National Cheng Kung University

Business Decision Methods

Fall 2022

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Meeting Times: Monday 6:10PM~9:00PM

Location: NCKU Yu-Ping

Office Hour: Wed 2:00PM~3:00PM

Objective

1. Apply statistics to test research hypotheses.
2. Construct effective models of decision making situations.
3. Compute optimal solutions to decision making models.
4. Analyze simulation models and decisions with uncertain outcomes.

Textbook

- Quantitative Analysis for management by Render, Stair, Hanna and Hale. Pearson 2018. 13rd ed.

Grading

- Grading for this course will come from five sources- Attendance (10%), Participation (20%), Quizzes (20%), Presentations (20%), Group Projects (30%).
- **Attendance:**
- ***Participation:*** Students are encouraged to engage in class discussion. Participation will be evaluated based on the frequency and the quality of the engagement in discussion.
- ***Quizzes:*** Some quizzes will be given from time to time in class for previous lecture. Your top 10 performed quizzes out of all will be used for this grade.
- ***Presentations:*** Literature review of your group project.
- **Final Project:** Students should form a group and work on a research project that is related to the course.

- W1 Introduction to Quantitative Analysis
- W2 Probability Concepts and applications
- W3 Decision Analysis
- W4 Regression Models
- W5 Forecasting
- W6 Inventory Control Models
- W7 Liner Programming
- W8 Transportation, Assignment, and Network Model
- W9 Integer Programming, Goal Programming, and Nonlinear Programming
- W10 Waiting Lines and Queuing Theory Models
- W11 Review Presentation
- W12 Simulation Modeling
- W13 Analytic Hierarchy Process (AHP)
- W14 Conjoint Analysis
- W15 Data Envelopment Analysis
- W16 Applications
- W17 Guess Speak
- W18 Final Project Presentation

Introduction

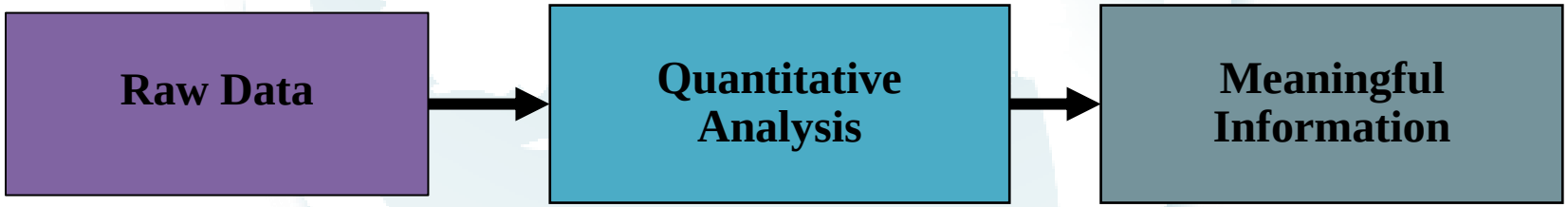
- Mathematical tools have been used for thousands of years
- Quantitative analysis can be applied to a wide variety of problems
  - Not enough to just know the mathematics of a technique
  - Must understand the specific applicability of the technique, its limitations, and assumptions
  - Successful use of quantitative techniques usually results in a solution that is timely, accurate, flexible, economical, reliable, and easy to understand and use

Examples of Quantitative Analyses

- Taco Bell saved over $150 million using forecasting and scheduling quantitative analysis models
- NBC television increased revenues by over $200 million between 1996 and 2000 by using quantitative analysis to develop better sales plans
- Continental Airlines saves over $40 million every year using quantitative analysis models to quickly recover from weather delays and other disruptions

What is Quantitative Analysis?

Quantitative analysis is a scientific approach to managerial decision making in which raw data are processed and manipulated to produce meaningful information



What is Quantitative Analysis?

- **Quantitative factors** are data that can be accurately calculated
  - Different investment alternatives
  - Interest rates
  - Inventory levels
  - Demand
  - Labor cost
- **Qualitative factors** are more difficult to quantify but affect the decision process
  - The weather
  - State and federal legislation
  - Technological breakthroughs

What is Quantitative Analysis?

- Quantitative and qualitative factors may have different roles
- Decisions based on quantitative data can be automated
- Generally quantitative analysis will aid the decision-making process
- Important in many areas of management
  - Production/Operations Management
  - Supply Chain Management
  - Business Analytics

Business Analytics

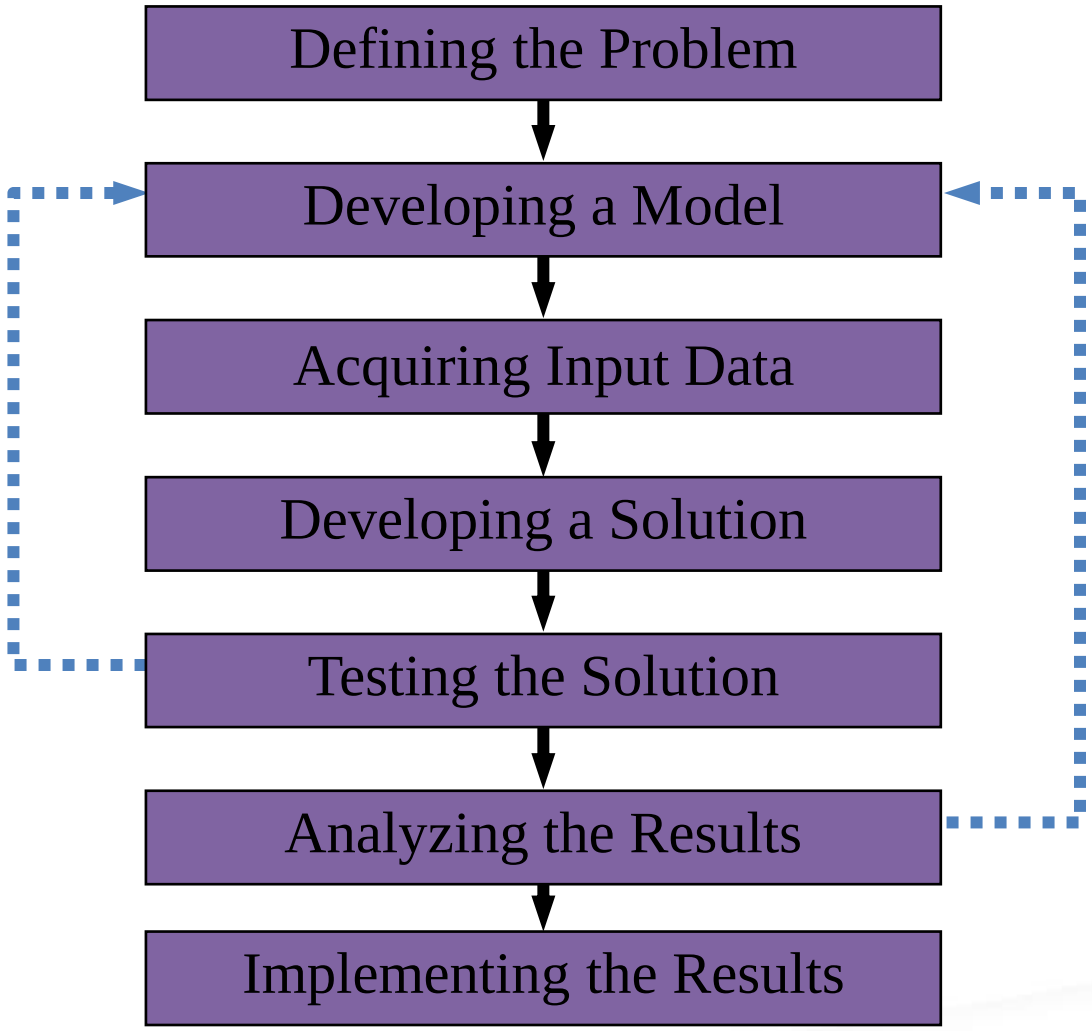
- A data-driven approach to decision making
  - Large amounts of data
  - Information technology is very important
  - Statistical and quantitative analysis are used to analyze the data and provide useful information
- **Descriptive analytics** – the study and consolidation of historical data
- **Predictive analytics** – forecasting future outcomes based on patterns in the past data
- **Prescriptive analytics –** the use of optimization methods

Business Analytics

BUSINESS ANALYTICS CATEGORY	QUANTITATIVE ANALYSIS TECHNIQUE (CHAPTER)
Descriptive analytics	Statistical measures such as means and standard deviations (Chapter 2) Statistical quality control (Chapter 15)
Predictive analytics	Decision analysis and decision trees (Chapter 3) Regression models (Chapter 4) Forecasting (Chapter 5) Project scheduling (Chapter 11) Waiting line models (Chapter 12) Simulation (Chapter 13) Markov analysis (Chapter 14)
Prescriptive analytics	Inventory models such as the economic order quantity (Chapter 6) Linear programming (Chapters 7, 8) Transportation and assignment models (Chapter 9) Integer programming, goal programming, and nonlinear programming (Chapter 10) Network models (Chapter 9)

The Quantitative Analysis Approach

FIGURE 1.1

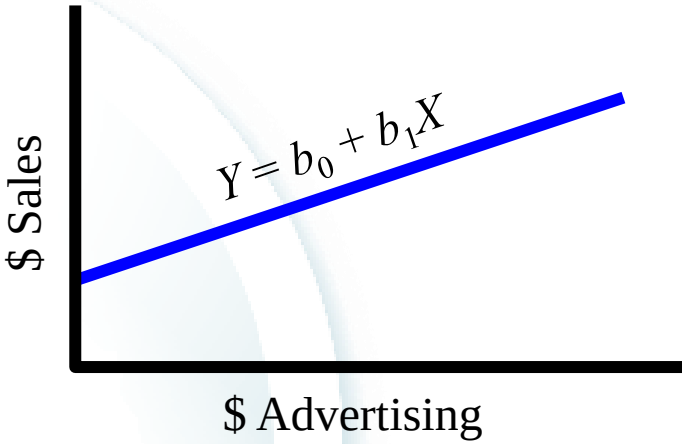


Defining the Problem

- Develop a clear and concise statement of the problem to provide direction and meaning
  - This may be the most important and difficult step
  - Go beyond symptoms and identify true causes
  - Concentrate on only a few of the problems – selecting the right problems is very important
  - Specific and measurable objectives may have to be developed

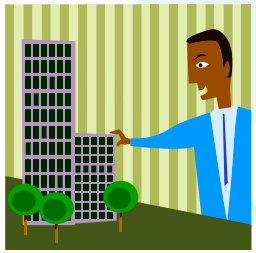
Developing a Model

- Models are realistic, solvable, and understandable mathematical representations of a situation

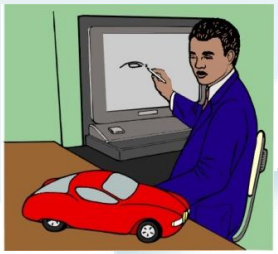


- Different types of models

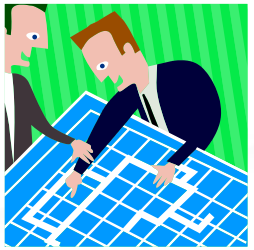
Physical models



Scale models



Schematic models

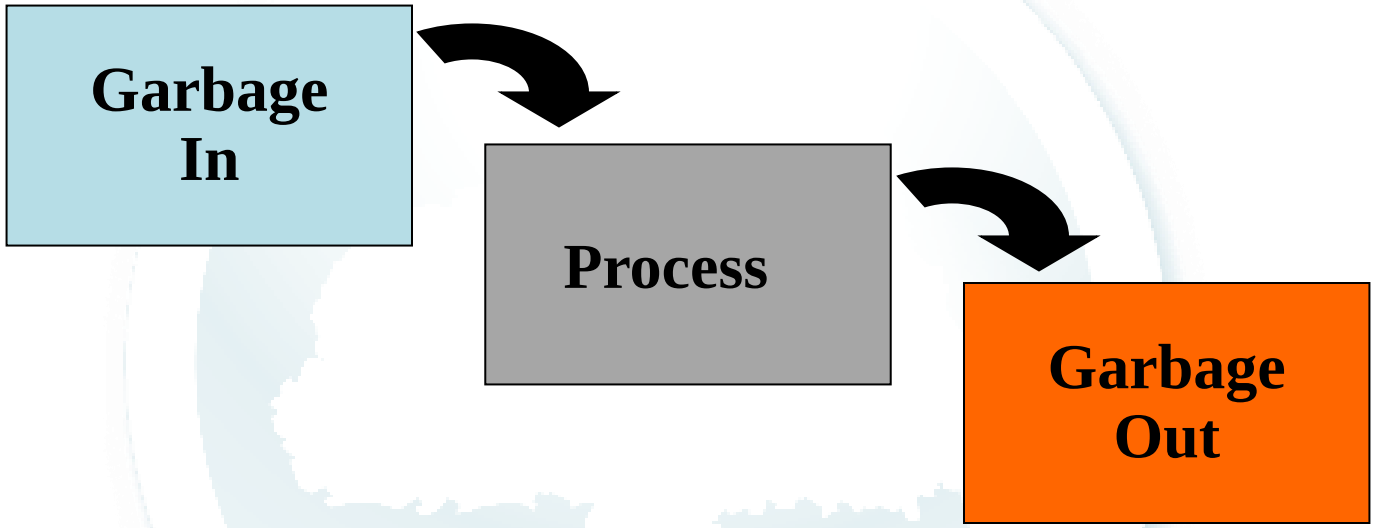


Developing a Model

- Mathematical model – a set of mathematical relationships
- Models generally contain variables and parameters
  - Controllable variables, decision variables, are generally unknown
    - How many items should be ordered for inventory?
  - Parameters are known quantities that are a part of the model
    - What is the cost of placing an order?
- Required input data must be available

Acquiring Input Data

- Input data must be accurate – GIGO rule



- Data may come from a variety of sources – company reports, documents, employee interviews, direct measurement, or statistical sampling

Developing a Solution

- Manipulating the model to arrive at the best (optimal) solution
- Common techniques are
  - **Solving** equations
  - **Trial and error** – trying various approaches and picking the best result
  - **Complete enumeration** – trying all possible values
  - Using an **algorithm** – a series of repeating steps to reach a solution

Testing the Solution

- Both input data and the model should be tested for accuracy before analysis and implementation
  - New data can be collected to test the model
  - Results should be logical, consistent, and represent the real situation

Analyzing the Results

- Determine the implications of the solution
  - Implementing results often requires change in an organization
  - The impact of actions or changes needs to be studied and understood before implementation
- **Sensitivity analysis** determines how much the results will change if the model or input data changes
  - Sensitive models should be very thoroughly tested

Implementing the Results

- Implementation incorporates the solution into the company
  - Implementation can be very difficult
  - People may be resistant to changes
  - Many quantitative analysis efforts have failed because a good, workable solution was not properly implemented
- Changes occur over time, so even successful implementations must be monitored to determine if modifications are necessary

Modeling in the Real World

- Quantitative analysis models are used extensively by real organizations to solve real problems
  - In the real world, quantitative analysis models can be complex, expensive, and difficult to sell
  - Following the steps in the process is an important component of success

How To Develop a Quantitative Analysis Model

A mathematical model of profit:

Profit = Revenue – Expenses

- Revenue and expenses can be expressed in different ways

How To Develop a Quantitative Analysis Model

Profit = Revenue – (Fixed cost + Variable cost)

Profit = (Selling price per unit)(Number of units sold) – [Fixed cost + (Variable costs per unit)(Number of units sold)]

Profit = $sX - [f + vX]$

Profit = $sX - f - vX$

where

s = selling price per unit

v = variable cost per unit

f = fixed cost

X = number of units sold

How To Develop a Quantitative Analysis Model

Profit = Revenue – (

Profit = (Selling pric
[Fixed cost
units sold)]

Profit = $sX – [f + vX$

Profit = $sX – f – vX$

The *parameters* of this model are *f*, *v*, and *s* as these are the inputs inherent in the model

The *decision variable* of interest is *X*

where

s = selling price per unit

v = variable cost per unit

f = fixed cost

X = number of units sold

Pritchett's Precious Time Pieces

- The company buys, sells, and repairs old clocks
  - Rebuilt springs sell for $8 per unit
  - Fixed cost of equipment to build springs is $1,000
  - Variable cost for spring material is $3 per unit

$s = 8$ $f = 1{,}000$ $v = 3$

Number of spring sets sold = X

$$\text{Profits} = \$8X - \$1{,}000 - \$3X$$

If sales = 0, profits $= -f =$ **–$1,000**

If sales = 1,000, profits $= [(\$8)(1{,}000) - \$1{,}000 - (\$3)(1{,}000)]$

$= \$4{,}000$

Pritchett's Precious Time Pieces

- Companies are often interested in the **break-even point** (BEP), the BEP is the number of units sold that will result in $0 profit

$$0 = sX - f - vX, \quad \text{or} \quad 0 = (s - v)X - f$$

Solving for X, we have

$$f = (s - v)X$$

$$X = \frac{f}{s - v}$$

$$\text{BEP} = \frac{\textit{Fixed cost}}{\textit{(Selling price per unit)} - \textit{(Variable cost per unit)}}$$

Pritchett's Precious Time Pieces

- BEP for Pritchett's Precious Time Pieces

  BEP = $1,000/($8 – $3) = 200 units

  - Sales of less than 200 units of rebuilt springs will result in a loss
  - Sales of over 200 units of rebuilt springs will result in a profit

$$\text{BEP} = \frac{\textit{Fixed cost}}{\textit{(Selling price per unit)} - \textit{(Variable cost per unit)}}$$

Advantages of Mathematical Modeling

1. Models can accurately represent reality
2. Models can help a decision maker formulate problems
3. Models can give us insight and information
4. Models can save time and money in decision making and problem solving
5. A model may be the only way to solve large or complex problems in a timely fashion
6. A model can be used to communicate problems and solutions to others

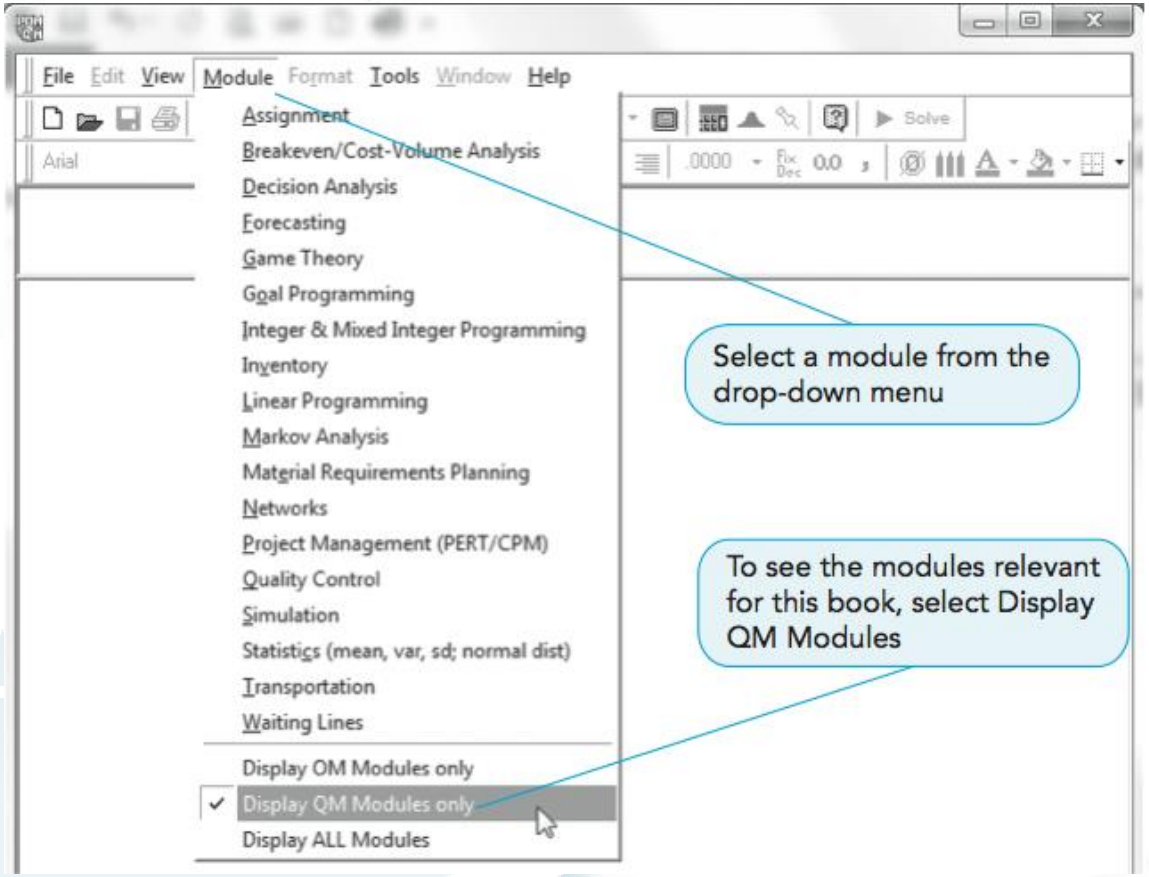
Models Categorized by Risk

- Mathematical models that do not involve risk or chance are called **deterministic** models
  - All of the values used in the model are known with complete certainty
- Mathematical models that involve risk or chance are called **probabilistic** models
  - Values used in the model are estimates based on probabilities

Computers and Spreadsheet Models

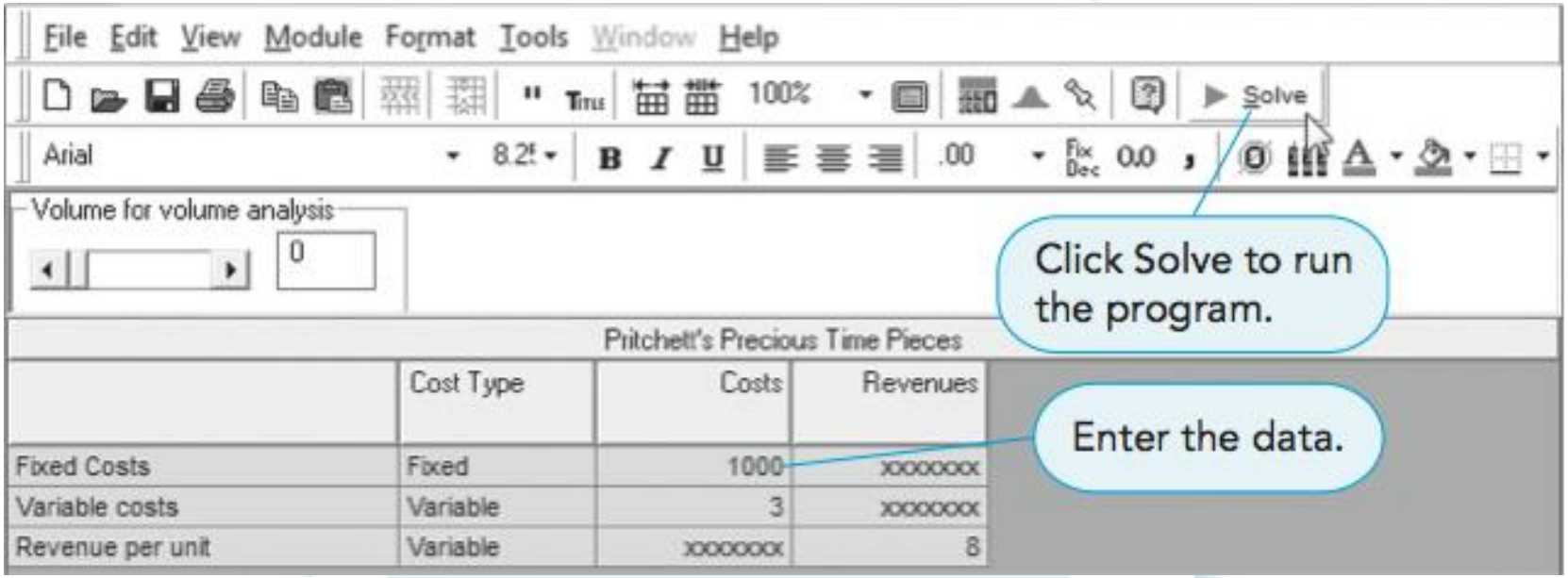
POM-QM for Windows

- An easy to use decision support system for use in POM and QM courses
- This is the main menu of quantitative models
- An Excel add-in



PROGRAM 1.1 – Main Menu

Computers and Spreadsheet Models

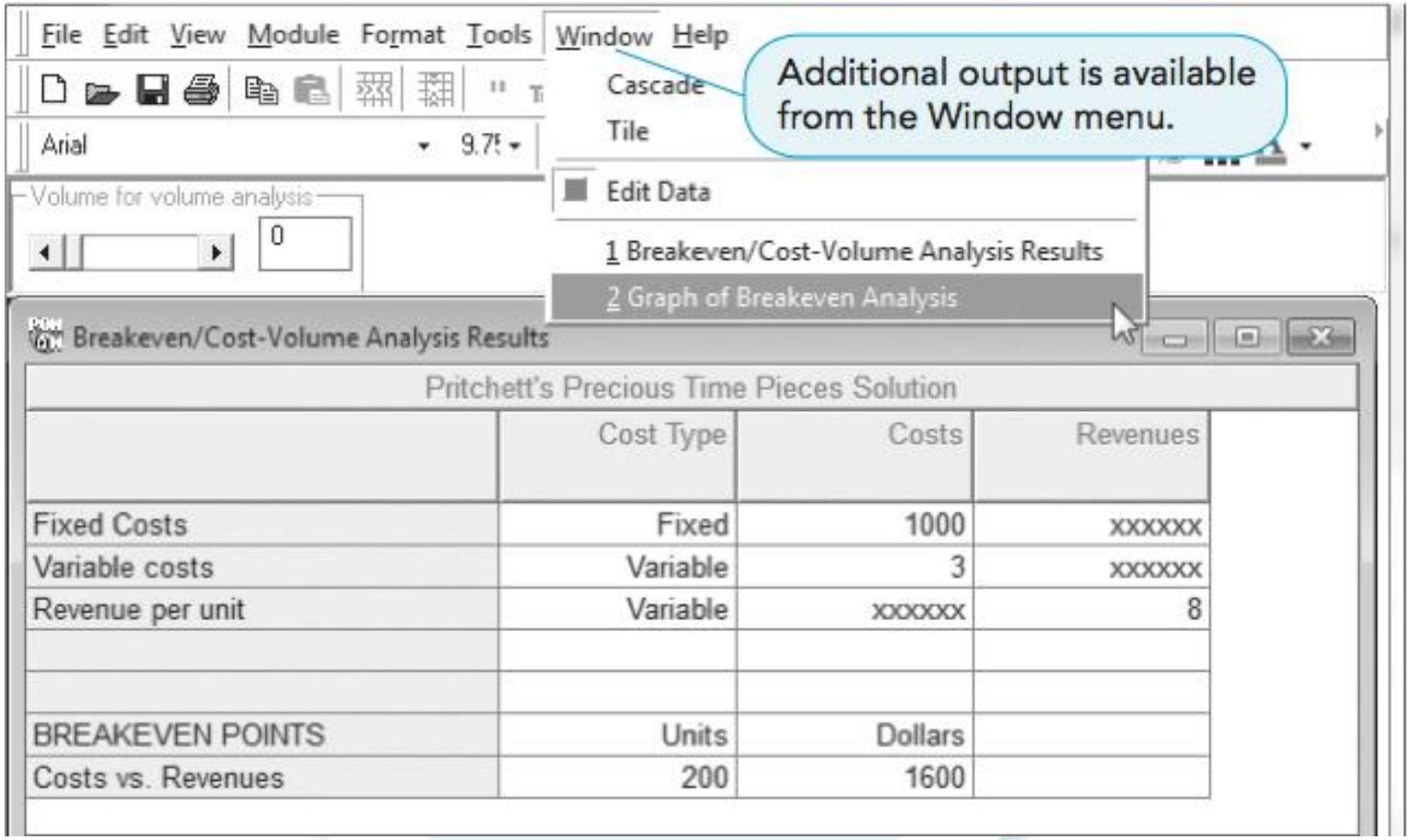


Pritchett's Precious Time Pieces

	Cost Type	Costs	Revenues
Fixed Costs	Fixed	1000	xxxxxxx
Variable costs	Variable	3	xxxxxxx
Revenue per unit	Variable	xxxxxxx	8

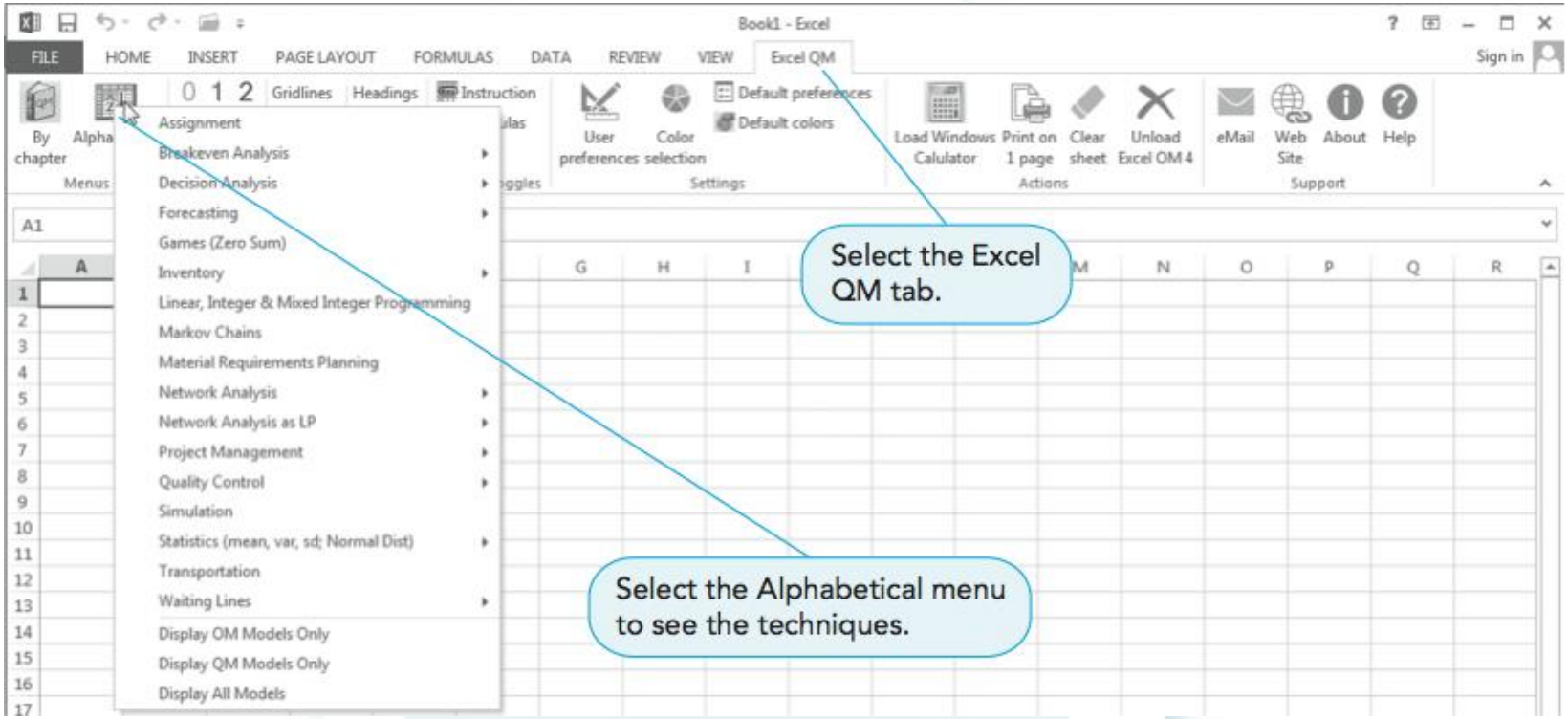
PROGRAM 1.2A – Entering Data

Computers and Spreadsheet Models



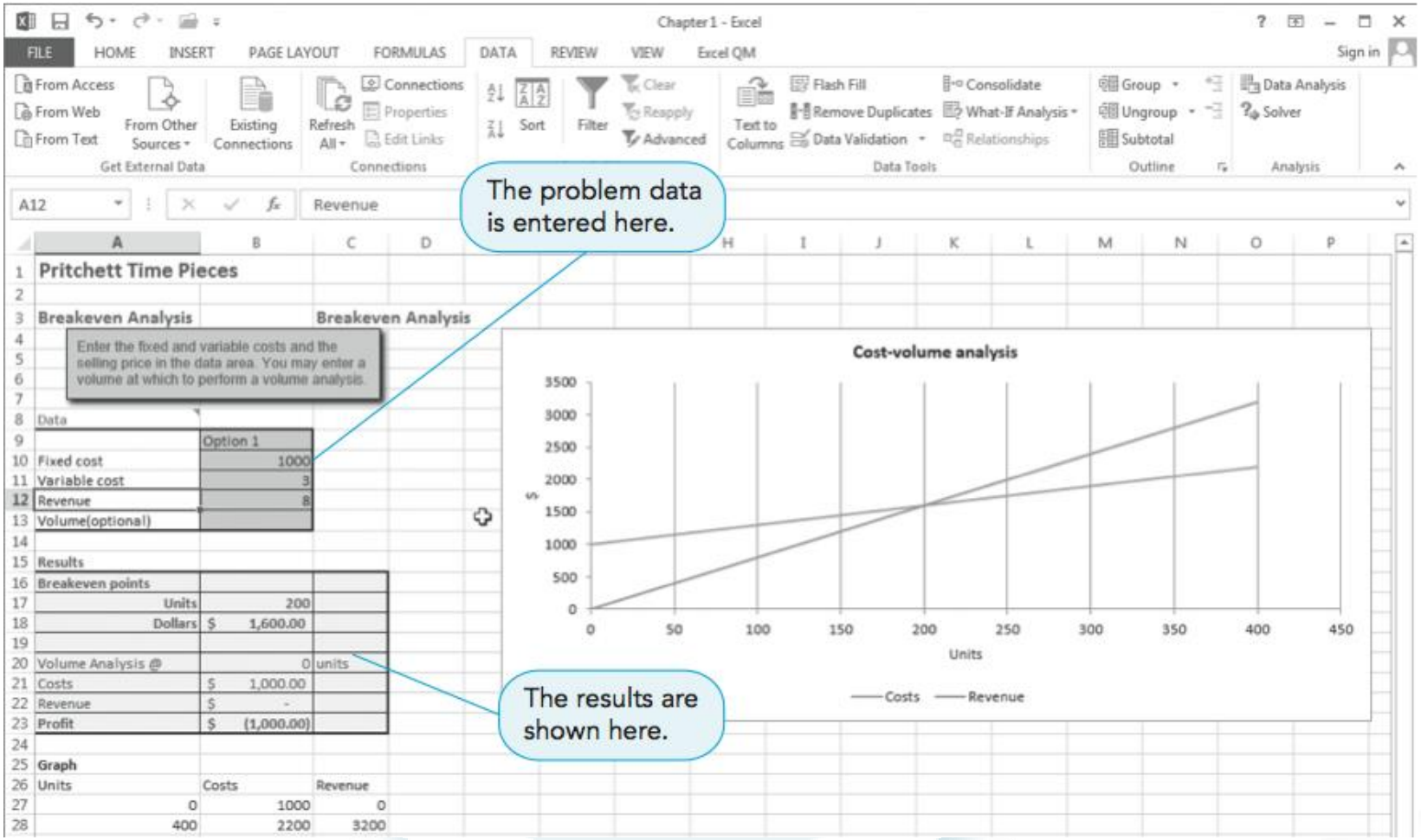
PROGRAM 1.2B – Solution Screen

Computers and Spreadsheet Models



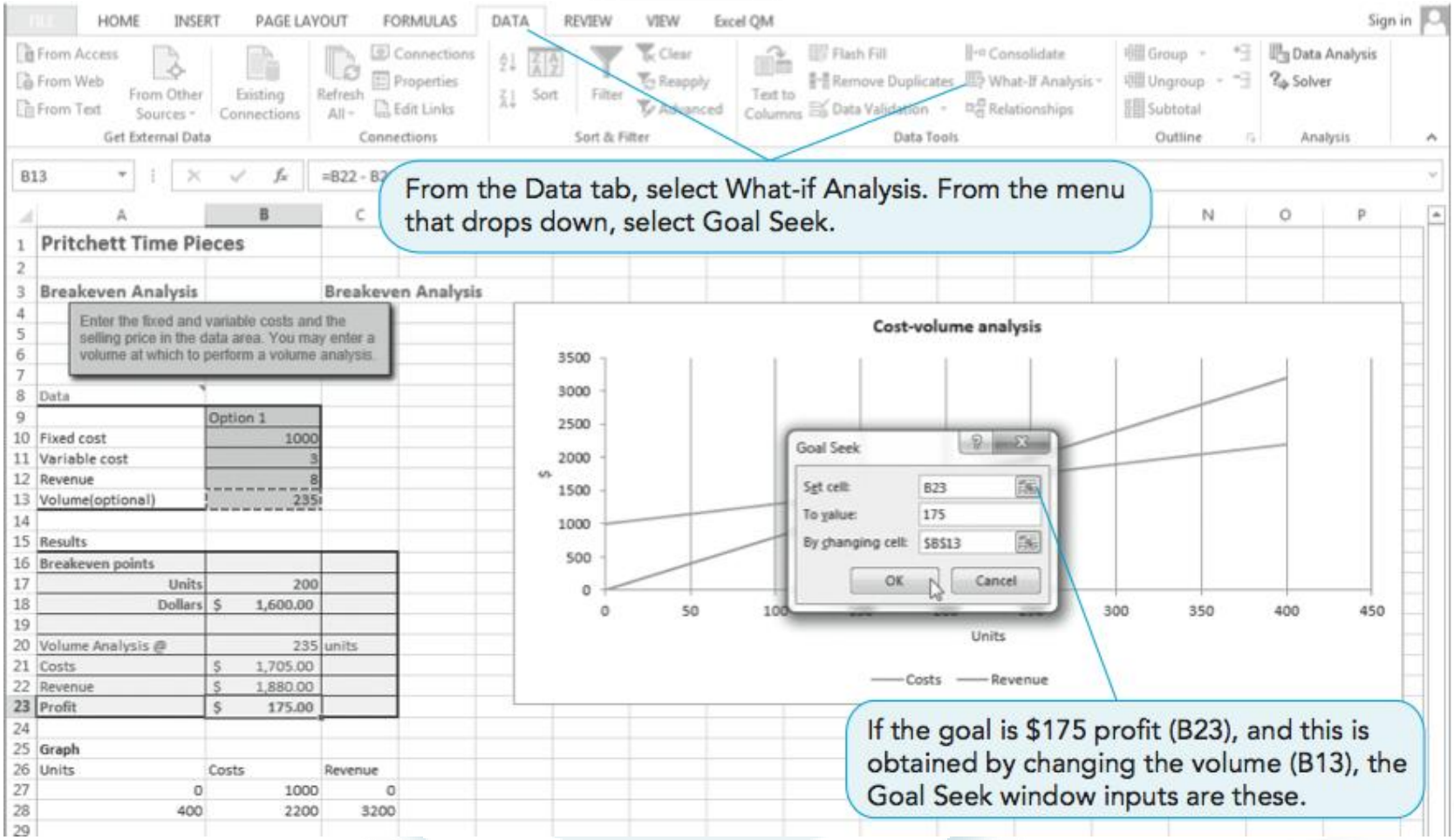
PROGRAM 1.3 – Excel Ribbon and Menu

Computers and Spreadsheet Models



PROGRAM 1.4 – Entering Data

Computers and Spreadsheet Models



	A	B	C
1	Pritchett Time Pieces		
3	Breakeven Analysis		Breakeven Analysis
8	Data		
9		Option 1	
10	Fixed cost	1000	
11	Variable cost	3	
12	Revenue	8	
13	Volume(optional)	235	
15	Results		
16	Breakeven points		
17	Units	200	
18	Dollars	$ 1,600.00	
20	Volume Analysis @	235	units
21	Costs	$ 1,705.00	
22	Revenue	$ 1,880.00	
23	Profit	$ 175.00	
25	Graph		
26	Units	Costs	Revenue
27	0	1000	0
28	400	2200	3200

PROGRAM 1.5 – Using Goal Seek

Possible Problems in the Quantitative Analysis Approach

- Defining the problem
  - Problems may not be easily identified
  - Conflicting viewpoints
  - Impact on other departments
  - Beginning assumptions
  - Solution outdated
- Developing a model
  - Fitting the textbook models
  - Understanding the model

Possible Problems in the Quantitative Analysis Approach

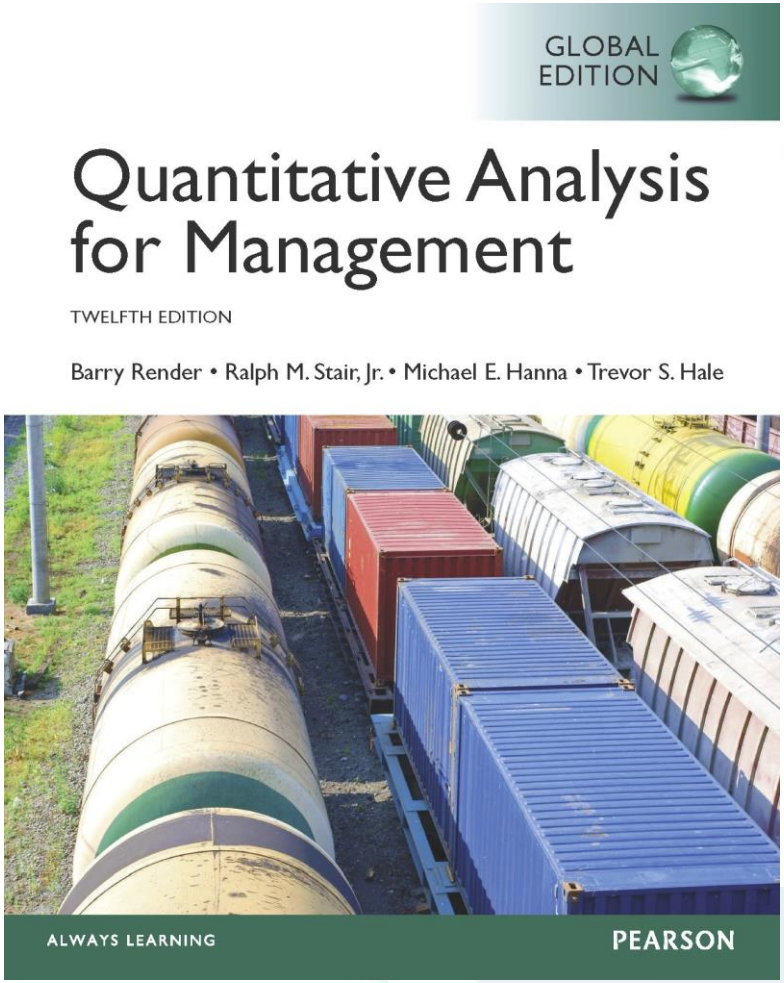
- Acquiring accurate input data
  - Using accounting data
  - Validity of the data
- Developing a solution
  - Hard-to-understand mathematics
  - Only one answer is limiting
- Testing the solution
    - Solutions not always intuitively obvious
- Analyzing the results
    - How will it affect the total organization

Implementation – Not Just the Final Step

- Lack of commitment and resistance to change
  - Fear formal analysis processes will reduce management's decision-making power
  - Fear previous intuitive decisions exposed as inadequate
  - Uncomfortable with new thinking patterns
  - Action-oriented managers may want "quick and dirty" techniques
  - Management support and user involvement are important

Implementation – Not Just the Final Step

- Lack of commitment by quantitative analysts
  - Analysts should be involved with the problem and care about the solution
  - Analysts should work with users and take their feelings into account



CHAPTER 2

Probability Concepts and Applications

To accompany
Quantitative Analysis for Management, Twelfth Edition, Global Edition,
by Render, Stair, Hanna and Hale
Power Point slides created by Jeff Heyl

LEARNING OBJECTIVES

After completing this chapter, students will be able to:

1. Understand the basic foundations of probability analysis.
2. Describe statistically dependent and independent events.
3. Use Bayes' theorem to establish posterior probabilities.
4. Describe and provide examples of both discrete and continuous random variables.
5. Explain the difference between discrete and continuous probability distributions.
6. Calculate expected values and variances and use the normal table.

CHAPTER OUTLINE

Introduction

- Life is uncertain; we are not sure what the future will bring
- **Probability** is a numerical statement about the likelihood that an event will occur

Chapters in This Book That Use Probability

TABLE 2.1

CHAPTER	TITLE
3	Decision Analysis
4	Regression Models
5	Forecasting
6	Inventory Control Models
11	Project Management
12	Waiting Lines and Queuing Theory Models
13	Simulation Modeling
14	Markov Analysis
15	Statistical Quality Control
Module 3	Decision Theory and the Normal Distribution
Module 4	Game Theory

Types of Probability

- **Objective Approach**
  - Relative frequency approach

$$P(\text{event}) = \frac{\text{Number of occurrences of the event}}{\text{Total number of trials or outcomes}}$$

  - Classical or logical method

$$P(\text{head}) = \frac{1 \leftarrow \text{Number of ways of getting a head}}{2 \leftarrow \text{Number of possible outcomes (head or tail)}}$$

$$P(\text{spade}) = \frac{13 \leftarrow \text{Number of chances of drawing a spade}}{52 \leftarrow \text{Number of possible outcomes}}$$

Diversey Paint Example

- Historical demand for white latex paint at = 0, 1, 2, 3, or 4 gallons per day
- Observed frequencies over the past 200 days

TABLE 2.2

QUANTITY DEMANDED (GALLONS)	NUMBER OF DAYS	PROBABILITY
0	40	0.20 (= 40/200)
1	80	0.40 (= 80/200)
2	50	0.25 (= 50/200)
3	20	0.10 (= 20/200)
4	10	0.05 (= 10/200)
	Total 200	Total 1.00 (= 200/200)

Diversey Paint Example

aint at = 0, 1, 2, 3, or 4

200 days

Individual probabilities are all between 0 and 1

$$0 \leq P(\text{event}) \leq 1$$

Total of all event probabilities equals 1

$$\sum P(\text{event}) = 1.00$$

TABLE 2.2

S		PROBABILITY	
		0.20	(= 40/200)
		0.40	(= 80/200)
2	50	0.25	(= 50/200)
3	20	0.10	(= 20/200)
4	10	0.05	(= 10/200)
Total	200	Total	1.00 (= 200/200)

Types of Probability

- **Subjective Approach**
  - Based on the experience and judgment of the person making the estimate
    - Opinion polls
    - Judgment of experts
    - Delphi method

Mutually Exclusive and Collectively Exhaustive Events

- Events are said to be **mutually exclusive** if only one of the events can occur on any one trial
  - Tossing a coin will result in either a head or a tail

  - Rolling a die will result in only one of six possible outcomes

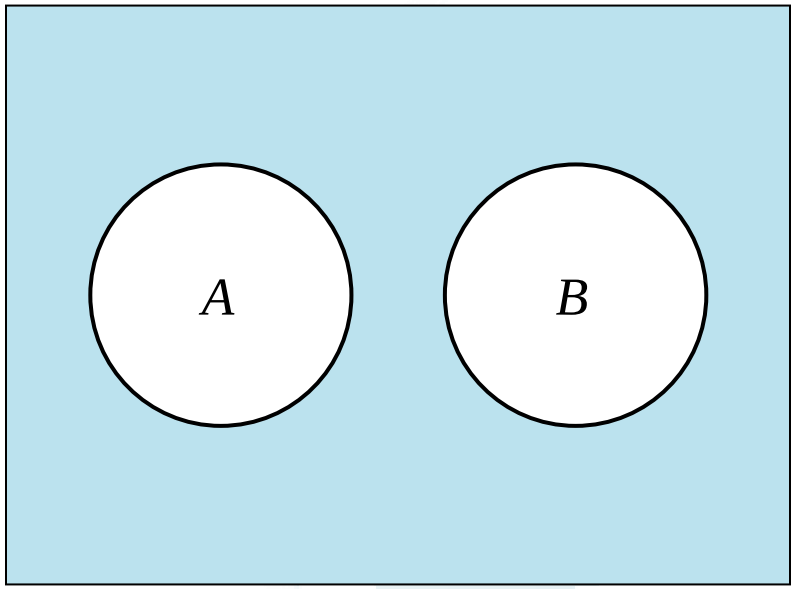
Mutually Exclusive and Collectively Exhaustive Events

- Events are said to be **collectively exhaustive** if the list of outcomes includes every possible outcome
  - Both heads and tails as possible outcomes of coin flips
  - All six possible outcomes of the roll of a die

OUTCOME OF ROLL	PROBABILITY
1	$^1/_6$
2	$^1/_6$
3	$^1/_6$
4	$^1/_6$
5	$^1/_6$
6	$^1/_6$
	Total 1

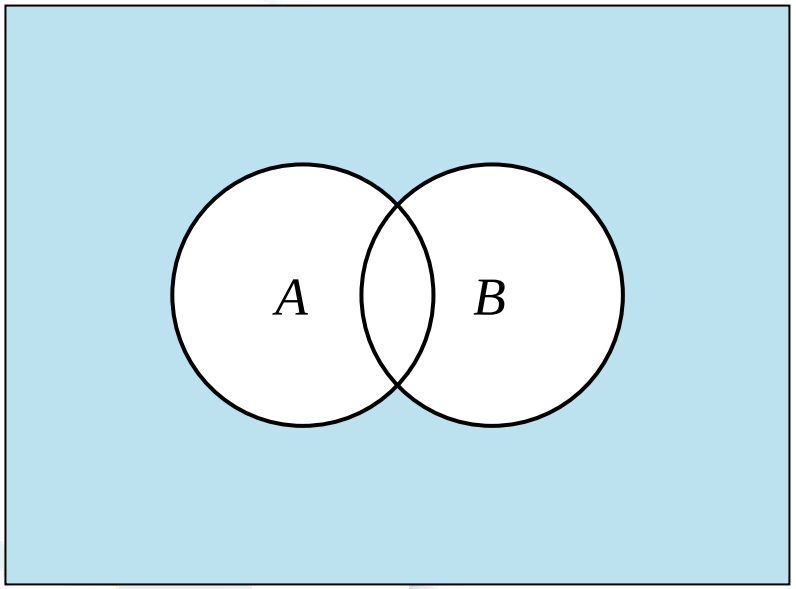
Venn Diagrams

FIGURE 2.1



Events that are mutually exclusive

FIGURE 2.2



Events that are not mutually exclusive

Drawing a Card

- Draw one card from a deck of 52 playing cards

A = event that a 7 is drawn

B = event that a heart is drawn

P (a 7 is drawn) = $P(A) = {}^{4}/_{52} = {}^{1}/_{13}$

P (a heart is drawn) = $P(B) = {}^{13}/_{52} = {}^{1}/_{4}$

  - These two events are not mutually exclusive since a 7 of hearts can be drawn
  - These two events are not collectively exhaustive since there are other cards in the deck besides 7s and hearts

Differences

DRAWS	MUTUALLY EXCLUSIVE	COLLECTIVELY EXHAUSTIVE
1. Draws a spade and a club	Yes	No
2. Draw a face card and a number card	Yes	Yes
3. Draw an ace and a 3	Yes	No
4. Draw a club and a non-club	Yes	Yes
5. Draw a 5 and a diamond	No	No
6. Draw a red card and a diamond	No	No