Statistics for Business and Economics

6th Edition

Chapter 2

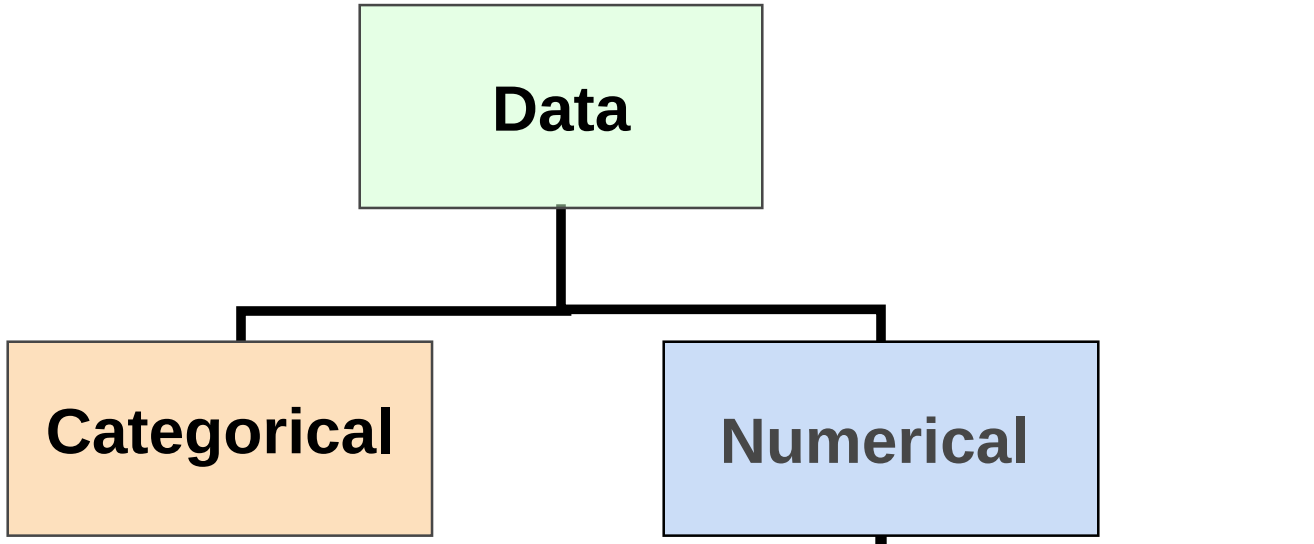
Describing Data: Graphical

Chapter Goals

After completing this chapter, you should be able to:

- Identify types of data and levels of measurement
- Create and interpret graphs to describe categorical variables:
  - frequency distribution, bar chart, pie chart, Pareto diagram
- Create a line chart to describe time-series data
- Create and interpret graphs to describe numerical variables:
  - frequency distribution, histogram, ogive, stem-and-leaf display
- Construct and interpret graphs to describe relationships between variables:
  - Scatter plot, cross table
- Describe appropriate and inappropriate ways to display data graphically

Types of Data



Examples:

- Marital Status
- Are you registered to vote?
- Eye Color

(Defined categories or groups)

Examples:

- Number of Children
- Defects per hour

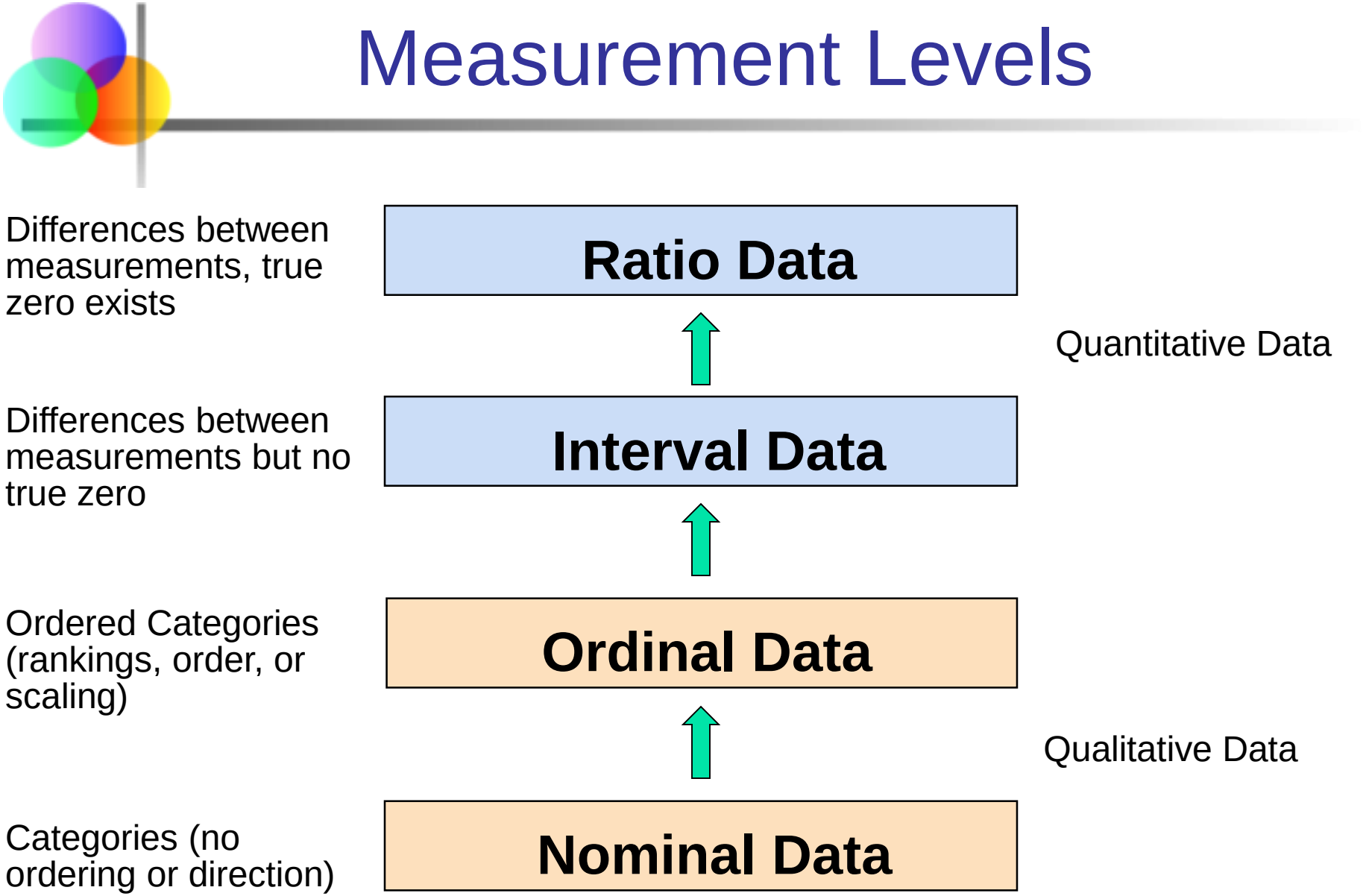
(Counted items)

Examples:

- Weight
- Voltage

(Measured characteristics)

Measurement Levels



Graphical Presentation of Data

- Data in raw form are usually not easy to use for decision making
- Some type of organization is needed
  - Table
  - Graph
- The type of graph to use depends on the variable being summarized

Graphical Presentation of Data

(continued)

- Techniques reviewed in this chapter:

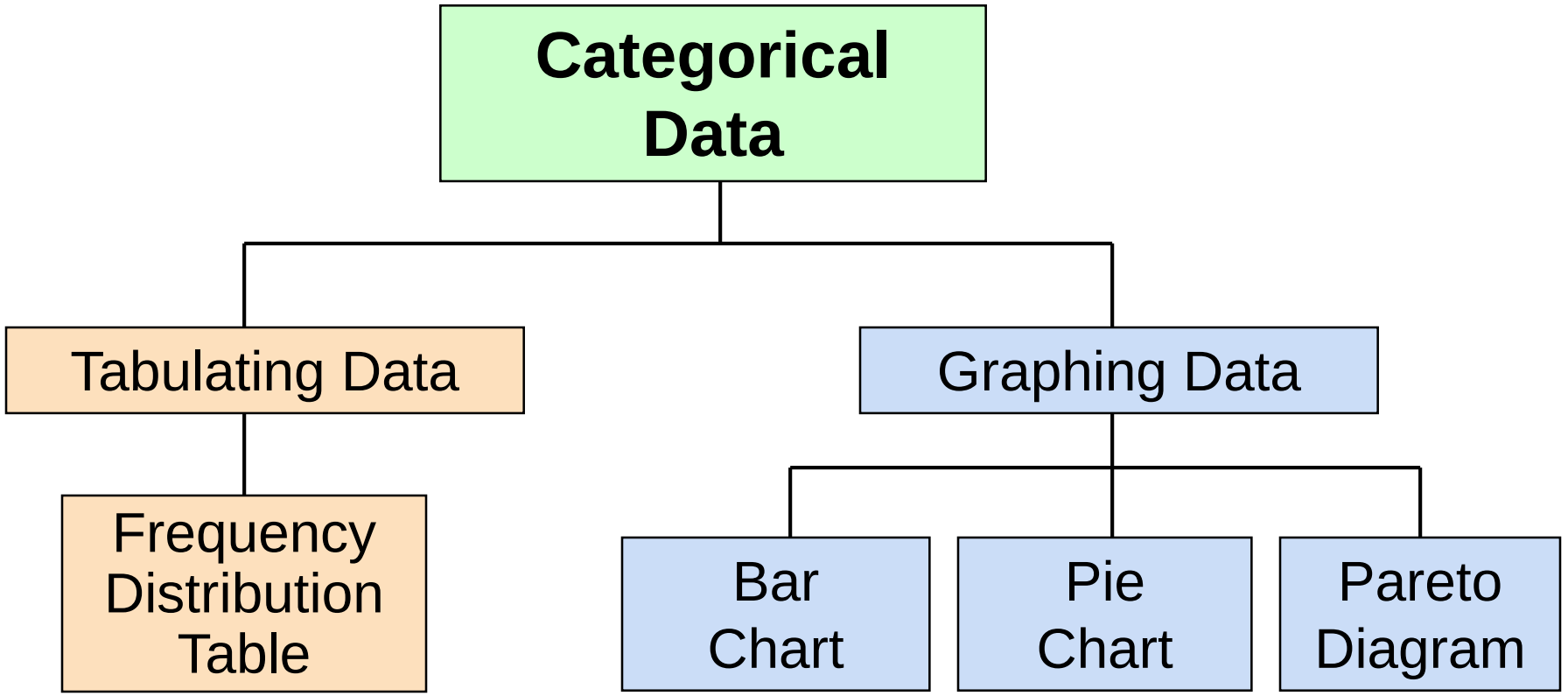
Categorical Variables

- Frequency distribution
- Bar chart
- Pie chart
- Pareto diagram

Numerical Variables

- Line chart
- Frequency distribution
- Histogram and ogive
- Stem-and-leaf display
- Scatter plot

Tables and Graphs for Categorical Variables



The Frequency Distribution Table

Summarize data by category

Example: Hospital Patients by Unit

Hospital Unit	Number of Patients
Cardiac Care	1,052
Emergency	2,245
Intensive Care	340
Maternity	552
Surgery	4,630

(Variables are categorical)

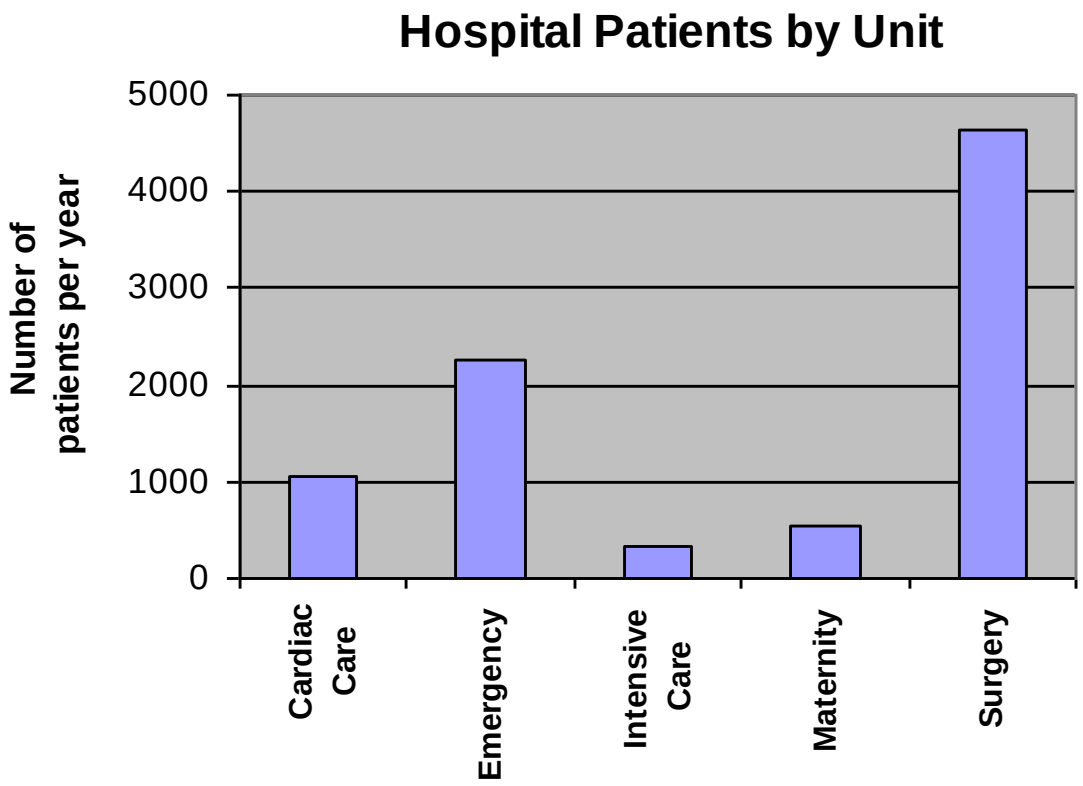
Bar and Pie Charts

- Bar charts and Pie charts are often used for qualitative (category) data

- Height of bar or size of pie slice shows the frequency or percentage for each category

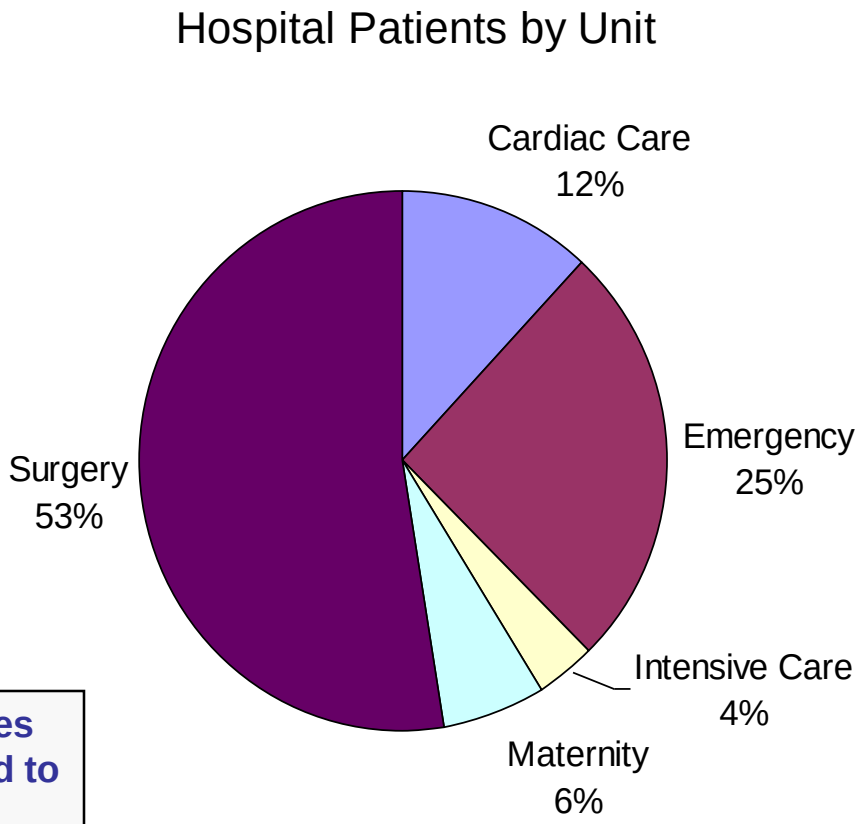
Bar Chart Example

Hospital Unit	Number of Patients
Cardiac Care	1,052
Emergency	2,245
Intensive Care	340
Maternity	552
Surgery	4,630



Pie Chart Example

Hospital Unit	Number of Patients	% of Total
Cardiac Care	1,052	11.93
Emergency	2,245	25.46
Intensive Care	340	3.86
Maternity	552	6.26
Surgery	4,630	52.50



(Percentages are rounded to the nearest percent)

Pareto Diagram

- Used to portray categorical data
- A bar chart, where categories are shown in descending order of frequency
- A cumulative polygon is often shown in the same graph
- Used to separate the "vital few" from the "trivial many"

Pareto Diagram Example

Example: 400 defective items are examined for cause of defect:

Source of Manufacturing Error	Number of defects
Bad Weld	34
Poor Alignment	223
Missing Part	25
Paint Flaw	78
Electrical Short	19
Cracked case	21
Total	**400**

Pareto Diagram Example

(continued)

Step 1: Sort by defect cause, in descending order

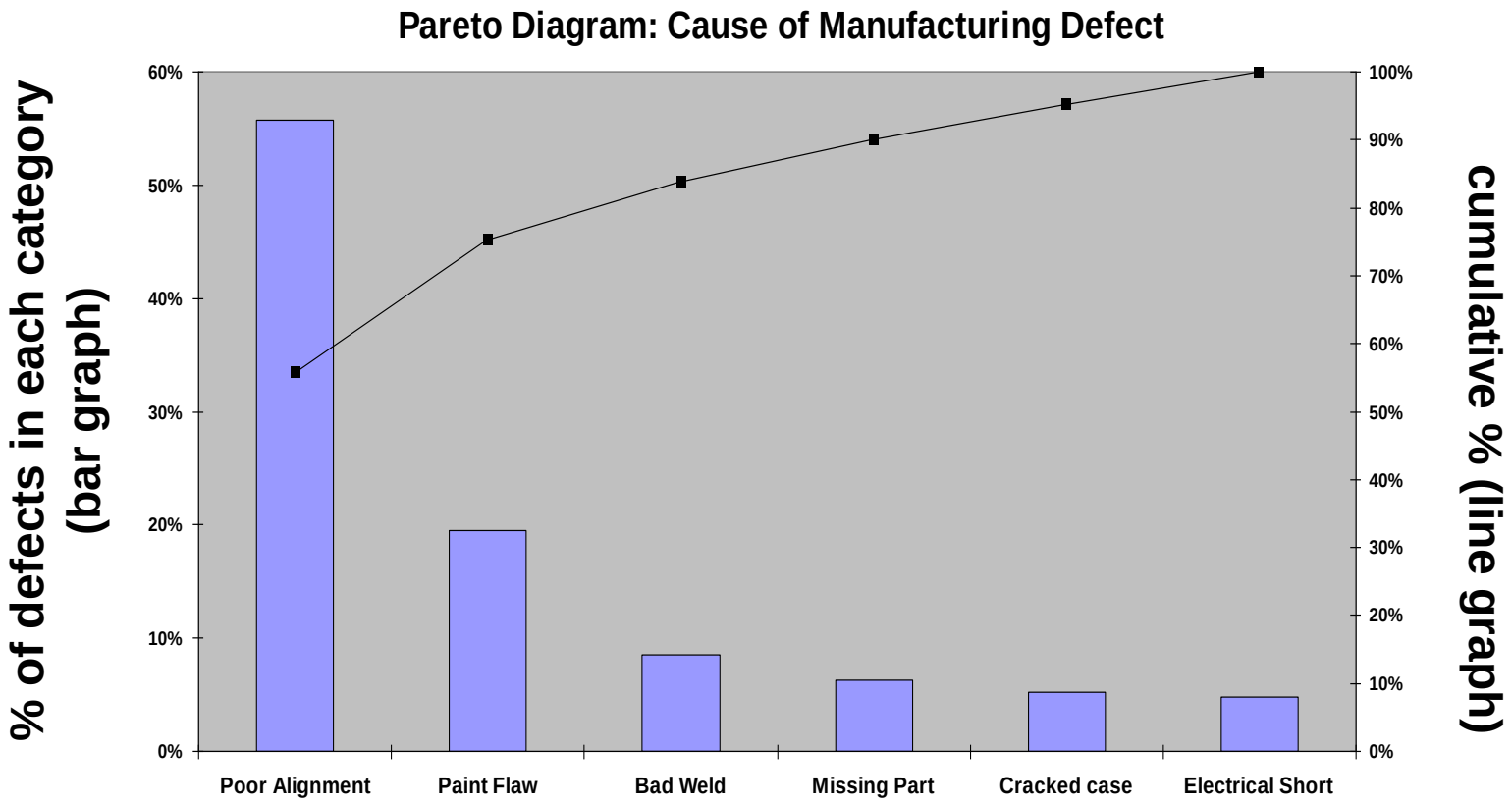
Step 2: Determine % in each category

Source of Manufacturing Error	Number of defects	% of Total Defects
Poor Alignment	223	55.75
Paint Flaw	78	19.50
Bad Weld	34	8.50
Missing Part	25	6.25
Cracked case	21	5.25
Electrical Short	19	4.75
Total	**400**	**100%**

Pareto Diagram Example

(continued)

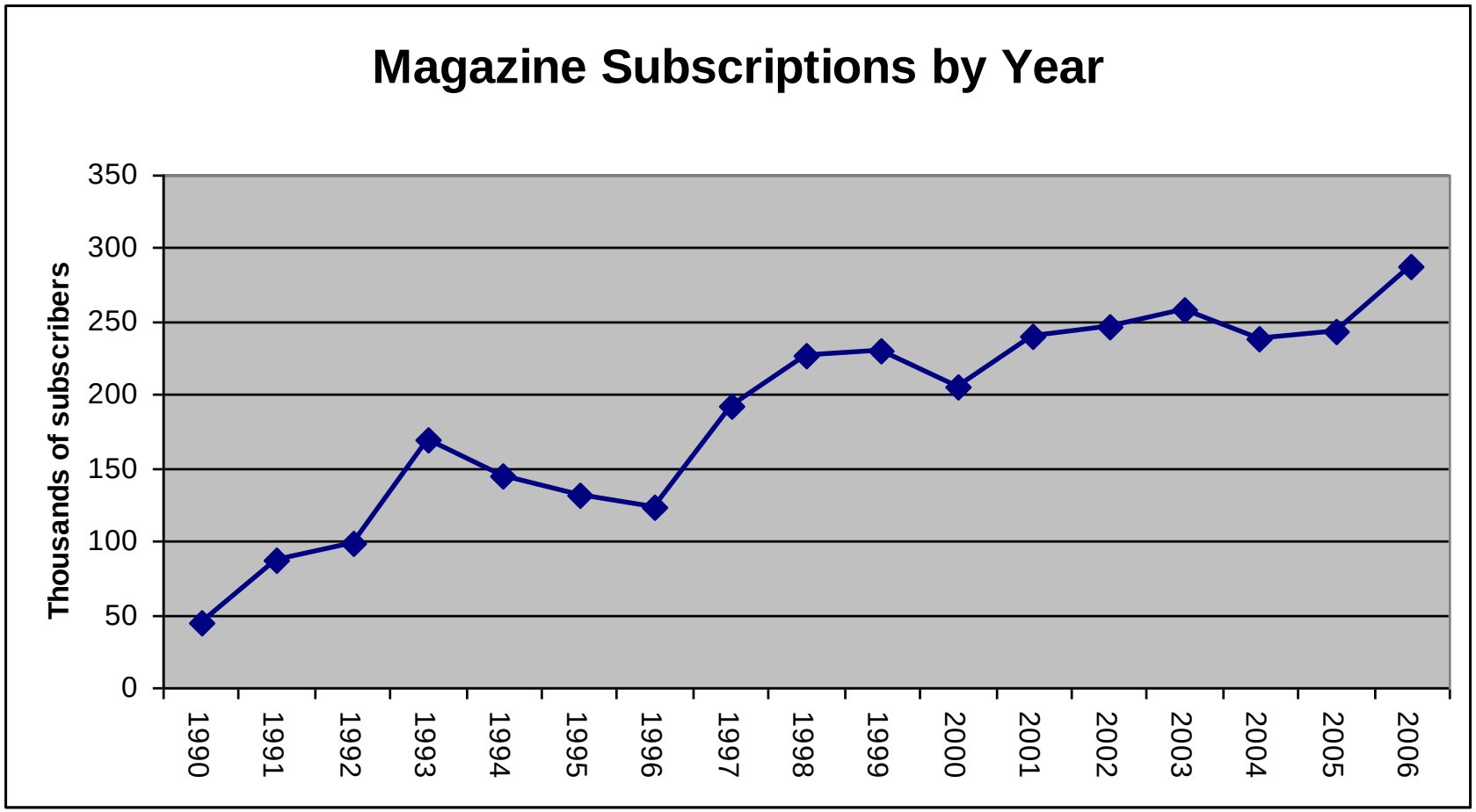
Step 3: Show results graphically



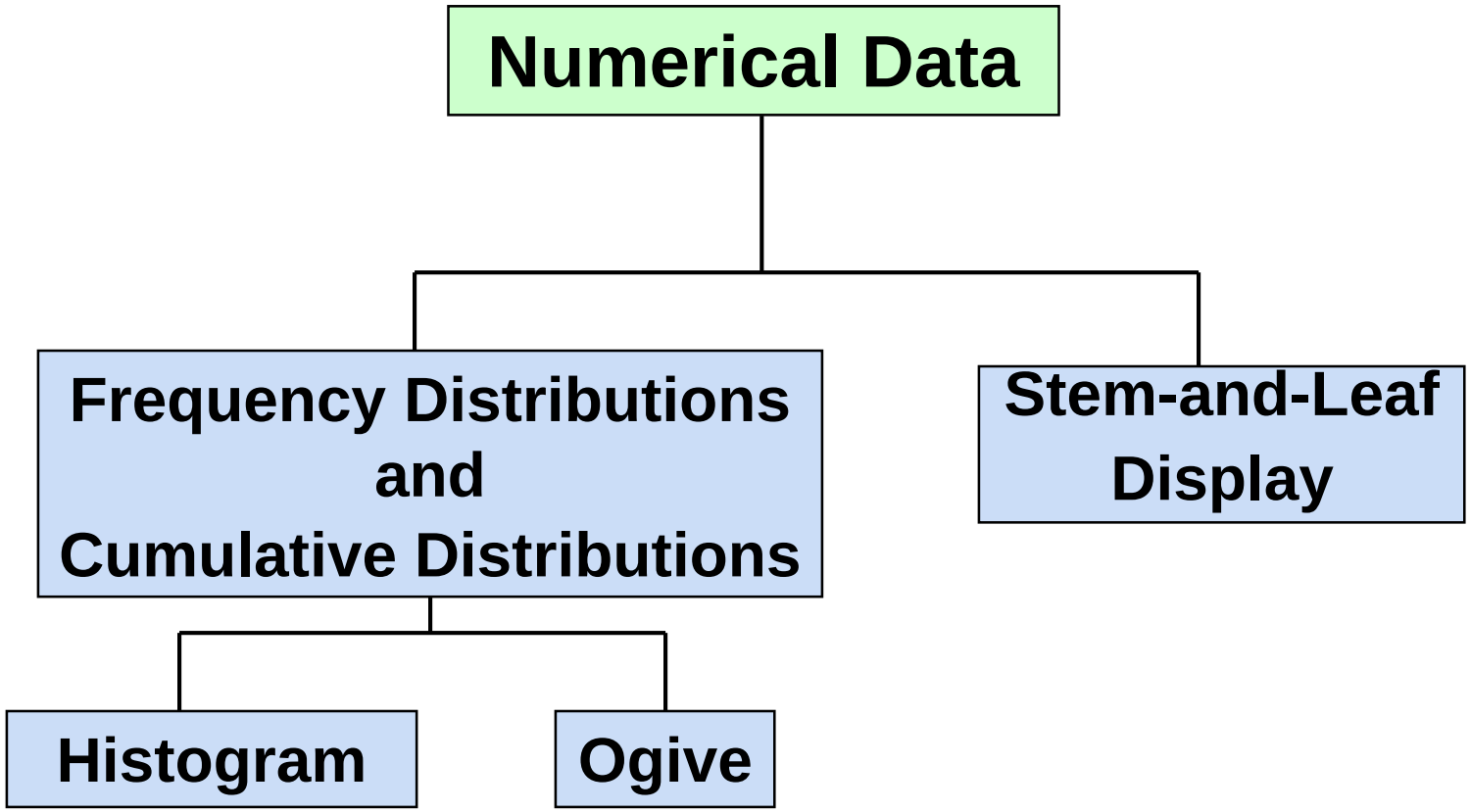
Graphs for Time-Series Data

- A line chart (time-series plot) is used to show the values of a variable over time
- Time is measured on the horizontal axis
- The variable of interest is measured on the vertical axis

Line Chart Example



Graphs to Describe Numerical Variables



Frequency Distributions

What is a Frequency Distribution?

- A frequency distribution is a list or a table …
- containing class groupings (categories or ranges within which the data fall) ...
- and the corresponding frequencies with which data fall within each class or category

Why Use Frequency Distributions?

- A frequency distribution is a way to summarize data
- The distribution condenses the raw data into a more useful form...
- and allows for a quick visual interpretation of the data

Class Intervals and Class Boundaries

- Each class grouping has the same width
- Determine the width of each interval by

$$w = \text{interval width} = \frac{\text{largest number} - \text{smallest number}}{\text{number of desired intervals}}$$

- Use at least 5 but no more than 15-20 intervals
- Intervals never overlap
- Round up the interval width to get desirable interval endpoints

Frequency Distribution Example

Example: A manufacturer of insulation randomly selects 20 winter days and records the daily high temperature

24, 35, 17, 21, 24, 37, 26, 46, 58, 30,

32, 13, 12, 38, 41, 43, 44, 27, 53, 27

Frequency Distribution Example

(continued)

- Sort raw data in ascending order:

12, 13, 17, 21, 24, 24, 26, 27, 27, 30, 32, 35, 37, 38, 41, 43, 44, 46, 53, 58

- Find range: **58 - 12 = 46**
- Select number of classes: **5 (usually between 5 and 15)**
- Compute interval width: **10** **(46/5 then round up)**
- Determine interval boundaries: **10 but less than 20, 20 but less than 30, . . . , 60 but less than 70**
- Count observations & assign to classes

Frequency Distribution Example

(continued)

Data in ordered array:

12, 13, 17, 21, 24, 24, 26, 27, 27, 30, 32, 35, 37, 38, 41, 43, 44, 46, 53, 58

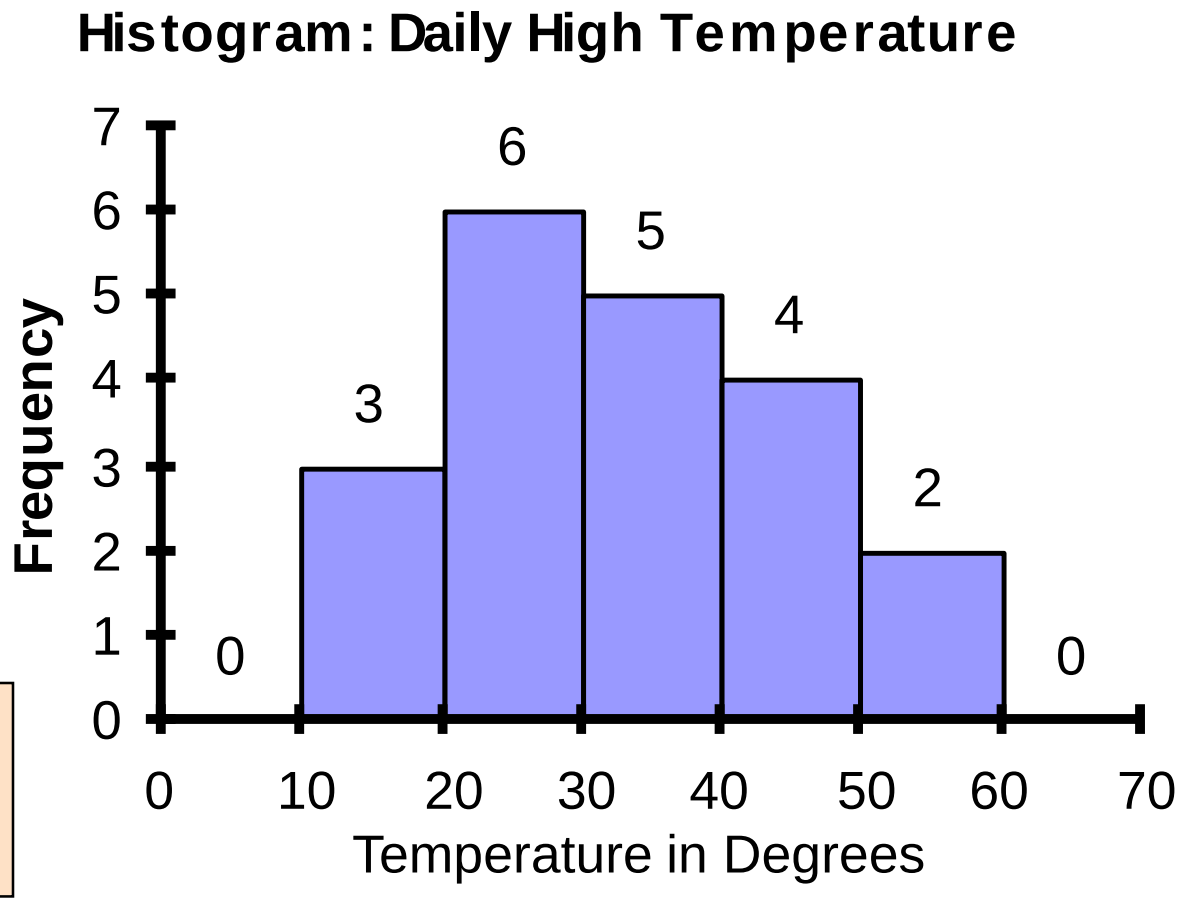
Interval	Frequency	Relative Frequency	Percentage
10 but less than 20	3	.15	15
20 but less than 30	6	.30	30
30 but less than 40	5	.25	25
40 but less than 50	4	.20	20
50 but less than 60	2	.10	10
Total	20	1.00	100

Histogram

- A graph of the data in a frequency distribution is called a **histogram**
- The **interval endpoints** are shown on the horizontal axis
- the vertical axis is either **frequency, relative frequency,** or **percentage**
- Bars of the appropriate heights are used to represent the number of observations within each class

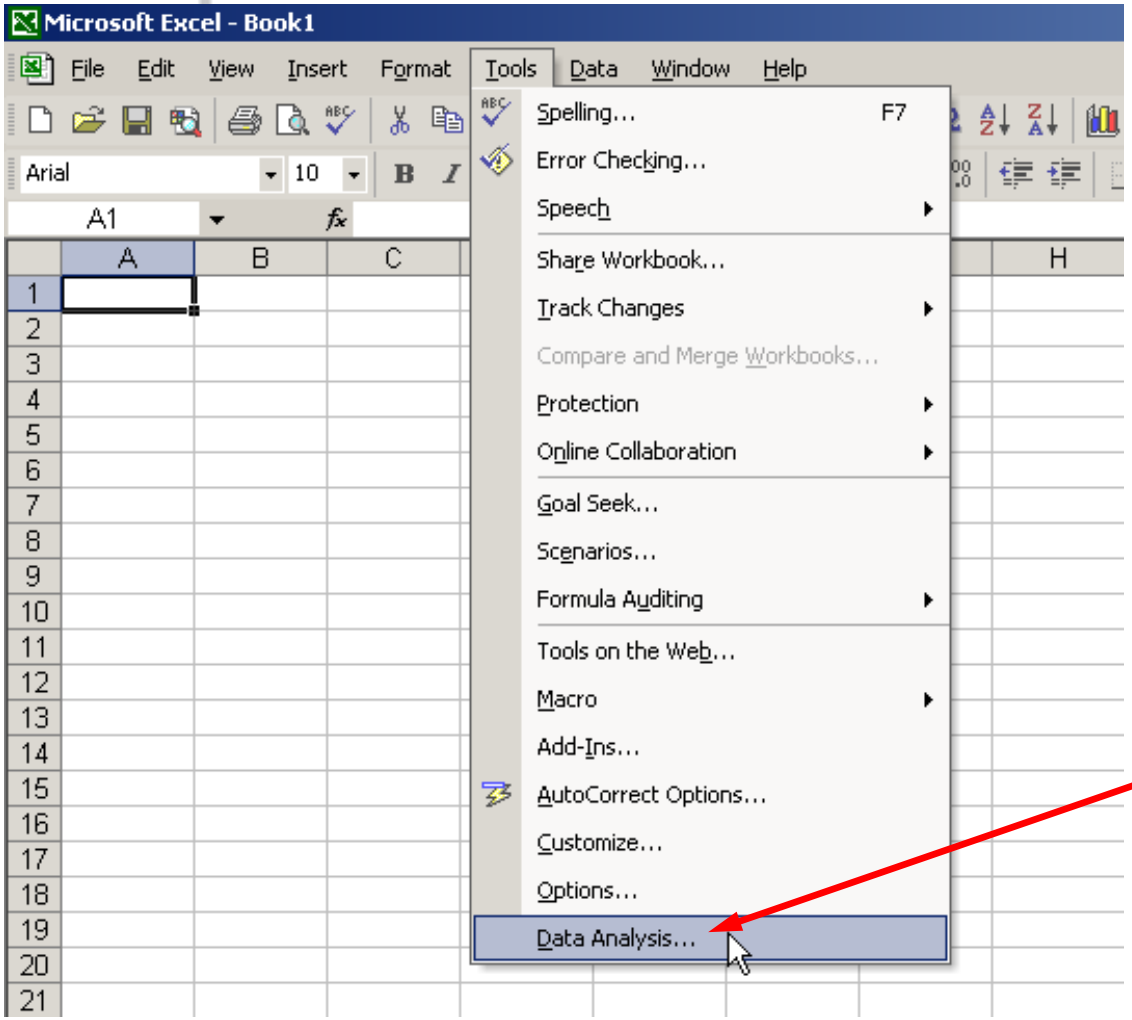
Histogram Example

Interval	Frequency
10 but less than 20	3
20 but less than 30	6
30 but less than 40	5
40 but less than 50	4
50 but less than 60	2



(No gaps between bars)

Histograms in Excel



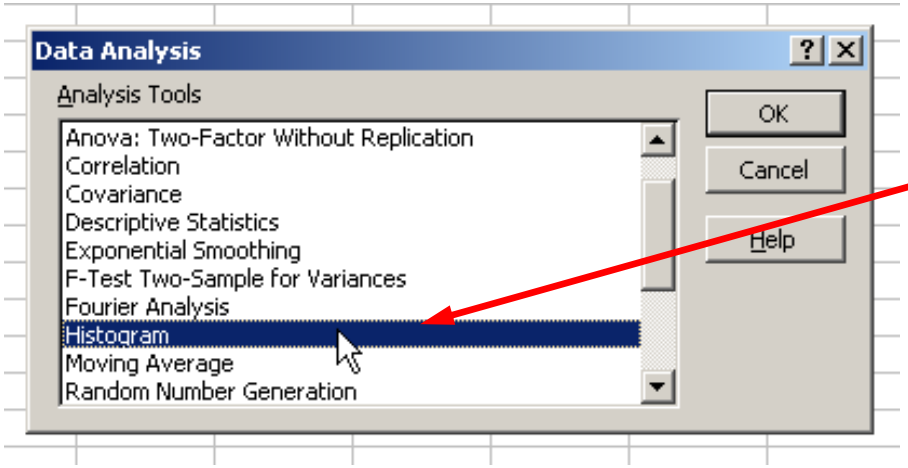
1

Select

Tools/Data Analysis

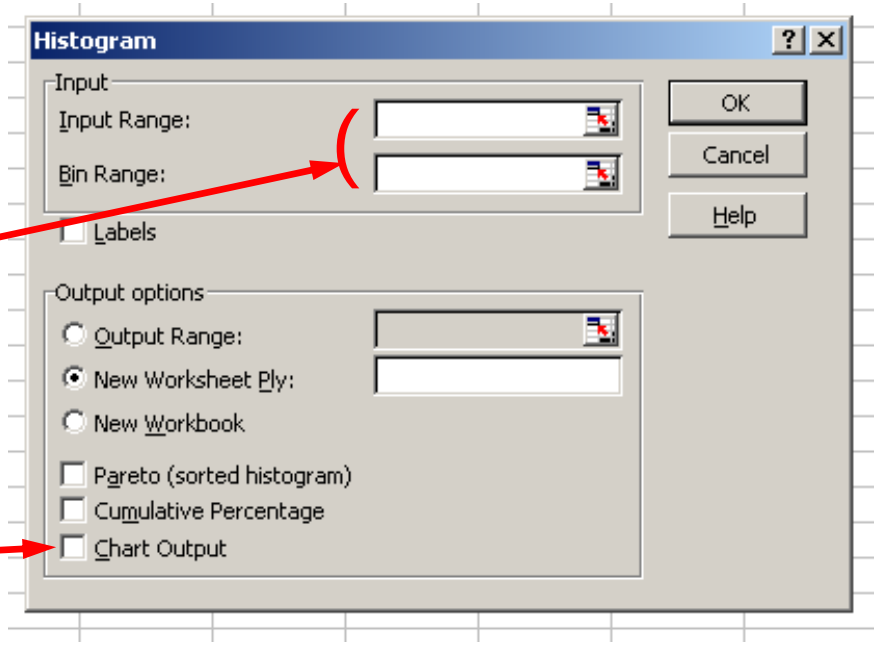
Histograms in Excel

(continued)



2

Choose Histogram



3

Input data range and bin range (bin range is a cell range containing the upper interval endpoints for each class grouping)

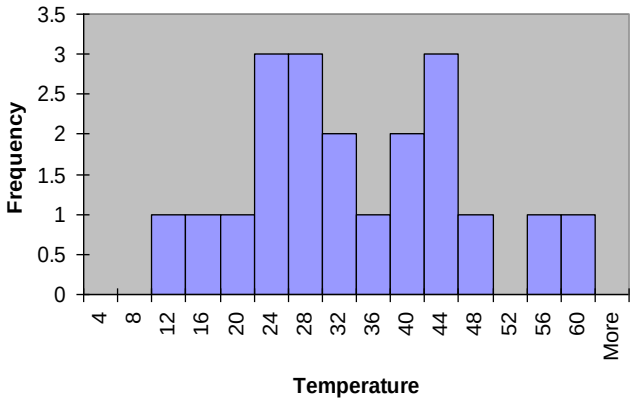
Select Chart Output and click “OK”

Questions for Grouping Data into Intervals

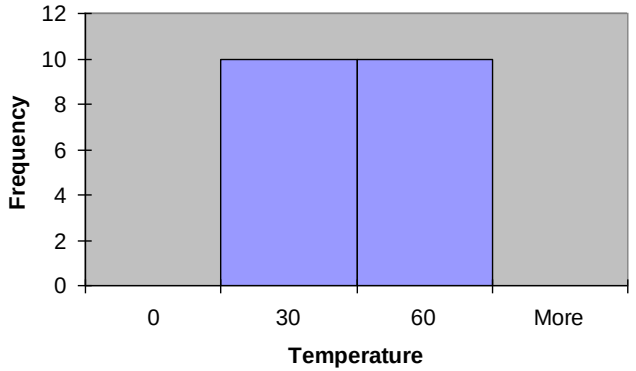
- 1. How wide should each interval be?
  (How many classes should be used?)
- 2. How should the endpoints of the intervals be determined?
  - Often answered by trial and error, subject to user judgment
  - The goal is to create a distribution that is neither too "jagged" nor too "blocky"
  - Goal is to appropriately show the pattern of variation in the data

How Many Class Intervals?

- **Many (Narrow class intervals)**
  - may yield a very jagged distribution with gaps from empty classes
  - Can give a poor indication of how frequency varies across classes



- **Few (Wide class intervals)**
  - may compress variation too much and yield a blocky distribution
  - can obscure important patterns of variation.



(X axis labels are upper class endpoints)

The Cumulative Frequency Distribuiton

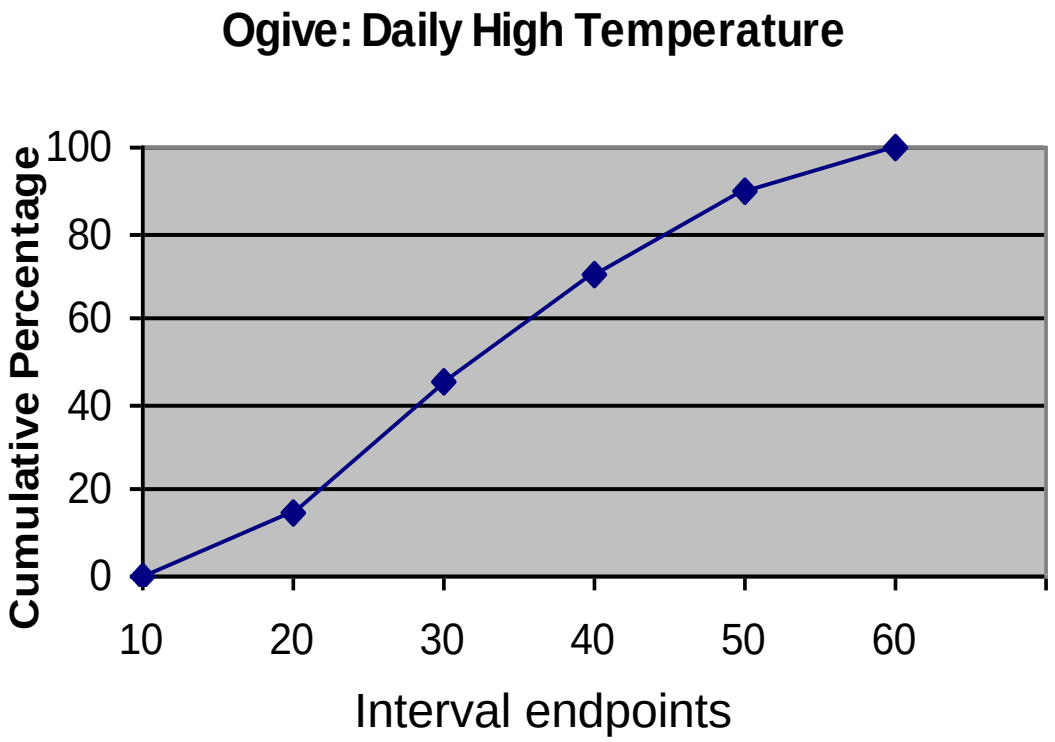
Data in ordered array:

12, 13, 17, 21, 24, 24, 26, 27, 27, 30, 32, 35, 37, 38, 41, 43, 44, 46, 53, 58

Class	Frequency	Percentage	Cumulative Frequency	Cumulative Percentage
10 but less than 20	3	15	3	15
20 but less than 30	6	30	9	45
30 but less than 40	5	25	14	70
40 but less than 50	4	20	18	90
50 but less than 60	2	10	20	100
Total	20	100		

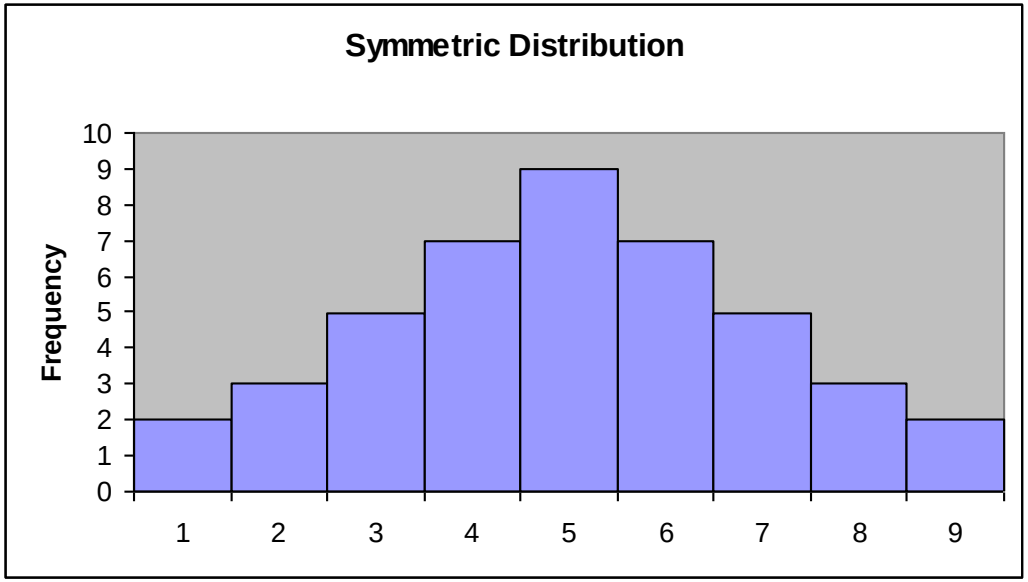
The Ogive
Graphing Cumulative Frequencies

Interval	Upper interval endpoint	Cumulative Percentage
Less than 10	10	0
10 but less than 20	20	15
20 but less than 30	30	45
30 but less than 40	40	70
40 but less than 50	50	90
50 but less than 60	60	100



Distribution Shape

- The shape of the distribution is said to be **symmetric** if the observations are balanced, or evenly distributed, about the center.

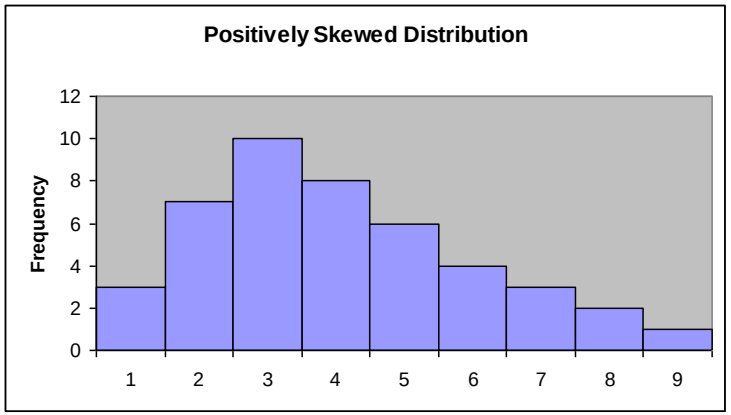


Distribution Shape

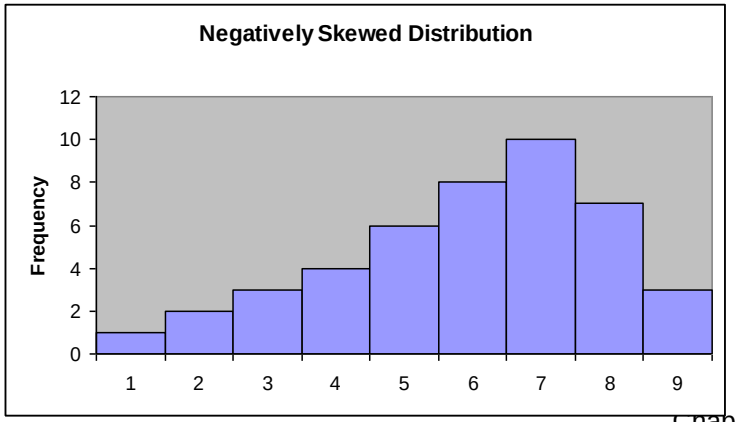
(continued)

- The shape of the distribution is said to be **skewed** if the observations are not symmetrically distributed around the center.

A positively skewed distribution (skewed to the right) has a tail that extends to the right in the direction of positive values.



A negatively skewed distribution (skewed to the left) has a tail that extends to the left in the direction of negative values.



Stem-and-Leaf Diagram

- A simple way to see distribution details in a data set

METHOD: Separate the sorted data series into leading digits (the **stem**) and the trailing digits (the **leaves**)

Example

Data in ordered array:

21, 24, 24, 26, 27, 27, 30, 32, 38, 41

- Here, use the 10's digit for the stem unit:
  - 21 is shown as
  - 38 is shown as

Stem	Leaf
2	1
3	8

Example

(continued)

Data in ordered array:

21, 24, 24, 26, 27, 27, 30, 32, 38, 41

- Completed stem-and-leaf diagram:

Stem	Leaves
2	1 4 4 6 7 7
3	0 2 8
4	1

Using other stem units

- Using the 100's digit as the stem:
  - Round off the 10's digit to form the leaves

- 613 would become →
- 776 would become →
- . . .
- 1224 becomes →

Stem	Leaf
6	1
7	8
12	2

Using other stem units

(continued)

- Using the 100's digit as the stem:
  - The completed stem-and-leaf display:

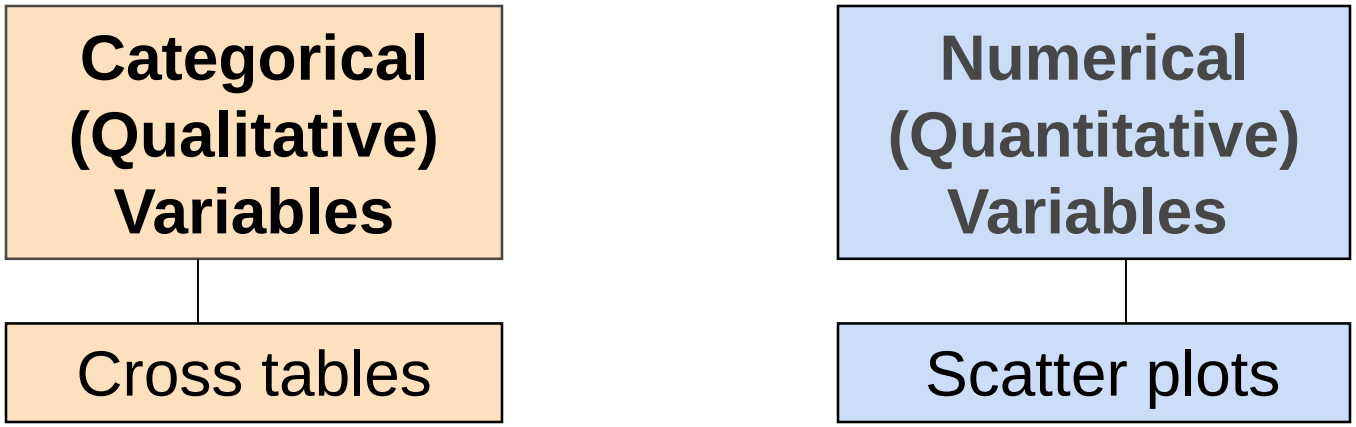
Data:

613, 632, 658, 717,
722, 750, 776, 827,
841, 859, 863, 891,
894, 906, 928, 933,
955, 982, 1034,
1047,1056, 1140,
1169, 1224

Stem	Leaves
6	1 3 6
7	2 2 5 8
8	3 4 6 6 9 9
9	1 3 3 6 8
10	3 5 6
11	4 7
12	2

Relationships Between Variables

- Graphs illustrated so far have involved only a single variable
- When two variables exist other techniques are used:



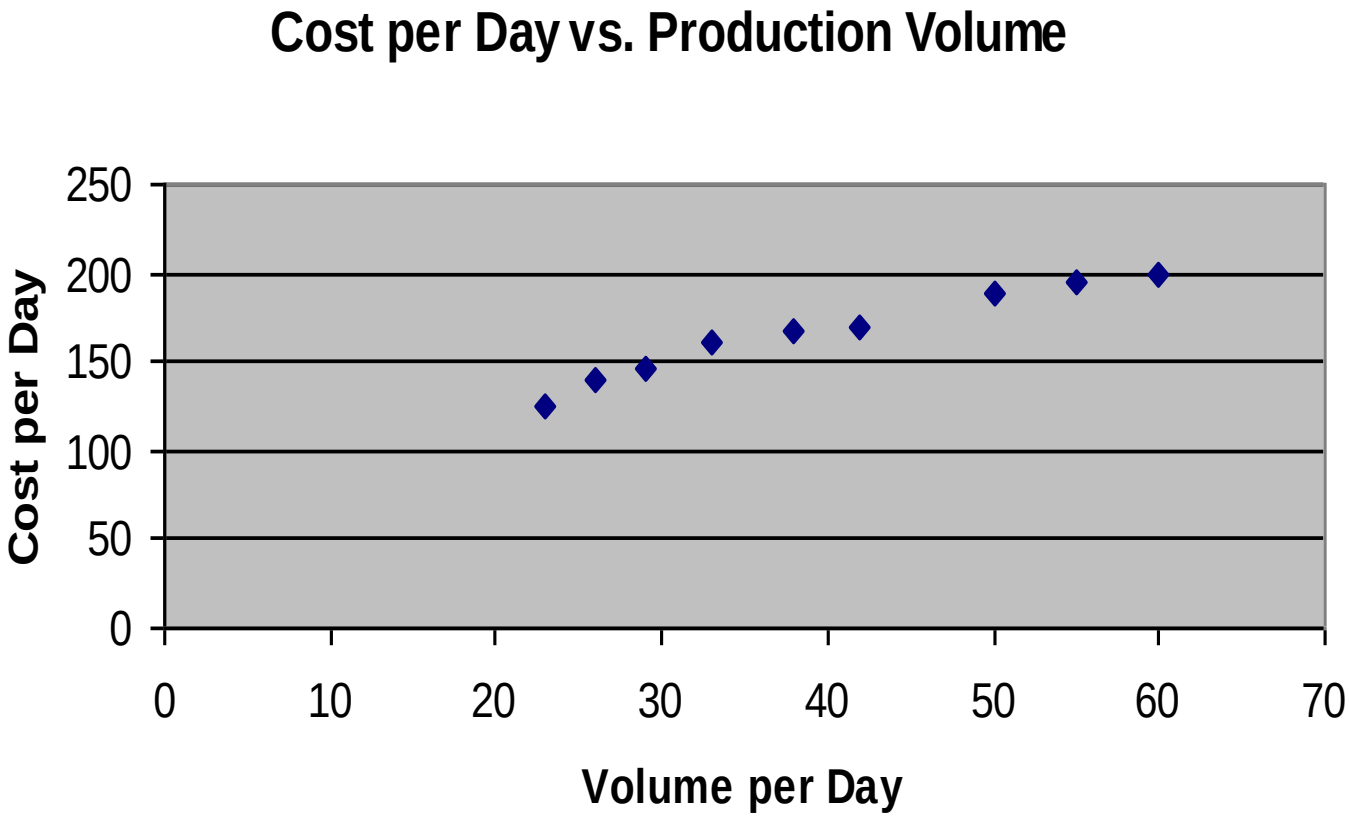
Scatter Diagrams

- Scatter Diagrams are used for paired observations taken from two numerical variables

- The Scatter Diagram:
  - one variable is measured on the vertical axis and the other variable is measured on the horizontal axis

Scatter Diagram Example

Volume per day	Cost per day
23	125
26	140
29	146
33	160
38	167
42	170
50	188
55	195
60	200

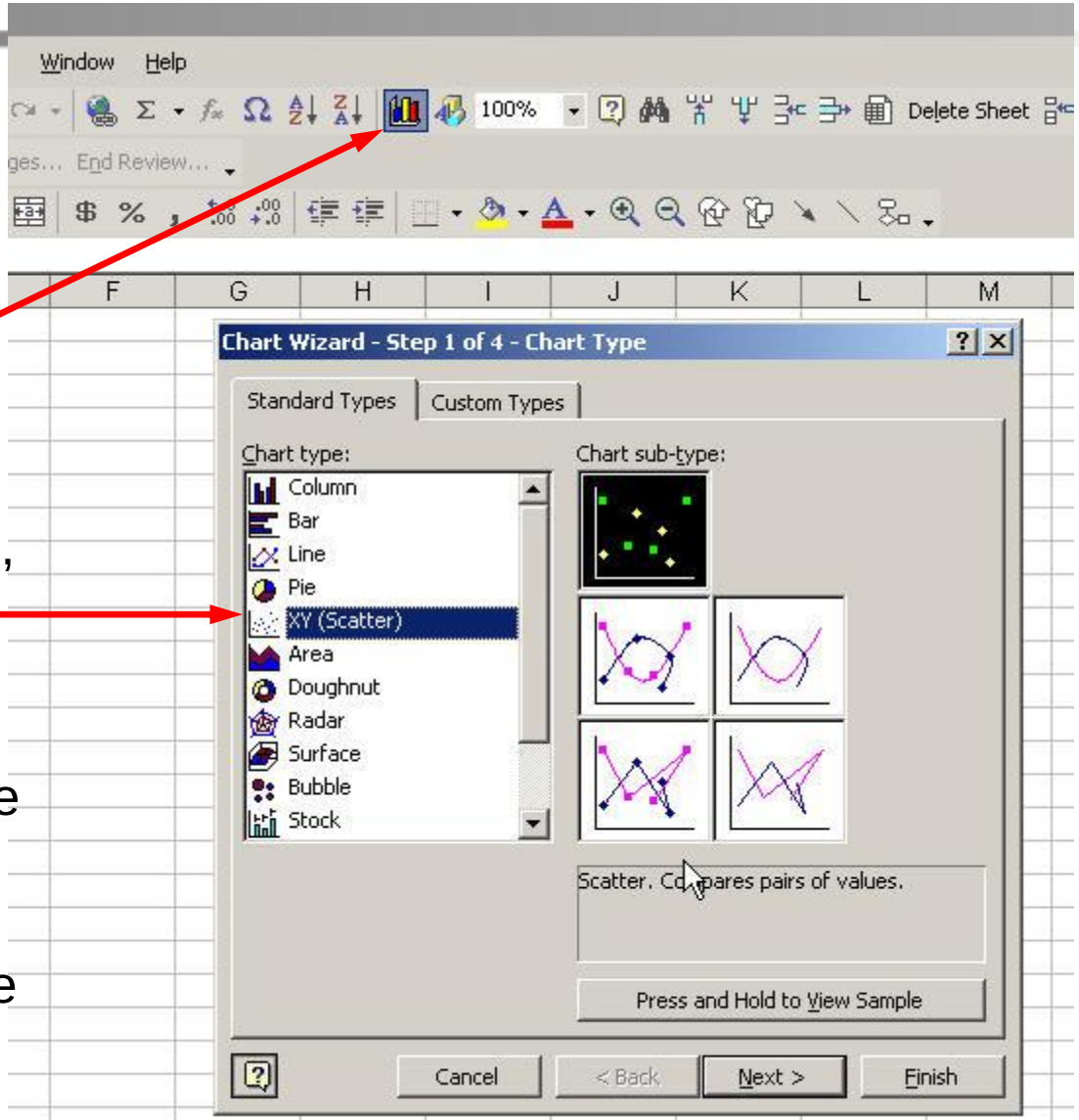


Scatter Diagrams in Excel

1. Select the chart wizard

2. Select XY(Scatter) option, then click “Next”

3. When prompted, enter the data range, desired legend, and desired destination to complete the scatter diagram



Cross Tables

- Cross Tables (or contingency tables) list the number of observations for every combination of values for two categorical or ordinal variables

- If there are *r* categories for the first variable (rows) and *c* categories for the second variable (columns), the table is called an *r* x *c* cross table

Cross Table Example

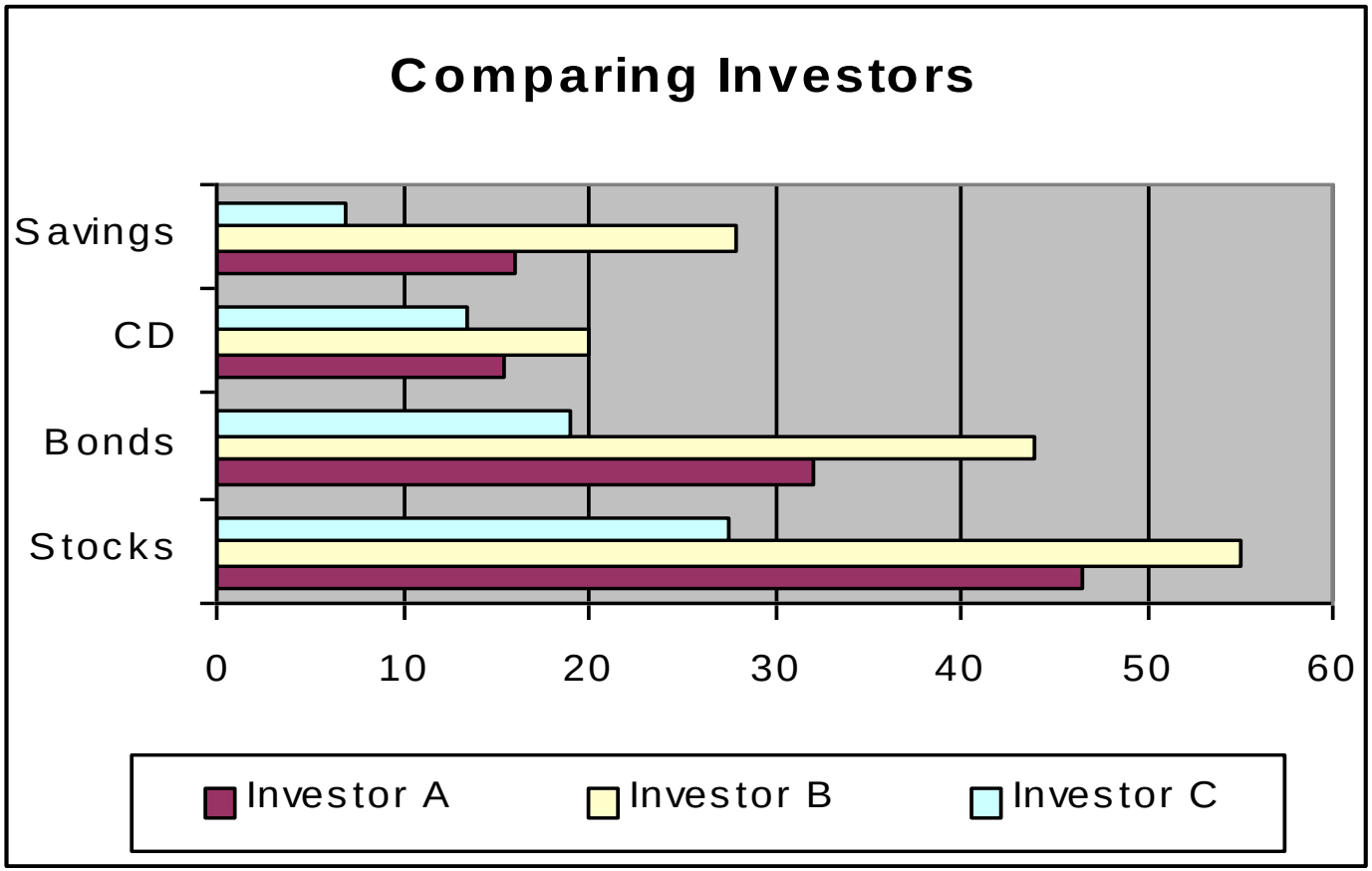
- 4 x 3 Cross Table for Investment Choices by Investor (values in $1000's)

Investment Category	Investor A	Investor B	Investor C	Total
Stocks	46.5	55	27.5	**129**
Bonds	32.0	44	19.0	**95**
CD	15.5	20	13.5	**49**
Savings	16.0	28	7.0	**51**
Total	**110.0**	**147**	**67.0**	**324**

Graphing Multivariate Categorical Data

(continued)

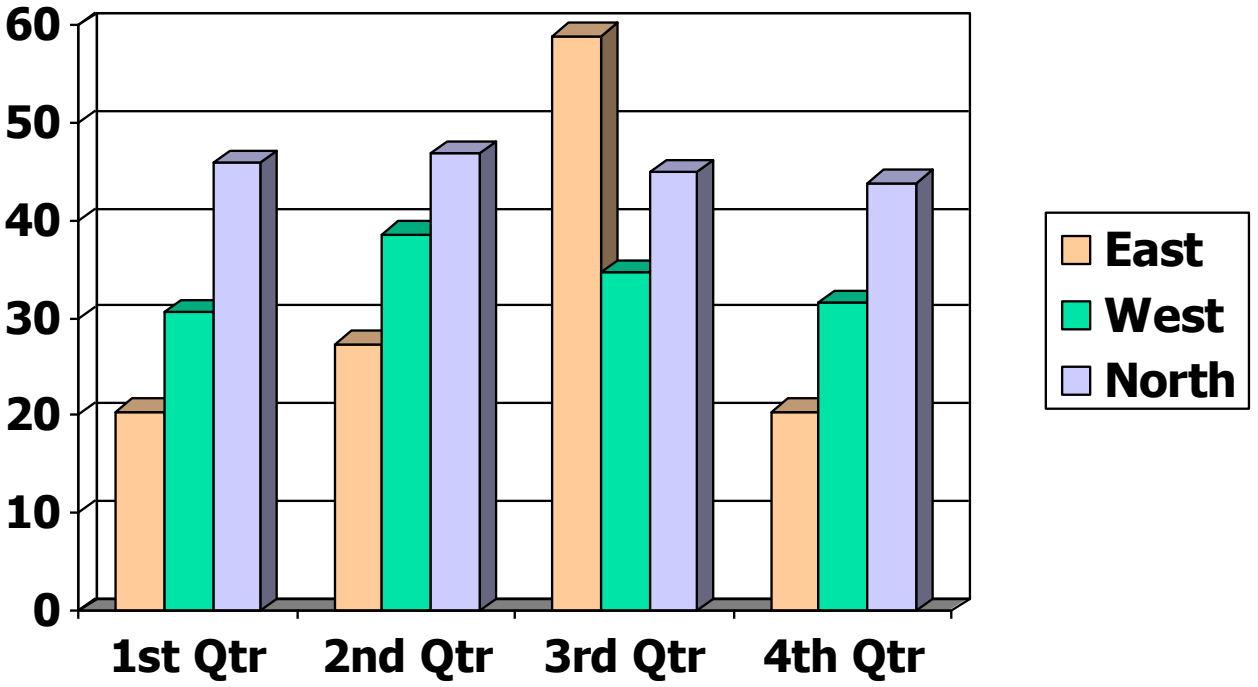
- Side by side bar charts



Side-by-Side Chart Example

- Sales by quarter for three sales territories:

	1st Qtr	2nd Qtr	3rd Qtr	4th Qtr
East	20.4	27.4	59	20.4
West	30.6	38.6	34.6	31.6
North	45.9	46.9	45	43.9



Data Presentation Errors

Goals for effective data presentation:

- Present data to display essential information
- Communicate complex ideas clearly and accurately
- Avoid distortion that might convey the wrong message

Data Presentation Errors

(continued)

- Unequal histogram interval widths
- Compressing or distorting the vertical axis
- Providing no zero point on the vertical axis
- Failing to provide a relative basis in comparing data between groups

Chapter Summary

- Reviewed types of data and measurement levels
- Data in raw form are usually not easy to use for decision making -- Some type of organization is needed:
  - Table
  - Graph
- Techniques reviewed in this chapter:
  - Frequency distribution
  - Bar chart
  - Pie chart
  - Pareto diagram
  - Line chart
  - Frequency distribution
  - Histogram and ogive
  - Stem-and-leaf display
  - Scatter plot
  - Cross tables and side-by-side bar charts