FORECASTING

Module 4

Forecasting

- **Predict the next number in the pattern:**

a) 3.7, 3.7, 3.7, 3.7, 3.7, ?

b) 2.5, 4.5, 6.5, 8.5, 10.5, ?

c) 5.0, 7.5, 6.0, 4.5, 7.0, 9.5, 8.0, 6.5, ?

Forecasting

- **Predict the next number in the pattern:**

a) 3.7, 3.7, 3.7, 3.7, 3.7, 3.7

b) 2.5, 4.5, 6.5, 8.5, 10.5, 12.5

c) 5.0, 7.5, 6.0, 4.5, 7.0, 9.5, 8.0, 6.5, 9.0

Outline

- What is forecasting?
- Types of forecasts
- Time-Series forecasting
- Good forecasts
- Monitoring forecasts

Forecasting

- What is Forecasting?
  - Determining Future Events Based on Historical Facts and Data
- Some Thoughts on Forecasts
  - Forecasts Tend to Be *Wrong*!
  - Forecasts Can Be *Biased*! (Marketing, Sales, etc.)
  - Forecasts Tend to Be Better for *Near Future*
- So, Why Forecast?
  - Better to Have “Educated Guess” About Future Than to Not Forecast At All!

What is Forecasting?

- Process of predicting a future event based on historical data
- Educated guessing
- Underlying basis of all business decisions
  - Production
  - Inventory
  - Personnel
  - Facilities

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

Why do we need to forecast?

In general, forecasts are almost always wrong. So,

Throughout the day we forecast very different things such as weather, traffic, stock market, state of our company from different perspectives.

Virtually every business attempt is based on forecasting. Not all of them are derived from sophisticated methods. However, “Best" educated guesses about future are more valuable for purpose of Planning than no forecasts and hence no planning.

Hochschule Bremen forecasts?

Importance of Forecasting in OM

Departments throughout the organization depend on forecasts to formulate and execute their plans.

- Finance needs forecasts to project cash flows and capital requirements.
- Human resources need forecasts to anticipate hiring needs.
- Production needs forecasts to plan production levels, workforce, material requirements, inventories, etc.
- What departments in your university needs to forecast?

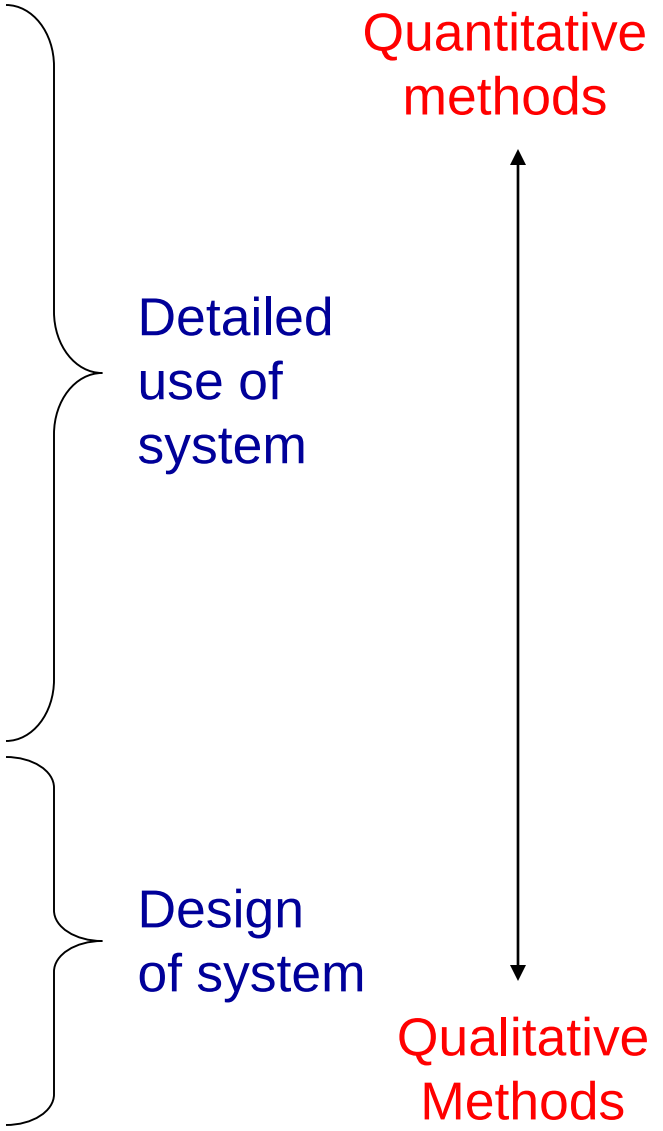
Importance of Forecasting in OM

Demand is not the only variable of interest to forecasters.

- Manufacturers also forecast worker absenteeism, machine availability, material costs, transportation and production lead times, etc.
- Besides demand, service providers are also interested in forecasts of population, of other demographic variables, of weather, etc.

Types of Forecasts by Time Horizon

- Short-range forecast
  - Usually < 3 months
    - Job scheduling, worker assignments
- Medium-range forecast
  - 3 months to 2 years
    - Sales/production planning
- Long-range forecast
  - > 2 years
    - New product planning



Short vs. Long Term

- Medium/long range forecasts
  - More comprehensive issues
  - Support management decisions
- Short-term forecasting usually employs different methodologies than longer-term forecasting
- Short-term forecasts tend to be more accurate than longer-term forecasts

How to Forecast?

- Qualitative Methods
  - Based On Educated Opinion & Judgment (Subjective)
  - Particularly Useful When Lacking Numerical Data (Example: Design and Introduction Phases of a Product's Life Cycle)
- Quantitative Methods
  - Based On Data (Objective)

Forecasting Approaches

Qualitative

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

Quantitative

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

Qualitative Methods

- Executive Judgment
- Sales Force Composite
- Market Research/Survey
- Delphi Method

Jury of Executive Opinion

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

Sales Force Composite

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

Consumer Market Survey

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

Delphi Method

- Iterative group process
- 3 types of people
  - Decision makers
  - Staff
  - Respondents
- Reduces ‘group-think

Delphi Method

As opposed to regular panels where the individuals involved are in direct communication, this method eliminates the effects of group potential dominance of the most vocal members. The group involves individuals from inside as well as outside the organization.

Typically, the procedure consists of the following steps:

Each expert in the group makes his/her own forecasts in form of statements

- The coordinator collects all group statements and summarizes them
- The coordinator provides this summary and gives another set of questions to each group member including feedback as to the input of other experts.
- The above steps are repeated until a consensus is reached.

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Quantitative Methods

- Time Series & Regression

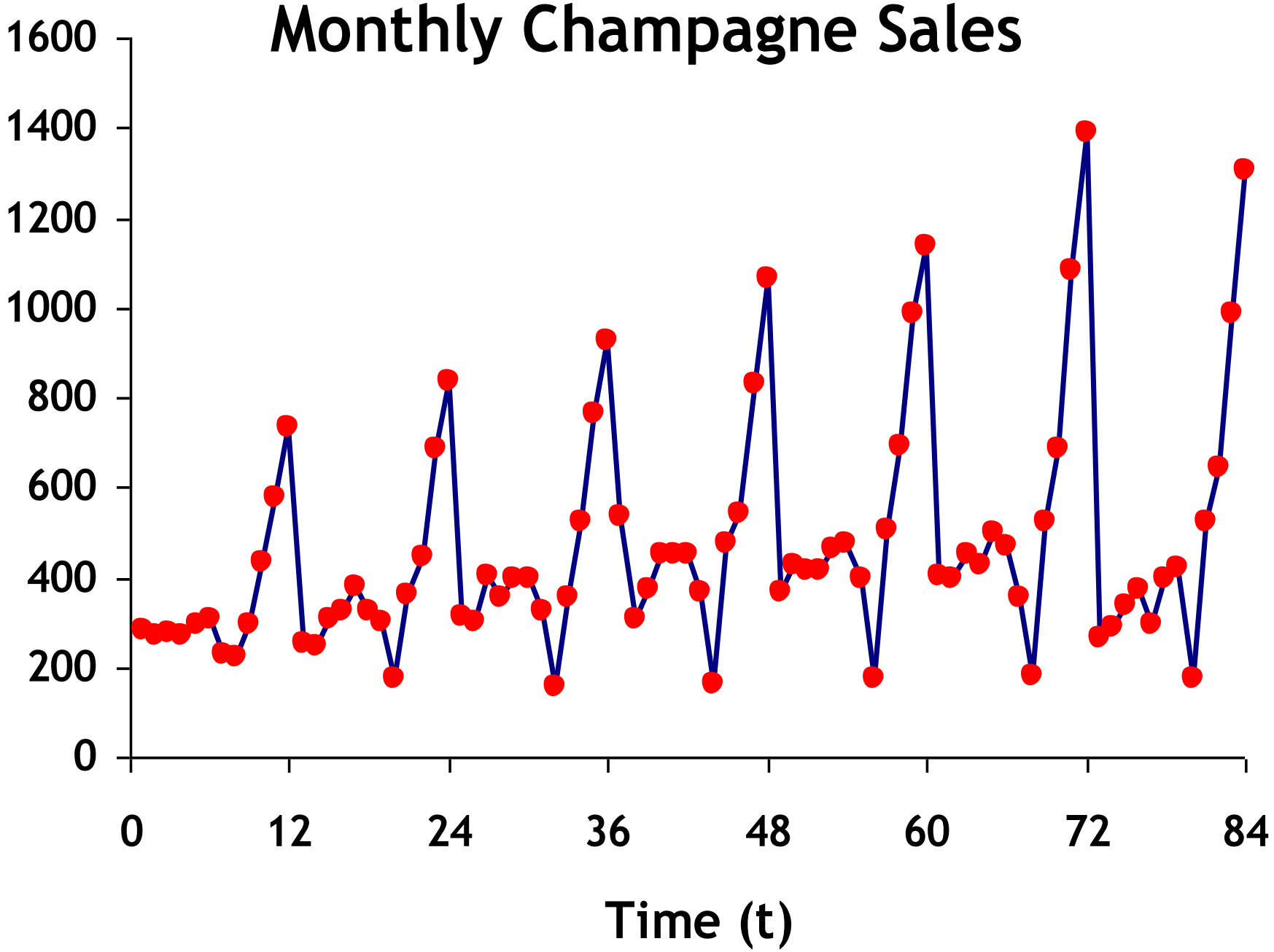
- Time Series → Popular Forecasting Approach in Operations Management

- Assumption:
  - “Patterns” That Occurred in the Past Will Continue to Occur In the Future

- Patterns
  - Random Variation
  - Trend
  - Seasonality
  - Composite

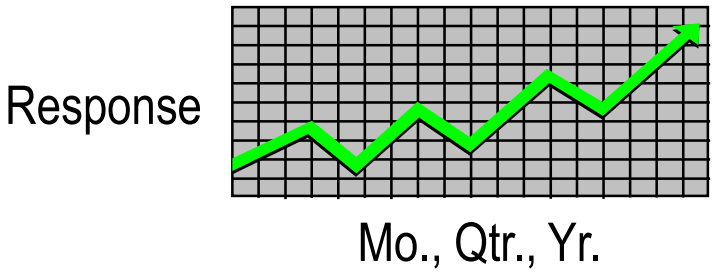
What is a Time Series?

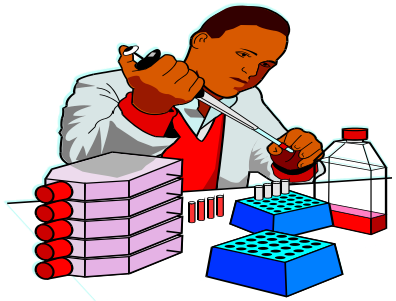
- Obtained by observing response variable at regular time periods
- Set of evenly spaced numerical data
- Forecast based only on past values
  - Assumes that factors influencing past and present will continue influence in future
- Assumes that factors influencing the past will continue to influence the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


Monthly Champagne Sales
1600
1400
1200
1000
800
600
400
200
0
0
12
24
36
48
60
72
84
Time (t)

Trend Component

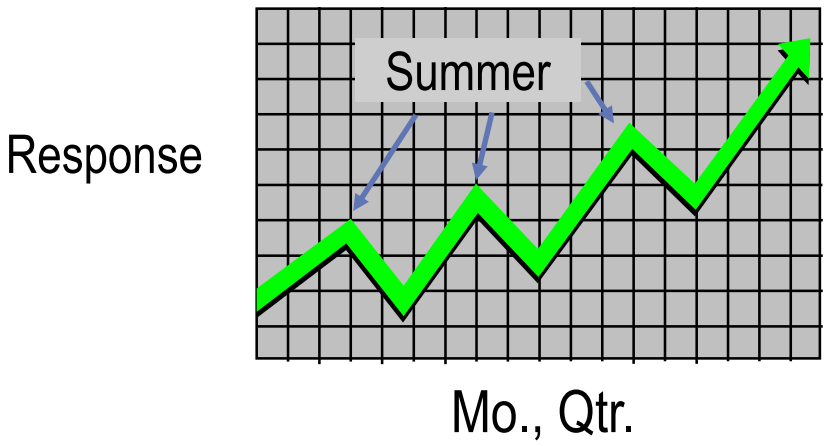
- Persistent, overall upward or downward pattern
- Due to population, technology etc.
- Several years duration

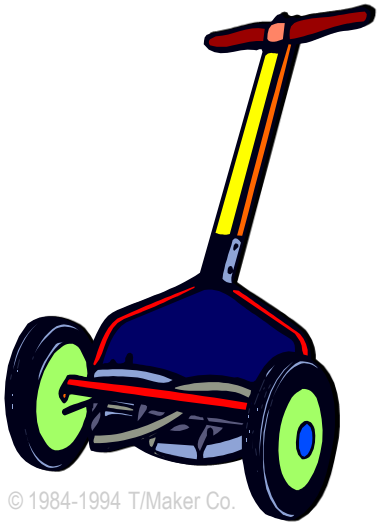




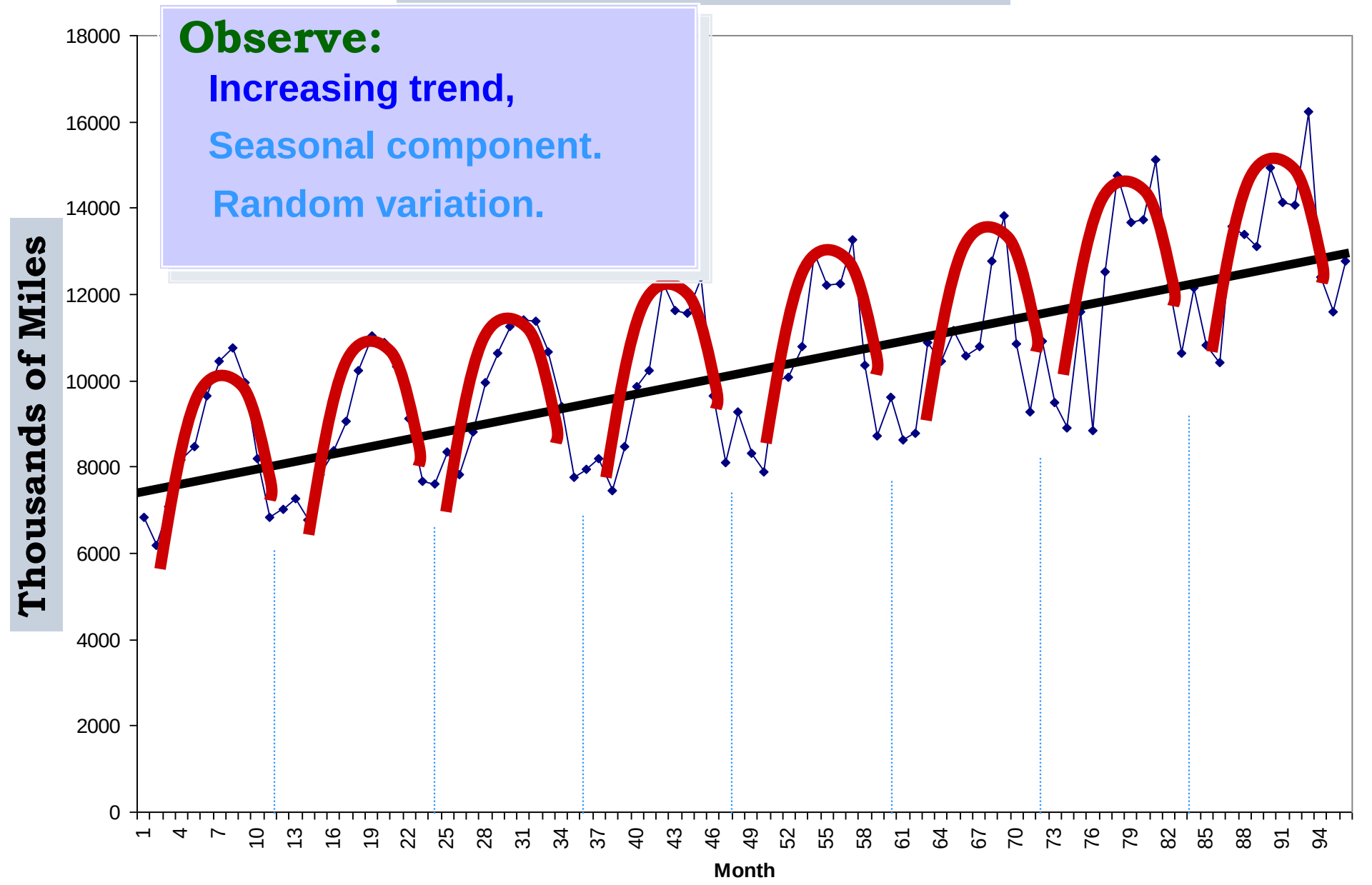
Seasonal Component

- Regular pattern of up & down fluctuations
- Due to weather, customs etc.
- Occurs within 1 year





UK Airline Miles

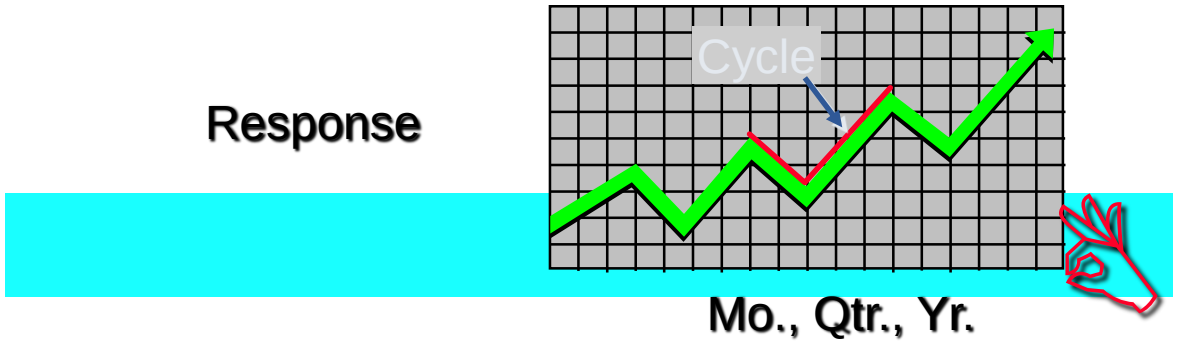


Common Seasonal Patterns

Period of Pattern	“Season” Length	Number of “Seasons” in Pattern
Week	Day	7
Month	Week	4 – 4 ½
Month	Day	28 – 31
Year	Quarter	4
Year	Month	12
Year	Week	52

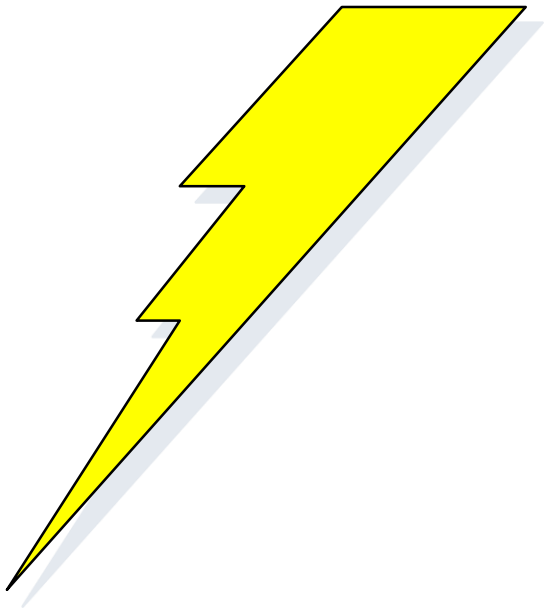
Cyclical Component

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

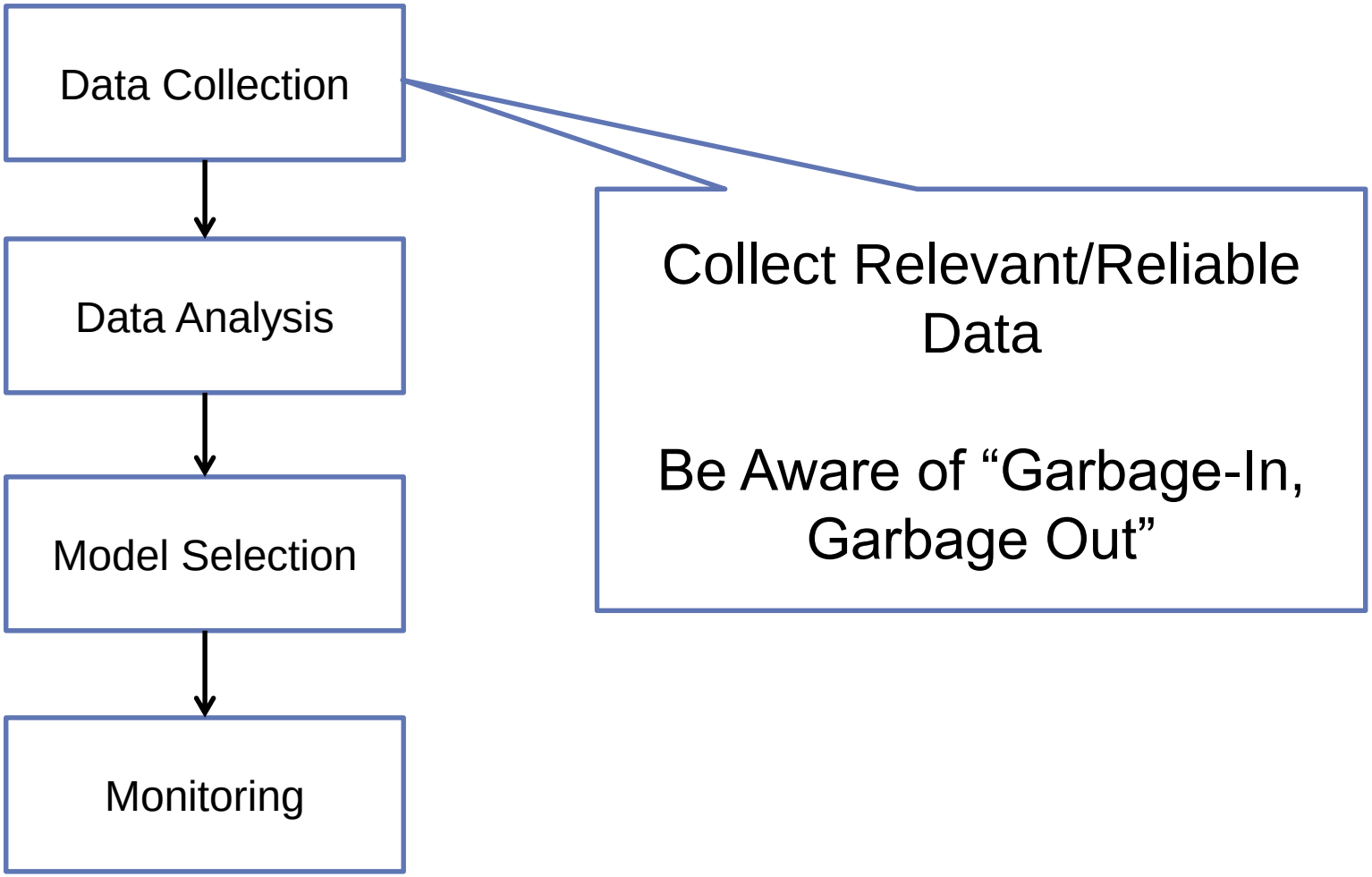


Random Component

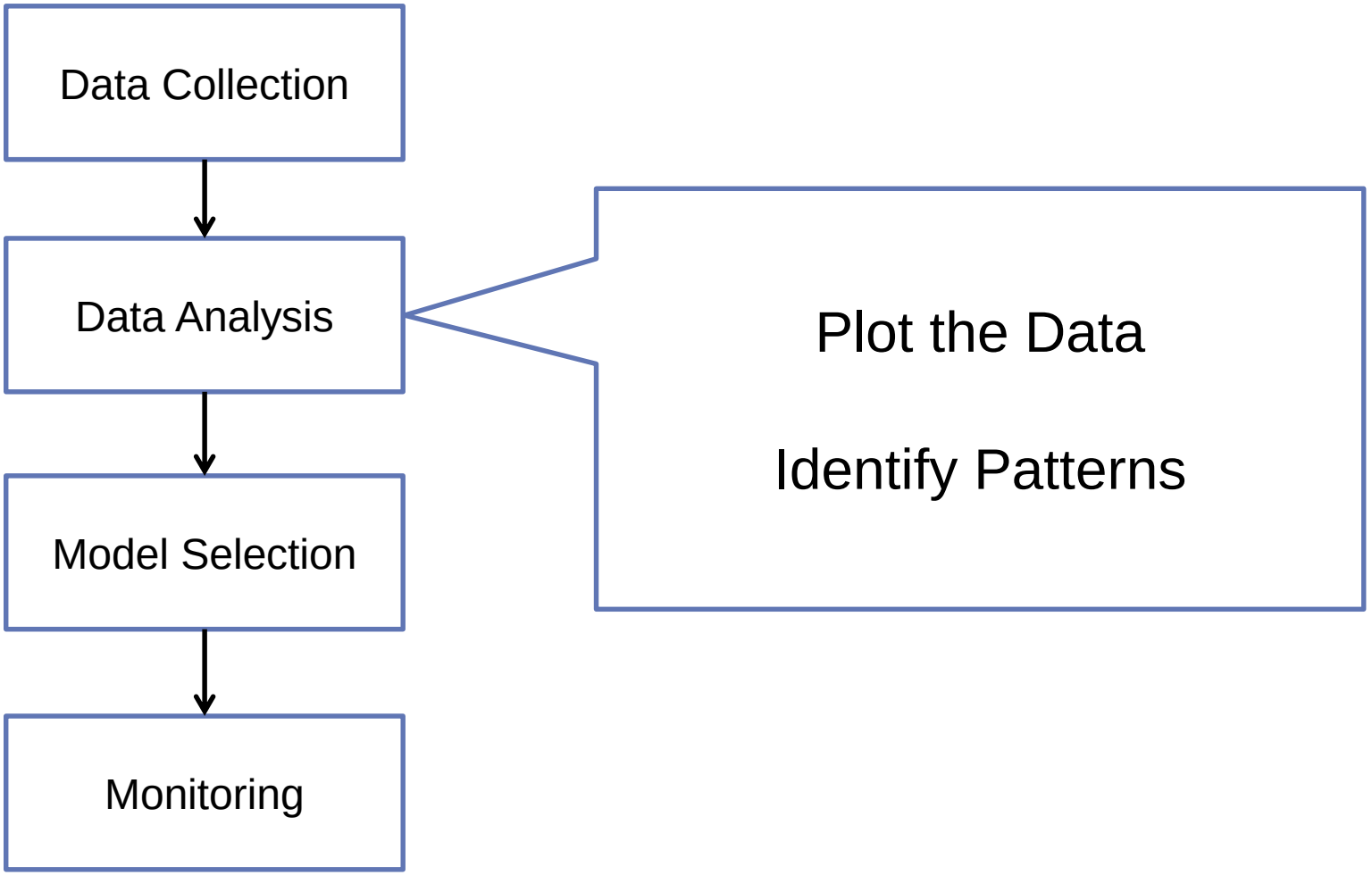
- Erratic, unsystematic, ‘residual’ fluctuations
- Due to random variation or unforeseen events
  - Union strike
  - Hurricane/Cyclone
- Short duration & non-repeating



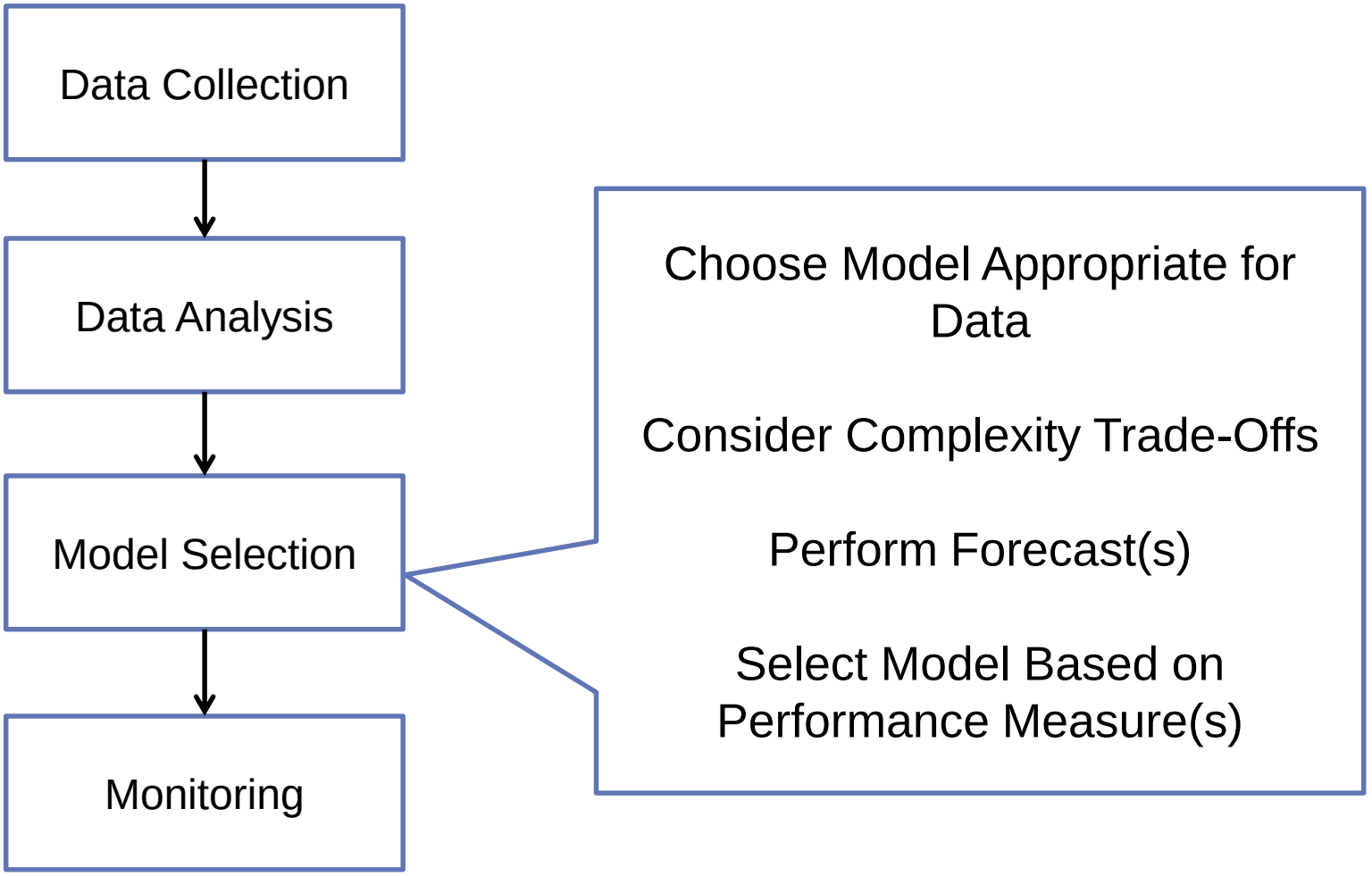
Forecasting Steps



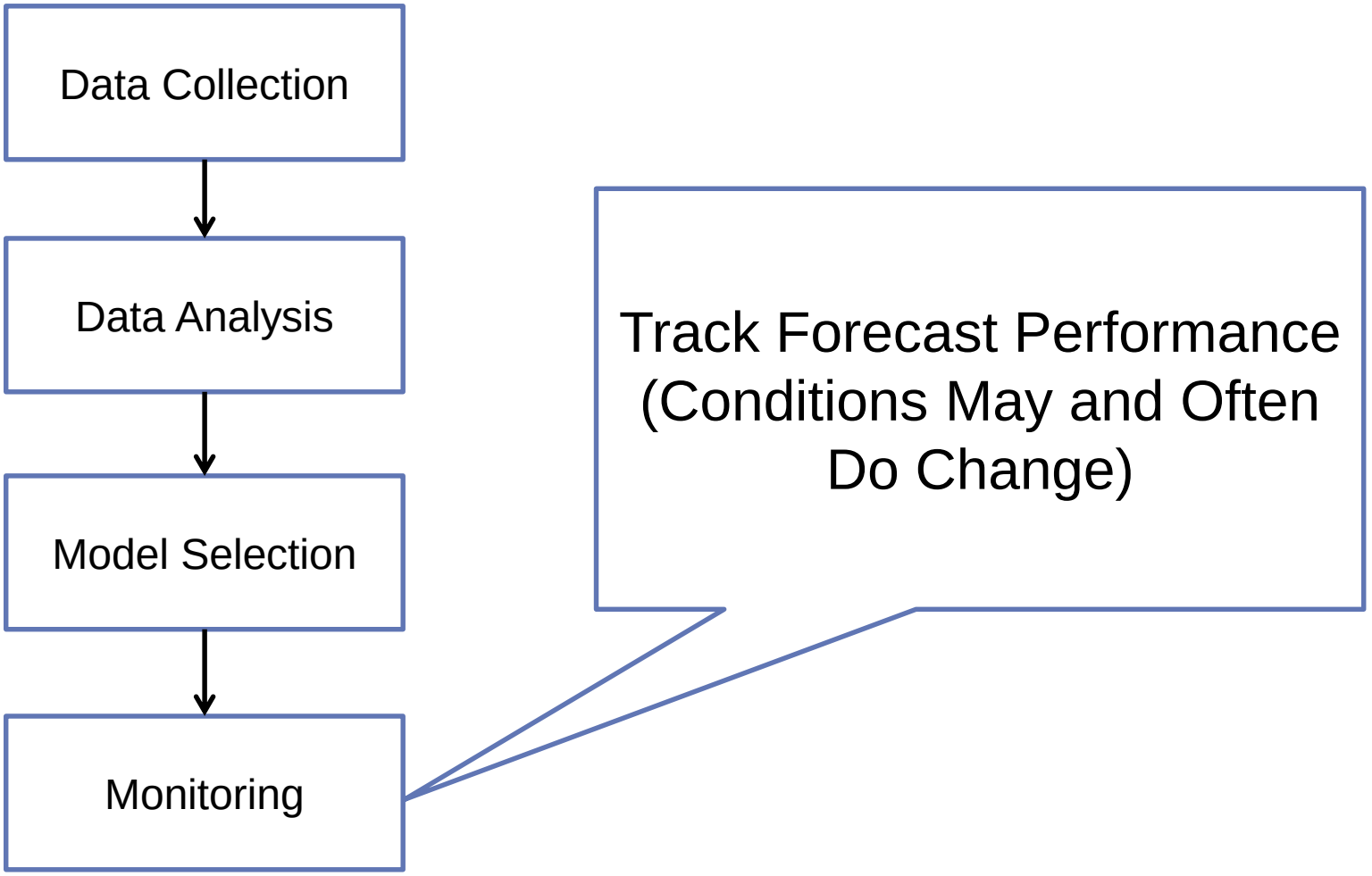
Forecasting Steps



Forecasting Steps



Forecasting Steps



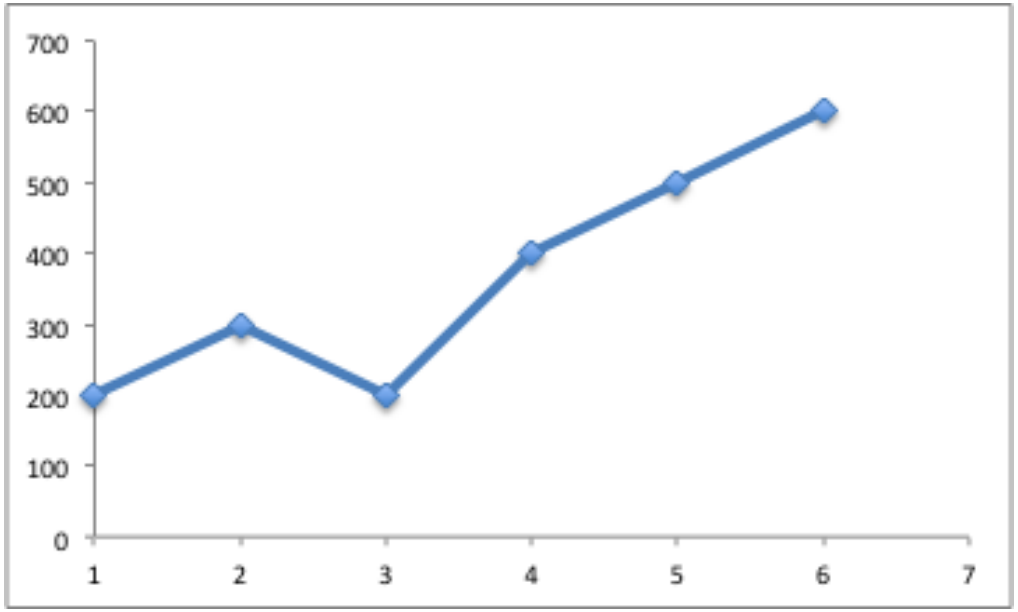
Time Series Models

- Short Term
  - Naïve
  - Simple Moving Average
  - Weighted Moving Average
  - Exponential Smoothing

Forecasting Example

- L&F Bakery has been forecasting by "gut feel." They would like to use a formal (i.e., quantitative) forecasting technique.

Month	Actual
Jan (1)	200
Feb (2)	300
Mar (3)	200
Apr (4)	400
May (5)	500
Jun (6)	600
Jul (7)	-



Forecasting Methods - Naïve

- Forecast for July = Actual for June
- $F_{t+1} = A_t$
- $F_{Jul} = A_{Jun} = 600$
- Forecast Very Sensitive to Demand Changes; Good for stable demand

Month	Actual
Jan (1)	200
Feb (2)	300
Mar (3)	200
Apr (4)	400
May (5)	500
Jun (6)	600
Jul (7)	-

Forecasting Methods - Naïve

	A	B	C	D
1				
2				
3		**Month**	**Actual**	**Naïve**
4		Jan (1)	200	
5		Feb (2)	300	200 ← =C4
6		Mar (3)	200	300 ← =C5
7		Apr (4)	400	200
8		May (5)	500	400
9		Jun (6)	600	500
10		Jul (7)	--	600

Forecasting Methods – Moving Avg

- Forecast for July = Average of June, May, and April
- $F_{t+1} = (A_t + A_{t-1} + \ldots)/n$
- $F_{Jul} = (600+500+400)/3 = 500$
- Values Equally Weighted;

  Good for stable demand;

  Sensitive to fluctuation;

  Lags

Month	Actual
Jan (1)	200
Feb (2)	300
Mar (3)	200
Apr (4)	400
May (5)	500
Jun (6)	600
Jul (7)	-

Forecasting Methods – Moving Avg

	A	B	C	D
1				
2				
3		**Month**	**Actual**	**MA(3)**
4		Jan (1)	200	--
5		Feb (2)	300	--
6		Mar (3)	200	--
7		Apr (4)	400	233.3333
8		May (5)	500	300
9		Jun (6)	600	366.6667
10		Jul (7)	--	500

=AVERAGE(C4:C6)

= AVERAGE(C5:C7)

$$F_{t+1} = \frac{A_t + A_{t-1} + A_{t-2} + \ldots + A_{t-n+1}}{n}$$

Simple Moving Average

You're manager in Amazon's electronics department. You want to forecast ipod sales for months 4-6 using a 3-period moving average.

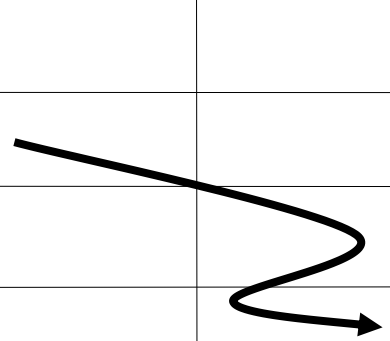
Month	Sales (000)	Moving Average (n=3)
1	4	NA
2	6	NA
3	5	NA
4	?	(4+6+5)/3=5
5	?	
6	?	

What if ipod sales were actually 3 in month 4

Month	Sales (000)	Moving Average (n=3)
1	4	NA
2	6	NA
3	5	NA
4	3	5
5	?	
6	?	

Forecast for Month 5?

Month	Sales (000)	Moving Average (n=3)
1	4	NA
2	6	NA
3	5	NA
4	3	5
5	?	(6+5+3)/3=4.667
6	?	



Actual Demand for Month 5 = 7

Month	Sales (000)	Moving Average (n=3)
1	4	NA
2	6	NA
3	5	NA
4	3	5
5	? 7	4.667
6	?	

Forecast for Month 6?

Month	Sales (000)	Moving Average (n=3)
1	4	NA
2	6	NA
3	5	NA
4	3	5
5	7	4.667
6	?	(5+3+7)/3=5

Weighted Moving Average Method

- Used when trend is present
  - Older data usually less important
- Weights based on intuition
  - Often lay between 0 & 1, & sum to 1.0
- Equation

$$WMA = \frac{\Sigma(\text{Weight for period } n)(\text{Demand in period } n)}{\Sigma \text{Weights}}$$

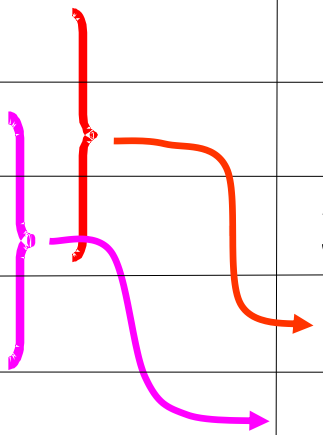
Weighted Moving Average: 3/6, 2/6, 1/6

Month	Sales (000)	Weighted Moving Average
1	4	NA
2	6	NA
3	5	NA
4	?	31/6 = 5.167
5	?	
6	?	

$$F_{t+1} = w_1 A_t + w_2 A_{t-1} + w_3 A_{t-2} + \ldots + w_n A_{t-n+1}$$

Weighted Moving Average: 3/6, 2/6, 1/6

Month	Sales (000)	Weighted Moving Average
1	4	NA
2	6	NA
3	5	NA
4	3	31/6 = 5.167
5	7	25/6 = 4.167
6		32/6 = 5.333



$$F_{t+1} = w_1 A_t + w_2 A_{t-1} + w_3 A_{t-2} + \ldots + w_n A_{t-n+1}$$

Exponential Smoothing

- **Assumes the most recent observations have the highest predictive value**
  - **gives more weight to recent time periods**

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

e_t

F_{t+1} = Forecast value for time $t+1$

A_t = Actual value at time t

α = Smoothing constant

Need initial forecast F_t to start.

Exponential Smoothing Equations

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

- *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

Exponential Smoothing – Example 1

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

i	Ai
Week	Demand
1	820
2	775
3	680
4	655
5	750
6	802
7	798
8	689
9	775
10	

Given the weekly demand data what are the exponential smoothing forecasts for periods 2-10 using α=0.10?

Assume $F_1=D_1$

3a. Exponential Smoothing – Example 1

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

i	Ai	Fi
Week	Demand	α = *0.1*
1	820	820.00
2	775	
3	680	
4	655	
5	750	
6	802	
7	798	
8	689	
9	775	
10		

$F_2 = F_1 + \alpha(A_1 - F_1)$ =820+.1(820–820)

=820

3a. Exponential Smoothing – Example 1

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

i	Ai	Fi
Week	Demand	α = *0.1*
1	820	820.00
2	775	820.00
3	680	
4	655	
5	750	
6	802	
7	798	
8	689	
9	775	
10		

$F_3 = F_2 + \alpha(A_2 - F_2)$

$=820+.1(775-820)$

$=815.5$

3a. Exponential Smoothing – Example 1

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

i	Ai	Fi
Week	Demand	α = *0.1*
1	820	820.00
2	775	820.00
3	680	815.50
4	655	
5	750	
6	802	
7	798	
8	689	
9	775	
10		

This process continues through week 10

3a. Exponential Smoothing – Example 1

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

i	Ai	Fi	
Week	Demand	α = *0.1*	α = *0.6*
1	820	820.00	820.00
2	775	820.00	820.00
3	680	815.50	793.00
4	655	801.95	725.20
5	750	787.26	683.08
6	802	783.53	723.23
7	798	785.38	770.49
8	689	786.64	787.00
9	775	776.88	728.20
10		776.69	756.28

What if the α constant equals 0.6

Exponential Smoothing

- How to choose α
  - depends on the emphasis you want to place on the most recent data
- Increasing α makes forecast more sensitive to recent data
- Small alpha → Less importance on recent results (Good for products with stable demand)
- Large alpha → Recent forecast results more important (Good for product with varying demands)

Determining Forecast Quality

- How Well Did a Forecast Perform?

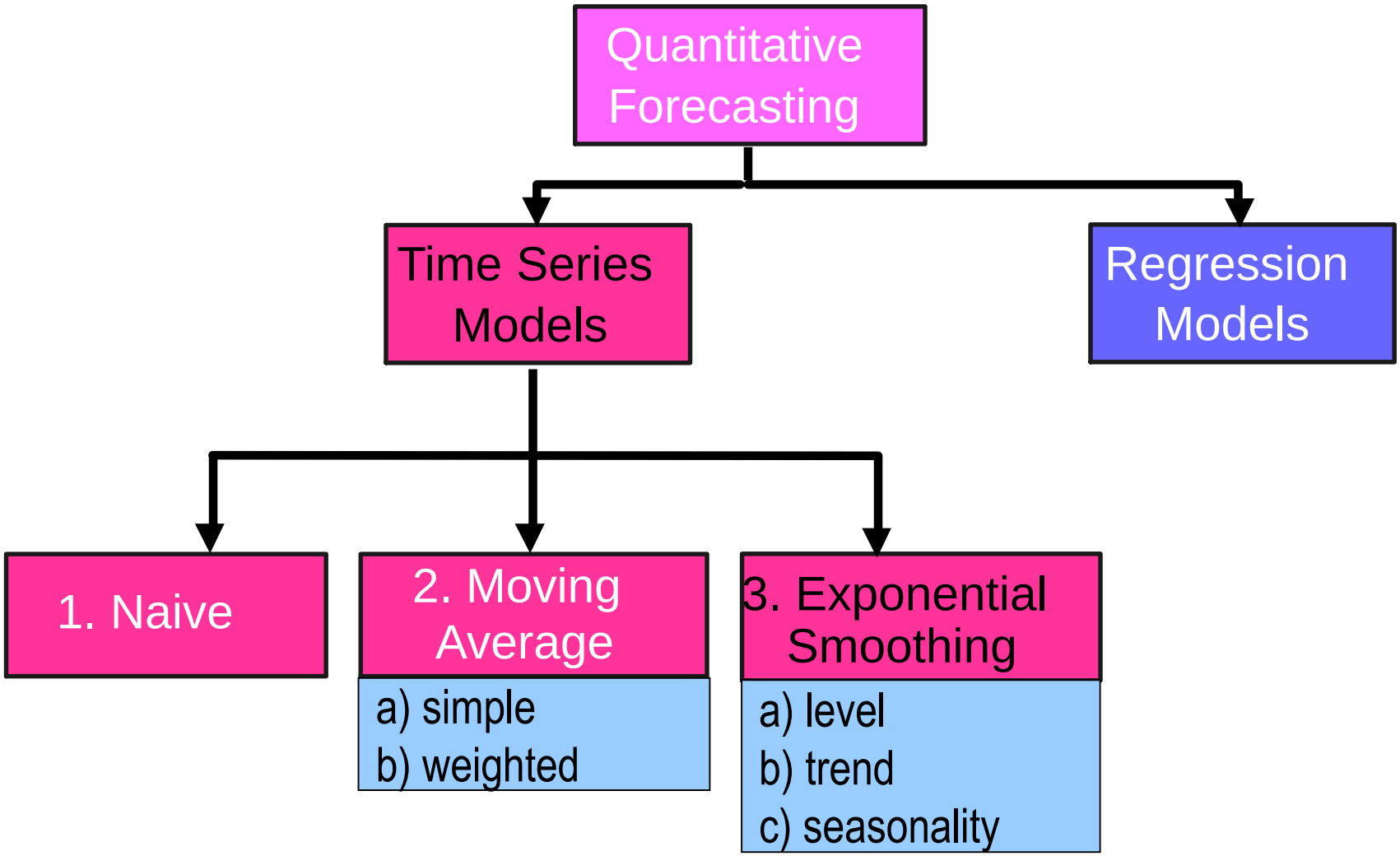
- Determine Forecast Error

  Error = Actual Demand – Forecasted Demand

Month	Actual	Forecast	Error
Jan	200	200	0
Feb	300	200	100
Mar	200	230	-30
Apr	400	221	179
May	500	275	225
Jun	600	343	257

Average Error
121.8

Quantitative Forecasting Methods



General Guiding Principles for Forecasting

1. Forecasts are more accurate for larger groups of items.
2. Forecasts are more accurate for shorter periods of time.
3. Every forecast should include an estimate of error.
4. Before applying any forecasting method, the total system should be understood.
5. Before applying any forecasting method, the method should be tested and evaluated.
6. Be aware of people; they can prove you wrong very easily in forecasting

Summary

- What is forecasting
  - How does it help a firm?
- What is the difference between potential tools one may use if the time frame is short term versus long term?
- Describe the four qualitative forecasting approaches
- Describe the quantitative forecasting approaches
- Calculate a simple moving average
- What approach will let you weight more recent data versus older data?