57	230.28	
MAPE			5.70%	6.85%	

Approaches to Forecasting

Forecasting Methods



Trend Projections (Ref. pg. 91)

Fitting a trend line to historical data points to project into the medium-to-long-range, Linear Trend Equation

$$F_t = a + b(t)$$

$$y = a + b(x)$$

where F_t = Forecast for period t
 a = y-axis intercept
 b = slope of the regression line
 t = time period

Least Squares Method

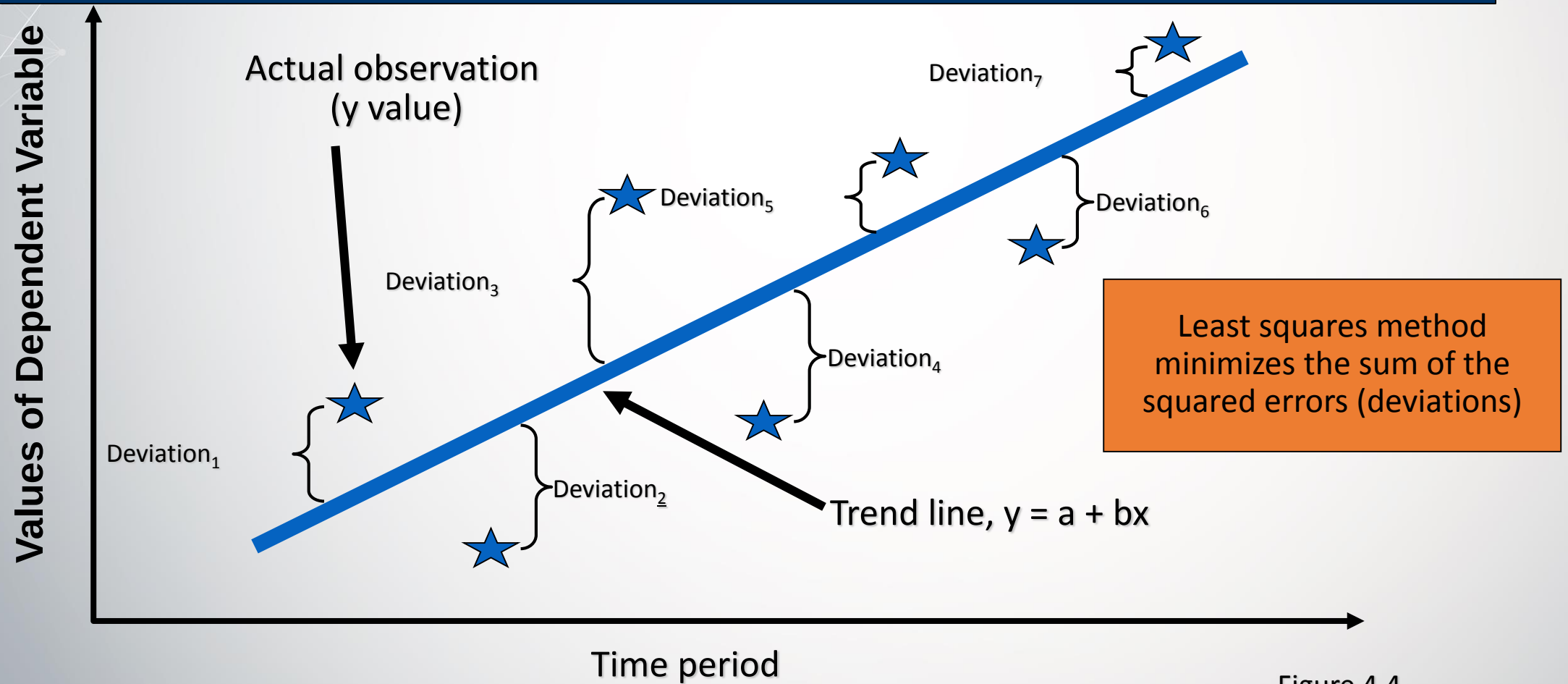


Figure 4.4

Least Squares Method (Ref. pg. 93)

Equations to calculate the regression variables *(both equations calculating for **b** and **a** are the same, whichever you wish to use, you can.)*

$$F_t = a + bt$$

$$b = \frac{n (\Sigma ty) - (\Sigma t)(\Sigma y)}{n (\Sigma t^2) - (\Sigma t)^2}$$

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

or

$$b = \frac{\Sigma ty - n \bar{t} \bar{y}}{\Sigma t^2 - n \bar{t}^2}$$

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

Least Squares Example

Year	Time Period (t)	Electrical Power Demand	t ²	ty
1999	1	74	1	74
2000	2	79	4	158
2001	3	80	9	240
2002	4	90	16	360
2003	5	105	25	525
2004	6	142	36	852
2005	7	122	49	854

$$\Sigma t = 28$$

$$\bar{t} = 4$$

$$\Sigma y = 692$$

$$\bar{y} = 98.86$$

$$\Sigma t^2 = 140$$

$$\Sigma ty = 3,063$$

The trend line is
 $y = 56.70 + 10.54t$

$$b = \frac{\Sigma ty - n \bar{t} \bar{y}}{\Sigma t^2 - n (\bar{t})^2} = \frac{3,063 - (7)(4)(98.86)}{140 - (7)(4^2)} = 10.54$$

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

Least Squares Example

