Management Science

Chapter 1

BA 250 Management Science

- Management science, also known as ***Operations Research, Quantitative Methods***, etc.,

  - involves a logical mathematical approach to problem solving.

  - used in a variety of organizations to solve many different types of problems in manufacturing, marketing, finance, logistics.

Text Book

Introduction to Management Science

Bernard W. Taylor III,

12th Edition, Prentice Hall, New Jersey

Learning Outcomes

The students who succeed in this course;

- ✔define basic mathematical modeling concepts and techniques
- ✔formulate a variety of management problems in *marketing, production, logistics and finance*
- ✔apply basic mathematical optimization models including linear programming and integer programming
- ✔interpret the computer output generated from "QM for Windows" to solve linear programming models
- ✔analyze various decision making problems under certainty, uncertainty and risk

BA 250 Management Science

Week	Subjects
1	Introduction to Modeling **(Ch.1)**
2	Linear Programming **(LP)** and **Graphical Solution** **(Ch.2)**
3	LP Computer Solution and **Sensitivity Analysis** **(Ch. 3)**
4	Various Linear Programming Modeling **Examples** **(Ch. 4)**
5	Various Linear Programming Modeling **Examples** **(Ch. 4)**
6	**MIDTERM EXAM 1, 26/10/2017**
7	Integer Linear Programming Models **(Ch. 5)**
8	Transportation, Transshipment and Assignment Models **(Ch. 6)**
9	Shortest Route, Minimal Spanning Tree, and Maximal Flow Problems (Network Flow Models) **(Ch. 7)**
11	**MIDTERM EXAM, 23/11/2017**
12	Project Management with CPM/PERT Models **(Ch. 8)**
13	Project Management with CPM/PERT Models (**Ch. 8)**
13	Decision Analysis **(Ch. 12)**
14	Review of the Semester

EVALUATION SYSTEM

	PERCENTAGE OF GRADE
First Mid-Term Exam	30
Second Mid-Term Exam	30
Final Exam	40
TOTAL	100
% OF SEMESTER WORK	60
% OF FINAL WORK	40
TOTAL	100

Chapter 1 Topics

- Examples of Managerial Problems
- The Management Science Approach to Problem Solving
- Mathematical Modeling with a simple example
- Model Building: Break-Even Analysis
- Classification of Management Science Techniques
- Introduction to Linear Programming

Examples of Managerial Problems (Manufacturing)

- A manufacturer has fixed amounts of different resources such as raw material, labor, and equipment.
- These resources can be combined to produce any one of several different products.
- The quantity of the resource i required to produce one unit of the product j is known.
- The problem is to determine the quantity of products to produce so that total income can be maximized.

Examples of Managerial Problems (Production Scheduling)

- A manufacturer knows that he must supply a given number of items of a certain product each month for the next *n* months.
- They can be produced either in ***regular time***, subject to a maximum each month, or in ***overtime***. The cost of producing an item during overtime is greater than during regular time. A *storage cost* is associated with each item not sold at the end of the month.
- The problem is **to determine the production schedule that minimizes the sum of production and storage costs.**

Examples of Managerial Problems (Transportation)

- A product is to be shipped in the amounts $a_1, a_2, \ldots, a_m$ from m shipping origins and received in amounts $b_1, b_2, \ldots, b_n$ at each of n shipping destinations.
- The cost of shipping a unit from the i[th] origin to the j[th] destination is known for all combinations of origins and destinations.
- The problem is to determine <u>the amount to be shipped from each origin to each destination</u> such that the total cost of transportation is a minimum.

Examples of Managerial Problems (Finance: Portfolio Selection Problem)

Alternative investments (shares, bonds, etc.)

Mutual funds, credit unions, banks, insurance companies

Maximization of expected return

Minimization of risk

Examples of Managerial Problems (Marketing Research)

- Evaluating consumer's reaction to new products and services

- Prepare a campaign with door-to-door personal interviews about households' opinion

- Households: with children
  without children

- Time of interview: daytime, evening

The Management Science Process

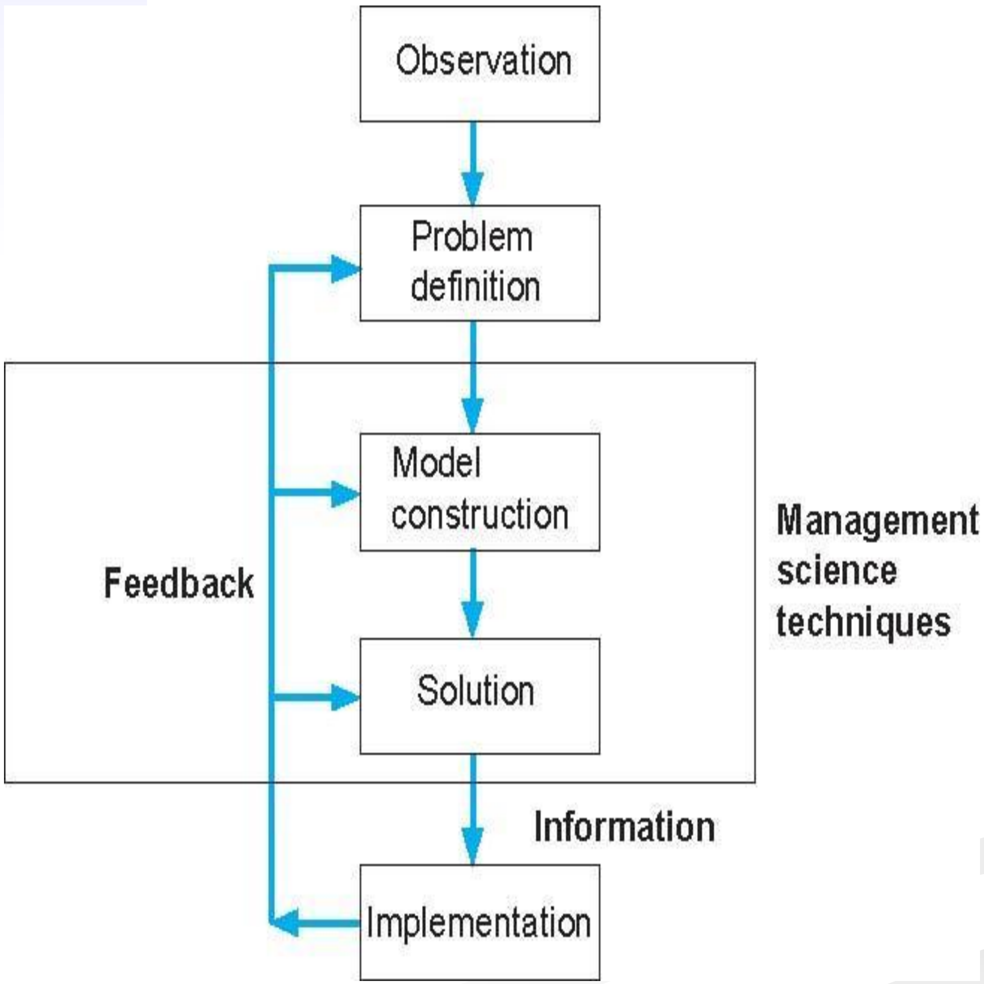

Figure 1.1

Steps in the Management Science Process

- **Observation** - Identification of a problem that exists (or may occur soon) in a system or organization.
- **Definition of the Problem** - problem must be clearly and consistently defined, showing its boundaries and interactions with the objectives of the organization.
- **Model Construction** - Development of the functional mathematical relationships that describe the decision variables, objective function and constraints of the problem.
- **Model Solution** - Models solved using management science techniques.
- **Model Implementation** - Actual use of the model or its solution.

Example of Model Construction (1 of 3)

Information and Data:

- Business firm makes and sells a steel product
- Product costs $5 to produce
- Product sells for $20
- Product requires 4 pounds of steel to make
- Firm has 100 pounds of steel

Business Problem:

- **Determine the number of units to produce to make the most profit, given the limited amount of steel available.**

Example of Model Construction (2 of 3)

Variables: X = # units to produce (decision variable)

Z = total profit (in $)

Model: Z = $20X - $5X (objective function)

4X = 100 lb of steel (resource constraint)

Parameters: $20, $5, 4 lbs, 100 lbs (known values)

Formal Specification of Model:

maximize Z = $20X - $5X

subject to 4X = 100

Example of Model Construction (3 of 3)

Model Solution:

Solve the constraint equation:

$$4x = 100$$
$$(4x)/4 = (100)/4$$
$$x = 25 \text{ units}$$

Substitute this value into the profit function:

$$Z = \$20x - \$5x$$
$$= (20)(25) - (5)(25)$$
$$= \$375$$

(Produce 25 units, to yield a profit of $375)

Model Building: Break-Even Analysis

- Used to determine the number of units of a product to sell or produce that will **equate total revenue with total cost.**
- The volume (number of products produced) at which total revenue equals total cost is called the **break-even point.**
- **Profit at break-even point is zero.**

Model Building: Break-Even Analysis

Model Components

- **Fixed Cost (c_f)** - costs that remain constant regardless of number of units produced. (e.g. Rent, taxes, management salaries, insurance, heating etc.)
- **Variable Cost (c_v)** - unit production cost of product. (including raw material, labor, resources, packaging, material handling, transportation)
- **Volume (V)** – the number of units produced or sold
- **Total variable cost (Vc_v)** - function of volume (v) and unit variable cost.

Model Building: Break-Even Analysis

Model Components

- **Total Cost (TC)** - total fixed cost plus total variable cost.

$$TC = c_f + vc_v$$

- **Profit (Z)** - difference between total revenue vp (p = unit price) and total cost, i.e.

$$Z = \text{Total Revenue - Total Cost}$$
$$Z = vp - c_f - vc_v$$

Model Building: Break-Even Analysis

Computing the Break-Even Point

The break-even point is that volume at which total revenue equals total cost and profit is zero:

$$vp - c_f - vc_v = 0$$

$$v(p - c_v) = c_f$$

The break-even point $v = \dfrac{c_f}{p - c_v}$

Model Building: Break-Even Analysis

Example: Western Clothing Company

Fixed Costs: c_f = \$10000

Variable Costs: c_v = \$8 per pair

Price : p = \$23 per pair

Break-Even Point

- The Break-Even Point is:

$$V = BEP = (10{,}000)/(23 - 8)$$

$$= 666.7 \text{ pairs}$$

OR

Total Cost = Total Revenue

$$10{,}000 + 8v = 23v$$

Model Building: Break-Even Analysis

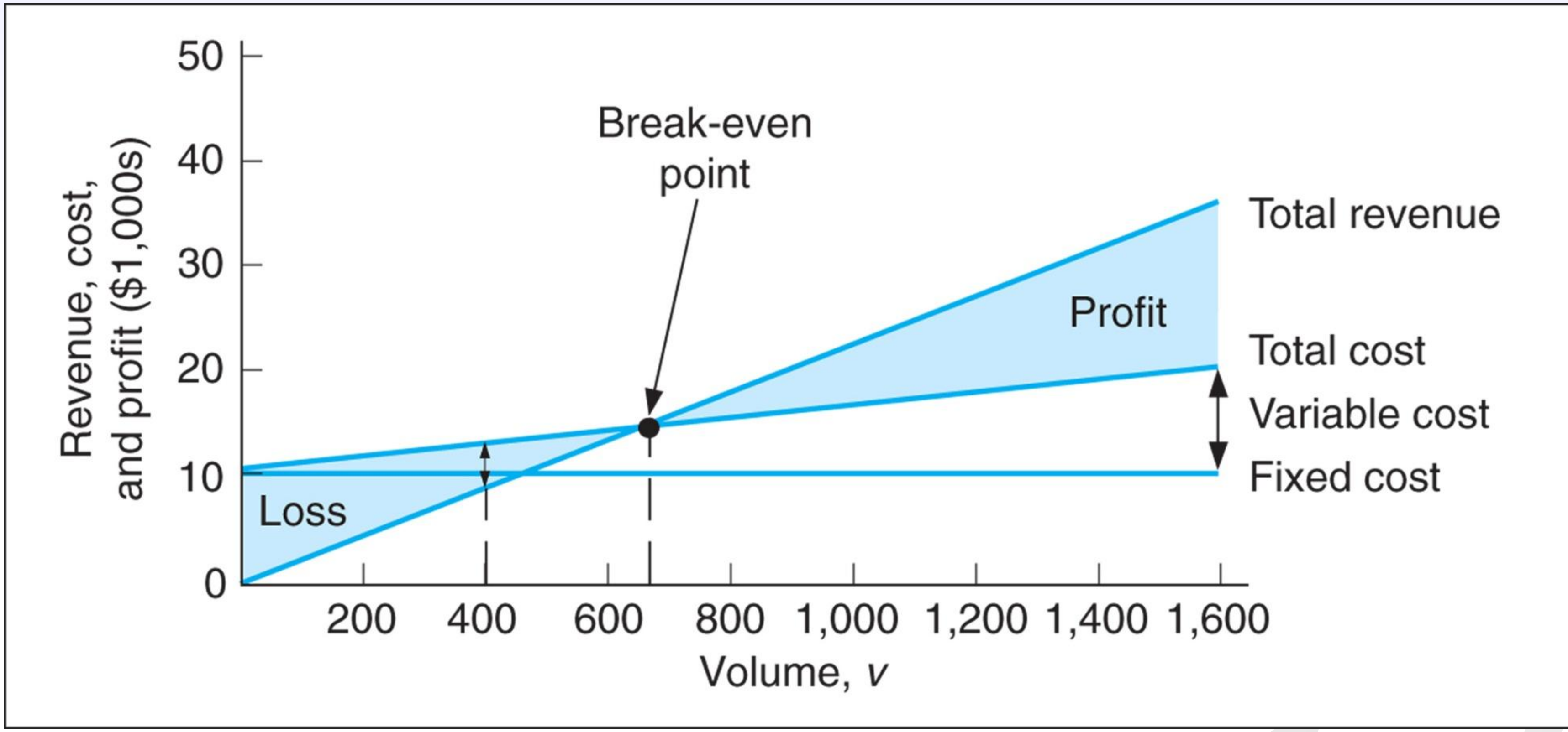

Figure 1.2

Model Building: Break-Even Analysis

Example: Western Clothing Company

Fixed Costs: $c_f = \$10000$

Variable Costs: $c_v = \$8$ per pair

Price : $p = \$30$ per pair

Model Building: Break-Even Analysis

- The Break-Even Point is:

$$v = (10{,}000)/(30 - 8)$$
$$= 454.5 \text{ pairs}$$

Model Building: Break-Even Analysis

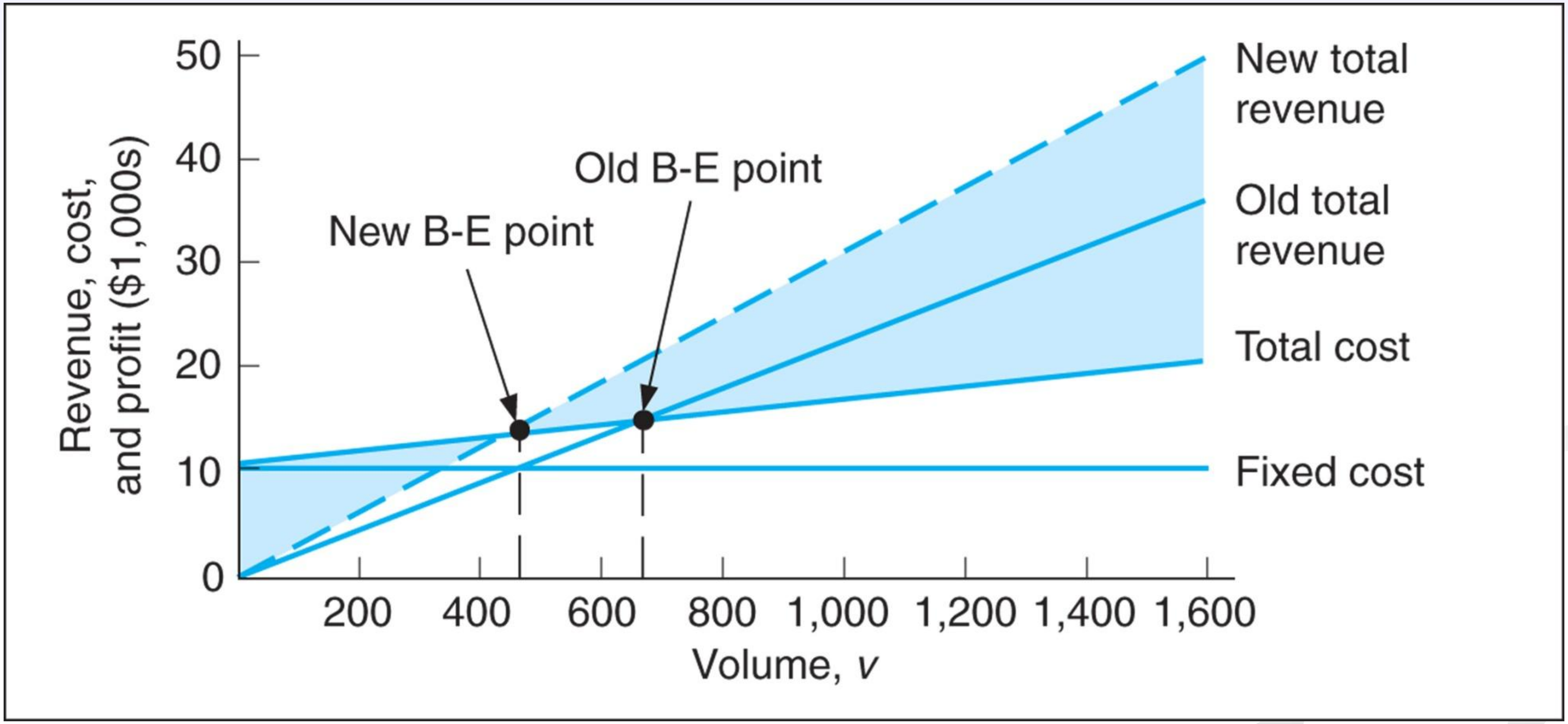

Figure 1.3

Model Building: Break-Even Analysis

Example: Western Clothing Company

Fixed Costs: c_f = \$10000

Variable Costs: c_v = \$12 per pair

Price : p = \$30 per pair

The Break-Even Point is:

$$v = (10{,}000)/(30 - 12)$$
$$= 555.5 \text{ pairs}$$

Model Building: Break-Even Analysis

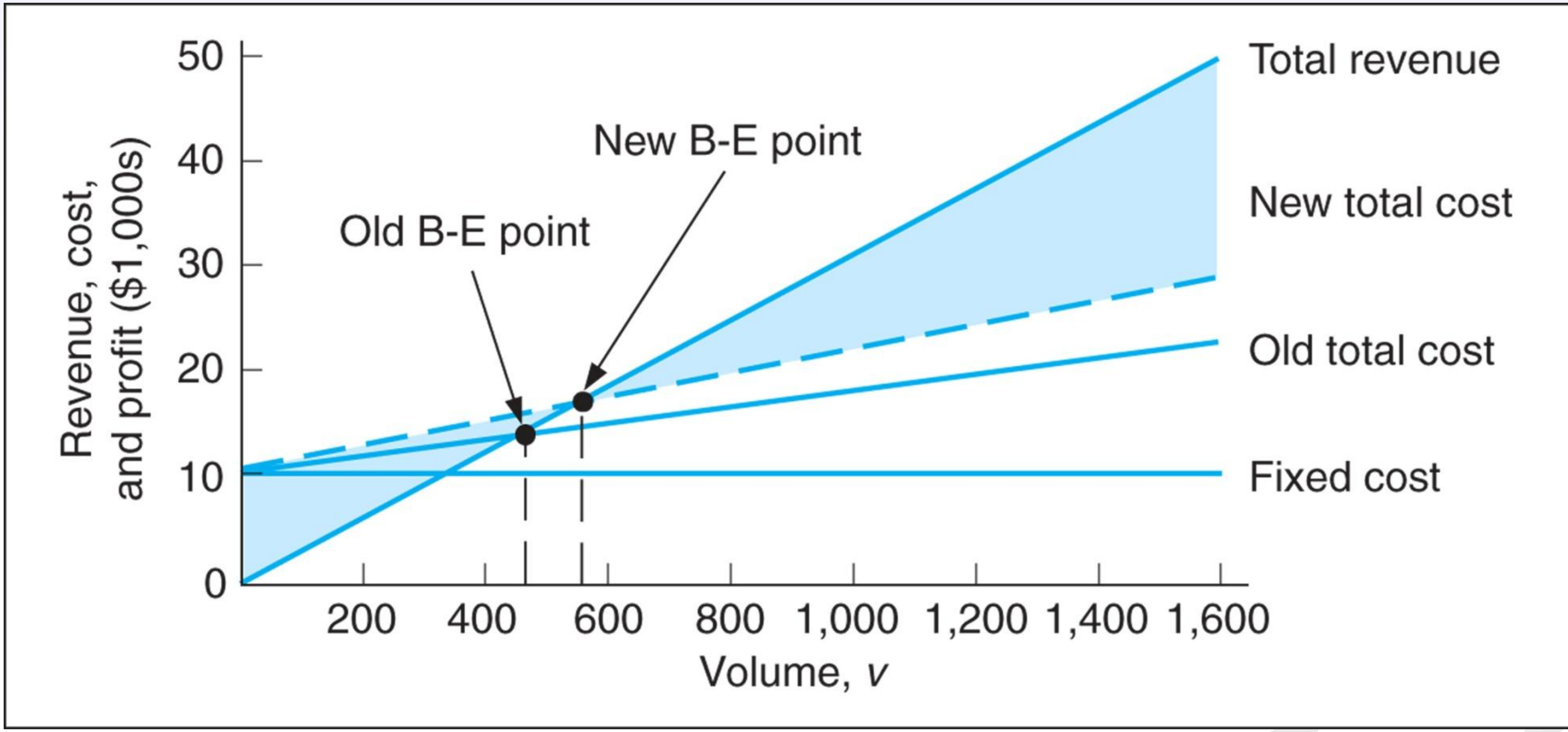

Figure 1.4

Model Building: Break-Even Analysis

Example: Western Clothing Company

Fixed Costs: $c_f = \$13000$

Variable Costs: $c_v = \$12$ per pair

Price : $p = \$30$ per pair

Model Building: Break-Even Analysis

- The Break-Even Point is:

$$v = (13{,}000)/(30 - 12)$$
$$= 722.2 \text{ pairs}$$

Model Building: Break-Even Analysis

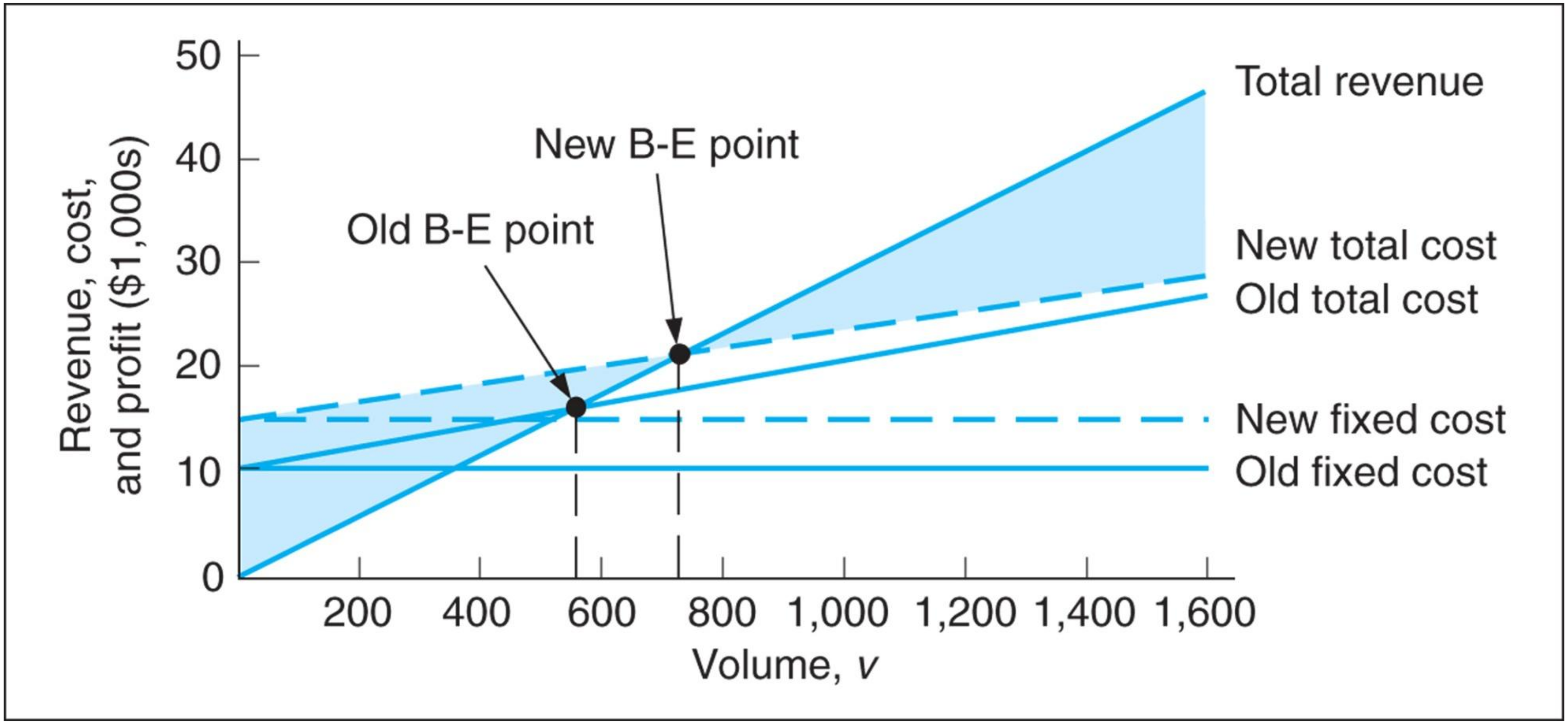

Figure 1.5

Break-Even Analysis: QM Solution (2 of 3)

Breakeven/Cost-Volume Analysis Results

Western Clothing Company Example Solution			
	Cost Type	Costs	Revenues
Fixed Costs	Fixed	10000	xxxxxx
Variable costs	Variable	8	xxxxxx
Revenue per unit	Variable	xxxxxx	23
BREAKEVEN POINTS	Units	Dollars	
Costs vs Revenues	666.67	15333.33	

Exhibit 1.4

Break-Even Analysis: QM Solution (3 of 3)

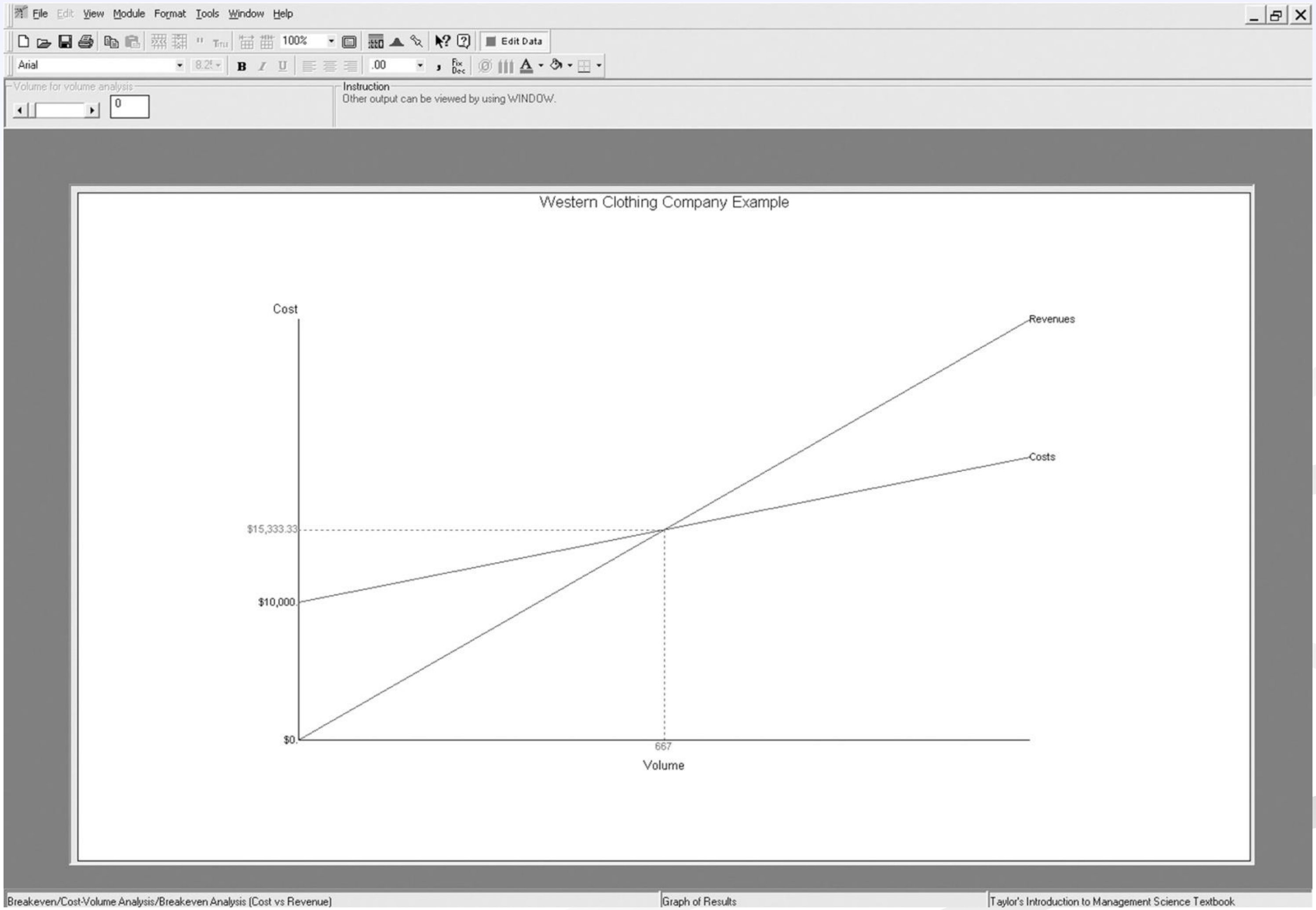

Exhibit 1.5

Classification of Management Science Techniques

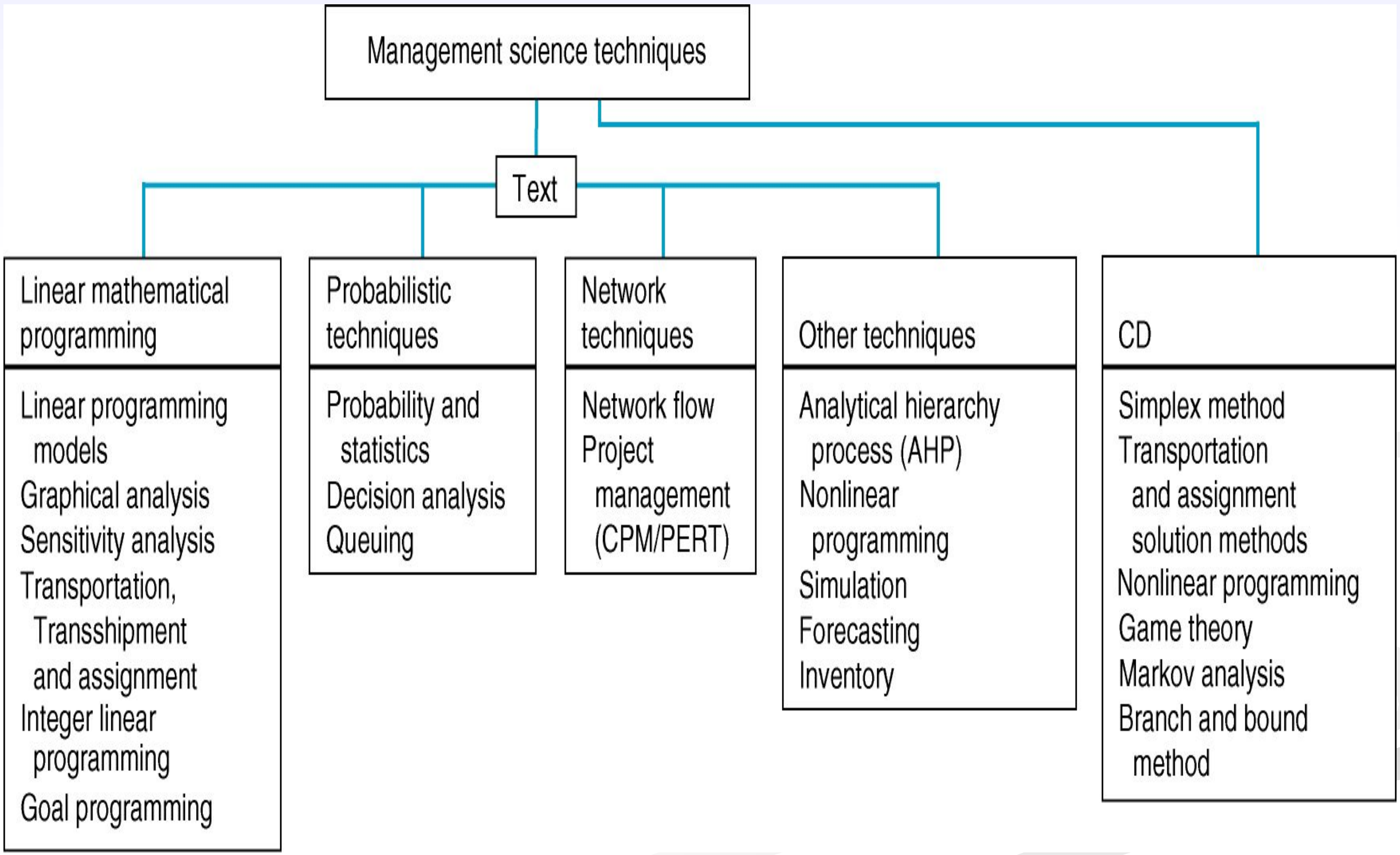

Figure 1.6 Modeling Techniques

Characteristics of Modeling Techniques

- **Linear Mathematical Programming** - clear objective; restrictions on resources and requirements; parameters known with certainty. (Chap 2-6, 9)
- **Probabilistic Techniques** - results contain uncertainty. (Chap 11-13)
- **Network Techniques** - model often formulated as diagram; deterministic or probabilistic. (Chap 7-8)
- **Other Techniques** - variety of deterministic and probabilistic methods for specific types of problems including forecasting, inventory, simulation, multicriteria, etc. (Chap 10, 14-16)

The Linear Programming Model (1)

Let: $X_1, X_2, X_3, \ldots\ldots\ldots, X_n$ = decision variables

Z = Objective function or linear function.

$$\text{Max } Z = c_1X_1 + c_2X_2 + c_3X_3 + \ldots\ldots\ldots + c_nX_n$$

subject to the following constraints:

$$
\begin{aligned}
a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n &\leq b_1 \\
a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n &\leq b_2 \\
\vdots \qquad\qquad\qquad & \quad \vdots \\
a_{m1}x_1 + a_{m2}x_2 + \cdots + a_{mn}x_n &\leq b_n \\
\text{all } x_j &\geq 0
\end{aligned}
$$

The Linear Programming Model (2)

Maximize

$$Z = \sum_{j=1}^{n} c_j x_j$$

subject to:

$$\sum_{j=1}^{n} a_{ij} x_j \leq b_i$$

where

$$i = 1, 2, \ldots, m$$

and

$$x_j \geq 0$$

where

$$j = 1, 2, \ldots, n$$