

# Chapter One

## The Art and Science of Becoming a More Effective and Efficient Problem Solver

### Learning Objectives

After completing this chapter, students will be able to:

1. Describe the process of quantitative problem solving
2. Describe the use of business decision modeling in quantitative problem solving
3. Understand the application of business decision modeling in a real situation
4. Discuss problems using quantitative problem solving techniques
5. Be cognizant of computer and spreadsheet use in business decision modeling

### Chapter outline

Business Decision Modeling in Action—Algorithm? What the Heck is an Algorithm?

The Art and Science of Using Business Decision Modeling to Become a More Effective and Efficient Problem Solver• Definition of Quantitative Business Decision Making

*Areas of Business Decision Modeling Application*

*Companies Using Business Decision Modeling Concepts*

*The Business Decision Modeling Process*

Business Decision Modeling Throughout the Ages: A Brief History

The Business Decision Modeling Process

*Step 1: Problem Identification*

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*Break-Even Analysis*

Computer-Generated Solutions Using Spreadsheets

*Solving Complex Problems Using Spreadsheets*

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*Writing Business Decision Modeling Reports for Business*

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*Executive Summary*  
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*Executive Summary Example for tSurfboard Inc.*  
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## BUSINESS DECISION MODELING IN ACTION—ALGORITHM? WHAT THE HECK IS AN ALGORITHM?

### Introduction

Algorithms, algorithms, algorithms everywhere! What is an algorithm? Where does this stuff come from? This question probably takes you back to those nasty word problems in math class, remember, “If a train leaves Chicago at 6 A.M. traveling at 60 mph and a train leaves Omaha at 7 A.M. traveling at 80 mph ....”

Algorithms = step-by-step solution process

Even though some of us may not have very fond memories of these sorts of problems, we use algorithms on a daily basis. Algorithms are really step-by-step methods for solving a problem. Algorithms are set in motion when you order a hamburger at a fast food restaurant or when you book your airline reservation.

### Algorithms, Computers, and Problem Solutions

How does this apply to us today as future managers, supervisors, and entrepreneurs? Well, with the advent of the computer in the 1940s and the further proliferation of that concept on to our desktops, the way we use mathematics to solve problems is getting a huge boost. The power of today’s computers has added a new dimension to using algorithms to solve problems and to solve problems more effectively and efficiently.

### Faster, Cheaper, and Better

Algorithms have allowed businesses to solve problems faster and to provide goods and services cheaper and better.\* The study of these algorithms for problem solving is called quantitative methods (business decision modeling), management science (MS), or operations research (OR). This text will provide a solid foundation in what business decision modeling is and give numerous examples on how it is used to solve problems. This text will give you the ability to solve complex problems effectively and efficiently out in the real world.

## THE ART AND SCIENCE OF USING BUSINESS DECISION MODELING TO BECOME A MORE EFFECTIVE AND EFFICIENT PROBLEM SOLVER

The art and science of becoming a more effective and efficient problem solver is what this book is all about. Readers are invited to develop skills and judgment in becoming more effective and efficient problem solvers. Sections on the communication of results are introduced to aid in the decision and writing process. Real-life problems are addressed throughout the text to integrate the theory with practical applications.

Techniques as well as mathematical models are presented for seeking solutions to these problems. The ability to produce professional-quality reports is a major goal of the text. The text

\* Kevin Maney, “Higher Math Delivers Formula for Success,” *USA Today*, December 31, 1997.

Business decision modeling is the application of a scientific approach to solving management problems.

The terms management science, quantitative analysis, operations research, and operations management are at times used interchangeably to describe the discipline.

Business decision modeling techniques and models are used in many areas that affect our everyday lives.

strives to educate managers in the science of problem solving using critical thought and judgment. This process will aid in the management of real life, unstructured, messy situations.

## Definition of Quantitative Business Decision Making

What is business decision modeling? There are actually a number of different words used to describe the business decision modeling discipline and a number of different definitions used to characterize it. A few are listed below:

“[Business decision modeling] is the application of a scientific approach to solving management problems in order to help managers make better decisions.”

“... is the application of quantitative analysis to managerial decision making.”

“... may be described as a scientific approach to decision making.”

“... is the study of decision making in the operations function.”

So which do we follow? Which is correct? Before we try to decide this, let's take a quick look back at those definitions and scan them for any similarities. There are many similarities that exist.

- All definitions mention the idea of decision making.
- Those in charge of the decision making are managers.
- The managers are making decisions on the basis of a scientific approach or set of rules.

These definitions are not the only definitions. When looked at as a whole, however, the different definitions do have a common theme. What about the different names being used? In actuality, business decision modeling tends to be referred to by numerous monikers. In fact we see the following names used in just the four definitions used above:

- Management science
- Quantitative analysis
- Operations research
- Operations management

At times, business decision modeling and the aforementioned names are used interchangeably. Just take a look at the name of the course, what department and what school the course is taught in and the terminal degree of the professor teaching the course. You can start to get a feel for how closely all these names are interchangeable. It should be noted that even though each of these monikers has similar elements, there are subtle differences between the definitions and names.

Overall, as we travel through the text, challenge yourself to begin to make your own definition of what business decision modeling is with respect to your own background, field of study, industry, etc.

## Areas of Business Decision Modeling Application

Armed with these definitions, a student of business decision modeling needs to next think about areas where business decision modeling concepts and techniques are used.

Table 1.1 provides a description of the types of industries that use business decision modeling and its uses. The areas listed below are just a sampling of the places business decision modeling concepts are employed. In the process of studying business decision modeling, one should begin to see the numerous applications that affect our everyday lives. Each day as you drive to school, go shopping, access the Internet, or go on vacation, stop and take a look around and ask yourself is business decision modeling at work here?

## Companies Using Business Decision Modeling Concepts

As we look around to recognize areas where business decision modeling concepts are applied, we also need to be aware of companies involved in these applications. Many companies directly associated with the areas listed in Table 1.1 use business decision modeling.

**TABLE 1.1**  
Areas of Business  
Decision Modeling  
Application

Industry	Industry
Banking - Banking and credit card management - Loan portfolio management	Airline and travel - Reservation ticketing - Flight and crew scheduling
Manufacturing - Inventory and capacity planning - Quality control	Marketing - Consumer preferences - Market research
Entertainment - Queuing/crowd control - Demand forecasting	Information technology - Computer programming - Networking efficiency

**TABLE 1.2**  
Companies Using  
Business Decision  
Modeling

Company Name	Operational Activity
SABRE Decision Technologies	Airline reservation systems
Capital One, GE Capital, Provident	Banking and credit card management
CSX and Union Pacific Railroads	Rail shipping
Matson Ocean Liners	Over-the-water freight shipping
McKinsey, Accenture, Ernst & Young, AMS, Boston Consulting Group	Management consulting

Table 1.2 contains a brief list of companies using business decision modeling in their daily operations.

This list is by no means exhaustive. There are many more companies that use business decision modeling concepts in their everyday operations and that effect us in our everyday lives. The challenge for the student of business decision modeling is to keep your eyes open and continually observe if the companies that provide you with goods and services use business decision modeling.

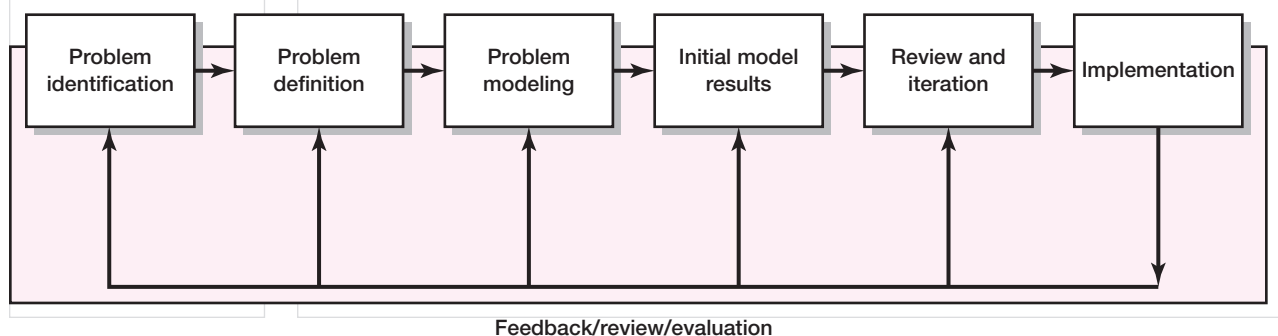
### The Business Decision Modeling Process

The previous sections included a definition of management science as a rational systematic approach to problem solving. In addition, areas of business decision modeling use were detailed and companies that use business decision modeling in their operational activities were listed. Overall, as students begin to become acquainted with the discipline, it should become clear that business decision modeling is actually a process for solving problems. This process resembles what is called the *scientific method* for solving problems.

The business decision modeling process, depicted in Figure 1.1, follows these general steps (1) identification of the problem, (2) definition of the problem, (3) modeling of the problem, (4) initial model solutions and feedback, (5) review and iteration, and (6) implementation. Each of the six steps will be analyzed individually after a brief history of business decision modeling.

Business decision modeling is actually a process for solving problems.

**Figure 1.1** Business Decision Modeling Process.



# Business Decision Modeling Throughout the Ages

## A Brief History

### HISTORICAL OBJECTIVE

Until the middle of the last century, most industrial enterprises employed only a few workers. As companies expanded, however, it became less feasible for one person to manage all of the new managerial functions of the business effectively. New scientific methodologies were developed to provide assistance to each new type of managerial function as it appeared.

As more specialized forms of management emerged, so did more specialized subfunctions, such as statistical quality control, equipment maintenance, marketing research, and inventory control. Whenever a managerial function is broken down into a set of different subfunctions, a new task—the executive function of management—is created to integrate the diverse sub-functions so that they serve efficiently the interests of the business as the whole. The executive function evolved gradually, as did organizations themselves. However, increasing demands were made on the manager who in turn sought aid from outside the organization that gave rise to management consultants.

### ORIGINS OF BUSINESS DECISION MODELING

Business decision modeling can be partially attributed to World War II, since many operations sought to bring mathematical or quantitative approaches to bear on military

operations. Business decision modeling has characteristics that include economics (known as econometrics), psychology (psychometrics), sociology (sociometrics), marketing (marketing research), and corporate planning problems. The growing complexity of management has necessitated the development of sophisticated mathematical techniques for planning and decision-making.

Some areas of business decision modeling, such as inventory and production control, and scheduling theory, have grown into subdisciplines in their own right and have become largely indispensable in the modern world. The potential of computers and information systems as new tools for management forced the non-technically trained executives to look for help in the utilization of the computer.

### OPTIMAL INFORMATION AREA

Operational Research Society web site at <http://www.orsoc.org.uk/home.html>

OpsResearch.com web site at URL <http://www.opsresearch.com/OR-Links/index.html>

Professor Hossein Arsham's Applied Management Science website at <http://ubmail.ubalt.edu/~harsham/opre640/opre640.htm#rintsites>

## THE BUSINESS DECISION MODELING PROCESS

### Quantitative Methods/ Management Science Time Line

Time	Major Milestones or Accomplishments
1890s	Frederick Taylor develops the field of "scientific management."
1900s	Henry Gantt develops a charting process widely used today. The Gantt charting process is the precursor to packages such as MS project.
1910s	A. K. Erlang investigates waiting time for telephone callers and formulates the first measure of average waiting time in queuing theory.
1920s	Walter Stewart introduces the concept of quality control charts, the precursor to employee empowerment through total quality management.
1930s	John von Neumann and Oskar Morgenstern develop the fundamental concepts for decision theory and analysis.
1940s	The field of operations research comes to the forefront with the advent of World War II. The first electronic computer is developed.
1950s	The Operations Research Society of America (ORSA) and The Institute of the Management Sciences (TIMS) were founded to foster further study of operations research and management science. Scheduling and project management techniques, PERT and CPM, are developed by DuPont, Sperry-Rand, U.S. Navy, and Lockheed.
1960s	Large corporations begin to use operations research techniques to solve problems more efficiently and effectively as computers become common tools in industry. The Decision Sciences Institute is formed to further the study of teaching and research in the field of decision science.
1970s	The Apple microcomputer and VisiCalc, the precursor to the common spreadsheet, are developed.

**Quantitative Methods/  
Management Science  
Time Line**  
*continued*

Time	Major Milestones or Accomplishments
1980s	The personal desktop computer is widely marketed and specialized business decision modeling software packages begin to proliferate (e.g., Lotus123, Quattro Pro, and Excel).
1990s	TIMS and ORSA merge to form the Institute for Operations Research and Management Science. Laptop computers now run complex software and tackle problems larger than the best computers from the past.
2000s	Students of business decision modeling can gather data, perform complex analysis using their home computers, and communicate the results via the World Wide Web at speeds unseen in the past.

### Step 1: Problem Identification

Identifying the problem that exists is the first step in the business decision modeling process. Many experts believe this is the most critical step. If we do not identify the problem correctly all of the subsequent steps are worthless. A statement of purpose, thesis, or set of goals is generated here.

### Step 2: Problem Definition

Once we have identified the problem we must clearly define the pertinent variables, those variables' parameters or limits, and any assumptions regarding the real world that apply to the situation at hand. If we do a poor job of defining the problem, our model may be inappropriate. Definitions regarding the problem must be linked to the problem identification and set of goals established therein.

### Step 3: Problem Modeling

Problem modeling can take on two common forms: the abstract, or high-level, model and the numeric, or concrete, model.

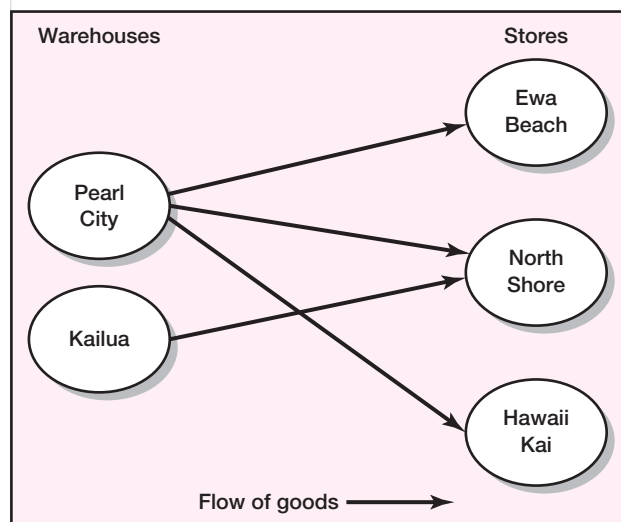
Individuals or groups attacking a problem many times begin with the abstract model and work towards a more specific model.

#### *Abstract, or High-Level, Models*

Examples of abstract models are flow diagrams and charts or graphs that physically describe a system or set of components or put structure to the definitions created in the problem definition section. Figure 1.2 is an example of a high level flow diagram used to model the transfer and shipping of goods in a particular region.

Models can be of a high-level/abstract nature or a more numeric/concrete nature.

**FIGURE 1.2**  
High-level flow of goods model.





Financial profit is defined as revenues less costs and is considered a basic financial model.

Managers must review model solutions, or “do a reality check,” on the output.

### ***Numeric, or Concrete, Models***

High-level models are used primarily in the early stages of the business decision modeling process but many times are carried forward, added to, or modified and also used in the specific modeling stage. Most often the specific models used in business decision modeling are mathematical in nature. These models consist of mathematical relationships that integrate the variables, parameters, and assumptions from the problem definition step into a set of mathematical numbers and symbols. A simple example of a specific model is the relationship of revenues and costs to profit. The numeric model that computes the profit the firm generates is in general,

$$\text{Profit} = \text{revenue} - \text{costs}$$

In fact, businesses use the equation for profit all the time.

Overall, models can become very complex and can include numerous mathematical equations and relationships. The individual topics covered in this textbook will present numerous models for solving many different types of problems. Some of the models we will study tend to be very specific with strict assumptions and definitions, while others are general and can be applied across many situations, scenarios, and disciplines.

### **Step 4: Initial Model Results**

After the problem has been identified, defined, and modeled, business decision modeling techniques are used to generate an initial solution. The word *initial* is used here because the next step in the business decision modeling process is the review and iteration step. Any business decision modeling professional would agree that rarely do we get everything perfect and generate the exact answer the first time around. Moreover, in real-life problems are messy and unstructured, and it may take a number of attempts to generate a model that is adequate and/or produces a satisfactory solution. In sum, as students of business decision modeling, we must develop the critical process and not a set of individual stand-alone techniques.

### **Step 5: Review and Iteration**

The review and iteration step is a time for what some call a *reality check*. Why should we as managers take a step back?

As you probably noticed in the earlier examples, mathematical formulas and simple algebra were used to create solutions or recommendations. The term reality check is used here because of the underlying theoretical nature of mathematics, the mathematical relationships developed in the modeling step, and the earlier definitions and assumptions made in the problem definition step. The review and iteration step encompasses the concept of critical thinking. To be an efficient and effective problem solver, we must develop critical thinking and judgment with regard to the solutions and recommendations that result from the models used.

This critical thinking or judgment is manifested in this step by literally stopping, reviewing the last four steps, and asking yourself a series of questions like the following:

- Does everything look okay? That is, does it all check with reality?
- Did we get an answer that pertains to the problem/goals we identified in step 1?
- Have any of the assumptions or definitions from step 2 changed, or should new assumptions be introduced?
- Is the model we developed functioning properly; i.e., are the answers we obtain feasible and applicable to the real world?

Overall, one of the most compelling reasons for the review and iteration step is to avoid making recommendations or presenting solutions that have no basis in the real world. We must also note that no model is ever perfect, so it is advisable to conduct sensitivity analysis. Good business decision modelers always do a best-, most likely, and worst-case analysis. There will be numerous discussions of sensitivity analysis throughout the upcoming chapters.

# Business Decision Modeling behind the Scenes:

*The RAND Corporation*



The RAND Corporation was established during World War II to further and promote scientific, educational, and charitable activities for the public welfare and security of the United States. In the early years, RAND's efforts were focused on national security issues, but as time passed, RAND aimed to tackle society's most pressing problems. The unique assembly of researchers, scientists, engineers, humanists, mathematicians, aerodynamicists, physicists, chemists, economists, psychologists, and members of other professions collaborated routinely and effectively to address problems and concerns of people around the world and at home.

The key players in the formation of RAND included General H. H. Arnold; Edward Bowles of MIT, a consultant to the Secretary of War; General Lauris Norstad, then Assistant Chief of Air Staff; Major General Curtis LeMay; Donald Douglas, President of Douglas Aircraft Company; Arthur Raymond, Chief Engineer at Douglas; and Franklin Collbohm, Raymond's assistant. RAND became a nonprofit private organization on May 14, 1948, and was able to

obtain loans from Wells Fargo Bank and Union Trust Co. Later, in July 1948, it received further funding on an interest-free loan basis from the Ford Foundation for an amount of \$1 million. Four years later, the loan from the Ford Foundation enabled the establishment of the RAND-Sponsored Research Program, which furnished staff with the means to conduct small nonmilitary research projects. This marked the beginning of the diversification of RAND's agenda and was the first of many grants to RAND by the Ford Foundation to support important new initiatives.

Some of RAND's early contributions include providing the foundation for the U.S. space program, digital computing, artificial intelligence, and even laying the building blocks for today's internet technology. Theories and tools for decision making under uncertainty were created, and basic contributions were made to game theory, linear and dynamic programming, mathematical modeling and simulation, network theory, and cost analysis.

RAND Corporation's website is at <http://www.rand.org/>

## Step 6: Implementation

Implementation of the model, solutions, and recommendations is the last step in the business decision modeling process described in Figure 1.1. As future managers, we will be using the models developed and/or the results and recommendations from those models. In the business world, managers must make decisions in order to keep their businesses running, sell products, and service customers. This is in stark contrast to what many academicians or theorists consider the last step of the process.



The implementation step, although the final and possibly the most critical step in the process, is often ignored. At times, necessary changes to a so-called normal way of doing business are revealed and in turn certain individuals may choose not to adopt the results or recommendations of the process due to reluctance for change. This way of thinking needs to be avoided. If the process solution is not implemented; the entire process was a waste of time and money.

## BASIC FINANCIAL MODELS

Basic financial models such as  $\text{profit} = \text{revenue} - \text{cost}$  are used in many places in the real world.

Most of the basic business decision modeling models arising in business and economics applications involve the use of the profit equation. The next sections will detail the general profit equation and discuss cost and volume models, revenue and volume models, profit and volume models, and break-even analysis.

### Three Parts of the General Profit Equation

The general equation contains three parts: profit, revenues, and costs. The general equation looks like this:

$$\text{Profit} = \text{revenues} - \text{costs}$$

Financial cost is generally made up of fixed and variable components.

Profit, revenues, and costs are related to the volume of items produced and sold. Algebraically all three parts are functions of the volume of items produced, volume of items sold, and the prices of those items. Each part of the general equation can be broken down into a mathematical equation detailing the specific relationships that profit, revenue, and costs have to volume.

### Cost and Volume Models

Total costs tend to rise as volume of production increases.

The cost of producing a product comprises two major cost components, fixed and variable. Fixed costs are the portions of the total cost that do not depend on the level of production volume. Fixed costs do not change, hence the name fixed costs. Variable costs are the portions of total cost that are dependent on the level of production volume. Total cost is the sum of fixed cost and variable cost.

Let's take a surfboard manufacturing firm as an example. The firm, Surfboard Inc., knows it takes \$100,000 to set up the shop for the production of the surfboards. This cost doesn't change as the number of surfboards goes up or down. It is considered fixed and is incurred even if no surfboards are made. The firm also knows that it takes \$100 in labor and materials to produce a surfboard. Therefore, \$100 is the variable cost associated with how many surfboards are produced. The resulting cost volume model for producing  $x$  surfboards is written as

$$\text{Total cost} = \$100,000 + \$100x$$

where

$$x = \text{number of surfboards to be produced}$$

$$\text{Total cost} = \text{fixed} + \text{variable costs of producing } x \text{ surfboards}$$

The total cost for the firm can now be calculated by using the equation presented above. For example, if the firm decides to produce at a volume of 100 surfboards, or  $x = 100$ , the total cost is calculated as

$$\text{Total cost} = \$100,000 + \$100(100) = \$110,000$$

Business analysts and economists use this model to describe how the total costs of a firm change as the volume produced changes. This is called *marginal analysis*. In the case of costs, the marginal cost is defined as the rate of change of the total cost with respect to the volume produced or  $x$  in our equation. From the total cost equation above, we can see that for each extra surfboard produced, the total cost would rise by \$100. The marginal cost is equal to the variable cost in this case.

In general, revenue is the price of a unit multiplied by the quantity of units sold.

Breakeven refers to the point at which total costs equal total revenues.

At the break-even point, the firm sells enough product to cover total costs, but neither garners a profit nor incurs a loss.

Break-even analysis can be modeled graphically or numerically.

## Revenue and Volume Models

Managers are also concerned with the revenue stream associated with producing products. A model relating revenue and volume produced can be created. Let's use Surfboard Inc. again as an example. The firm realizes \$300 for each surfboard it sells. Therefore, the total revenue for the firm can be written as

$$\text{Total Revenue} = \$300x$$

where  $x$  = number of surfboards to be produced.

As in the case of costs, business analysts and economists use this model to describe how the total revenues of a firm change as the volume produced changes. Once again, this is called *marginal analysis*. In the case of revenues, the marginal revenue is defined as the rate of change of the total revenue with respect to the volume produced, or  $x$  in our equation. From the total revenue equation above, we can see that for each extra surfboard produced, the total revenue would rise by \$300. Obviously, if the firm sells one more surfboard it would receive another \$300 in revenue.

## Profit and Volume Models—Putting It All Together

As we have discussed already, profit is made up of revenue minus cost. The last two sections detailed the relationship between revenue, cost, and volume. Since profit is made up of revenues and costs, then profit must also be related to volume. On the assumption that the firm can sell all the surfboards it produces, we can develop an equation for profit based on volume.

As was stated earlier, profit equals revenue minus cost, and if we combine the revenue and cost volume equations, the total profit equation can be written as

$$\begin{aligned}\text{Total profit} &= \text{revenue} - \text{costs} \\ &= \$300x - (\$100,000 + \$100x) \\ &= \$200x - \$100,000\end{aligned}$$

Therefore, we can see that total profit is related to the volume of surfboards,  $x$ , that the firm produces.

## Break-Even Analysis

The managers of Surfboard Inc. have been asked to figure out how many surfboards the firm must produce and sell to break even. The term *breakeven* refers to the relationship between revenues and costs. Specifically, breakeven is the level of production and sales at which revenue and cost equal each other. After developing the relationship between profit and volume of surfboards produced, the managers can answer this question, using the profit equation and some simple algebra.

Using the profit equation derived above, let's attempt to find, by trial and error, the break-even point. First let's allow volume of surfboards to be produced and sold to equal 400, i.e.,  $x = 400$ , and calculate profits as follows:

$$\begin{aligned}\text{Total profit} &= \$200(400) - \$100,000 \\ &= -\$20,000\end{aligned}$$

The manager would conclude that at a volume or level of production and sales of 400 surfboards, the firm would incur a loss of \$20,000. However, if the volume of surfboards to be produced and sold is equal to 600, i.e.,  $x = 600$ , profit is calculated as follows:

$$\begin{aligned}\text{Total profit} &= \$200(600) - \$100,000 \\ &= \$20,000\end{aligned}$$

One can see that at a level of production and sales of 600 surfboards, the firm would realize a profit of \$20,000. Using simple logic, the manager can conclude that the break-even point must lie somewhere between a production and sales level of 400 to 600 surfboards. We can develop a simple equation to help us find the break-even point of any profit equation. The first step is to set revenue equal to cost. This is done by using the profit equation and setting it equal

to 0. The resulting equation is

$$\text{Total profit} = \$200x - \$100,000 = 0$$

$$\$200x = \$100,000$$

$$x = 500$$

The manager can conclude that the firm must produce and sell at least 500 surfboards to cover all costs and break-even

### Graphical Break-Even Solution

This relationship between revenue, cost, and profit can be graphed to show all possible combinations of volume and resulting profits. Figure 1.3 displays this graph along with the firm's break-even point, fixed cost, total cost, total revenue, profits, and losses.

In addition, a general relationship for computing the break-even point can be established. If we allow  $x$  to equal the number of units produced and sold (i.e., the volume) and we allow  $P$  to equal the selling price per unit, then total revenue can be written as

$$\text{Total revenue} = Px$$

Cost can also be represented in the same manner, where fixed cost is represented by  $FC$  and variable cost is represented by two symbols,  $Vx$ . The  $x$  is the same  $x$  as stated above and represents the number of units produced and sold. The  $V$  is equal to the variable cost associated with producing an extra unit. Total cost is written as

$$\text{Total cost} = FC + Vx$$

Combining these relationships, we can write total profit as

$$\text{Total profit} = Px - (FC + Vx)$$

The break-even point is calculated by setting total profit equal to zero and solving the resulting equation for, as follows:

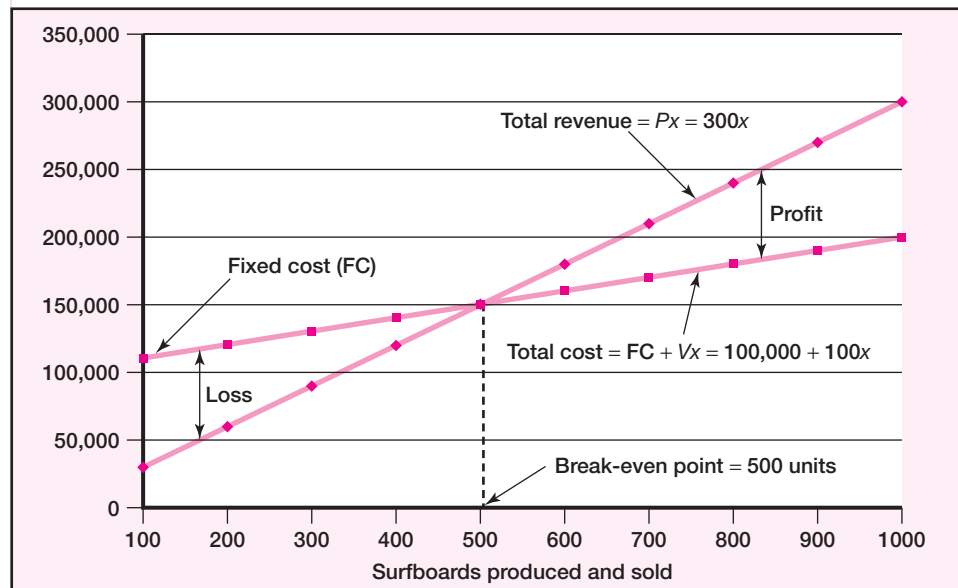
$$\text{Total profit} = 0 = Px - (FC + Vx)$$

$$FC = Px - Vx$$

$$FC = x(P - V)$$

$$x = \frac{FC}{(P - V)}$$

**FIGURE 1.3**  
Graphical break-even analysis.



The general equation for numerical break-even analysis is

$$x = \frac{FC}{(P - V)}$$

Computer spreadsheets have made solving problems such as break-even analysis much easier for managers

Given this relationship, a manager who knows the firm's fixed cost, sales price, and variable cost per unit can easily obtain the firm's break-even point.

## COMPUTER-GENERATED SOLUTIONS USING SPREADSHEETS

Throughout the text business decision modeling problems will be modeled and solutions proposed by using computer software packages. In some cases, all the student must do is follow the instructions, input a set of data or parameters into a model template, click a solve button, and then interpret the resulting solution output.

In other cases, students will be asked to model problems by using whatever method they believe is adequate. This type of activity develops the critical reasoning and judgment skills needed to effectively and efficiently solve more complex problems.

### Solving Complex Problems Using Spreadsheets

With the advent of the personal computer and the basic spreadsheet program, managers now have at their fingertips the tools to analyze a vast range of real-life problems. As we progress through the text, it will become apparent that spreadsheets are a powerful means of formulating, modeling, and solving complex problems. We wish to promote the use of spreadsheets as a logically self-contained and simple method to model problems. By no means, however, are we advocating that spreadsheets are the be-all, end-all solution to business decision modeling and/or real-world problem solving.

Students will find that the text starts out with simple model-building concepts and spreadsheet solutions and builds toward higher-order models with more complex formulations. Some models will be built from the ground up and others will be generated by using spreadsheet add-ins or specialized software. This progression is meant to help the student develop modeling, critical thinking, and judgment skills as well as to introduce them to numerous business decision modeling techniques.

The author firmly believes that students must understand the underlying business decision modeling process and not just "point and click" their way to computer-generated solutions. At times the business decision modeling discipline has been accused of supplying students with software or spreadsheet models that spit out problem solutions, while students understand neither how they were generated nor how they should be interpreted. This text provides a foundation in the construction of models, including those developed in conjunction with spreadsheets, the use of specialized software, and the ability to interpret the results that these software packages generate.

### Spreadsheet Solution for Break-Even Analysis Problem

The break-even analysis problem given above can also be solved by using a spreadsheet program such as Excel. The following steps illustrate how the surfboard break-even problem can be modeled and solved in an Excel spreadsheet.

1. Open Excel and a new Excel worksheet.
2. In cell A1, type **Break-Even Analysis for Surfboard Inc.**
3. In cell A3, type **FixedCosts =**. Proceed to cell B3 and type in the value associated with the fixed costs of manufacturing surfboards. For our example, type in **\$100,000**.
4. In cell A5, type **VariableCosts =**. Proceed to cell B5 and type in the value associated with the variable costs of manufacturing surfboards. For our example, type in **\$100**.
5. In cell A7, type **Price =**. Proceed to cell B7 and type in the value associated with the selling price of a surfboard. For our example, type in **\$300**.
6. In cell A9, type **Break-EvenPoint =**.
7. In cell B9, type in the following formula for the break-even point:  $= B3/(B7-B5)$

Cell B9 will then contain the break-even point for our surfboard example. Figure 1.4 displays how this will appear on an Excel spreadsheet.

**FIGURE 1.4**

Excel spreadsheet for break-even analysis.

	A	B	C
1	<b>Break-Even Analysis for Surfboard Inc.</b>		
2			
3	<b>Fixed Cost =</b>	<b>\$100,000</b>	
4			
5	<b>Variable Cost =</b>	<b>\$100</b>	
6			
7	<b>Price =</b>	<b>\$300</b>	
8			
9	<b>Break-Even Point =</b>	<b>500</b>	

### Writing Business Decision Modeling Reports for Business

Reports comprise analysis, conclusions, and recommendations. The quality of the final report is a function of the quality of the content and the quality of the packaging. A beautifully packaged report that has meaningless analysis is as worthless as a powerful analysis that is packaged so poorly that it never gets read. You must have both quality content and packaging to present an effective report.

### General Rules of Thumb

It has been said that people tend to be persuaded more easily if a story or anecdote is used to prove a point. In many cases, managers must provide statistics or numbers to convince a client. However, most conclude it is more effective to give a short anecdote before providing the statistics.

There has been much written about business report presentation. There are a few areas that definitely apply to business decision modeling reports. These areas are crucial to helping your client understand your analysis. Areas of utmost importance when writing business decision modeling reports are:

1. **Use common, everyday language.** The terminology and symbols used in business decision modeling at times are very complex. Your client may not be familiar with this terminology or the symbols used. If possible, avoid the use of technical jargon but use your knowledge of business decision modeling to translate the technical terminology into phrases that your client can understand.
2. **Be concise; tighten up your writing.** Get to the point. Managers do not have the time to read lengthy, ill-written reports. In fact, many managers will not continue to read proposals that do not quickly reveal the purpose and recommendations of the author. The writing and revising process aids dramatically in reducing the superfluous material in a report or executive summary. The process of writing and revising your work is difficult but a very rewarding task.
3. **Use graphics to aid in the explanation.** There are many opinions on whether to include graphics, tables, and visuals in a report and/or executive summary. Overall, professionals in the business decision modeling and technical writing disciplines would agree that the proper use of graphics, tables, and visuals is a must in effective report writing. A few general guidelines do apply:
  - **Labeling.** All charts, graphs, and tables must be labeled.
  - **Size:** All charts, graphs, and tables should be large and easy to read.
  - **Position.** All charts, graphs, and tables should be contiguous. If possible, do not split visuals over two pages.

In summary, visuals should aid the client in understanding your material. They should not cloud or distort the information.

## Creating a Structure

One of the most important issues in creating effective business decision modeling reports is to know the goal of the report and to create a structure that guides you through the analysis and writing. A common report structure is as follows.

Executive Summary  
 Introduction—Background  
 Problem Statement—Purpose  
 Analysis  
 Conclusions and Recommendations

## Executive Summary

The executive summary is the **most critical piece** of the final report. In reality, most busy executives never read beyond this section. Think to yourself how many times you have actually read a report cover to cover; most of us skim the introduction, read the executive summary, and then skip to the conclusions/recommendations.

How much detail should be included in an executive summary? The rule of thumb is the shorter the better. An executive summary is the report in miniature that covers key findings, conclusions, and recommendations. A number of good reference documents on writing executive summaries are listed at the end of this section.

## Introduction—Background

The length and the style of the introduction and background section may differ depending on the audience and the problem at hand. This section should be kept to a minimum and should outline the problem and its background as decided on by the client and the report analysts.

## Problem Statement—Purpose

The statement of purpose, or problem statement, can be included in the introduction but many times is set apart for effect. In addition, this section can provide details and information about definitions and assumptions made in the analysis.

## Analysis

This is the heart of the report. The model of how the problem is solved must be presented here along with the “what if,” or sensitivity, analysis. Sensitivity analysis will be defined and detailed in Chapter 4. Anyone who is still interested after reading the executive summary will peruse this section, looking for verification and validation of the outcomes seen earlier.

This section must be written very clearly and completely and should include charts, tables, and other graphics. On the other hand, do not overdo it. Excessive use of tables, computer printouts, or mathematical formulas in the body of the report is highly discouraged. Use appendices to house this material and provide proper reference in the body of the report.

## Conclusions and Recommendations

The recommendation section should sum up what the analysis section and the sensitivity analysis concluded. At a minimum, a restatement of the choice or decision to be made accompanied by the implications of that choice or decision must appear. In other words, explain to your client what the best alternatives are, the process to begin exploring those options, and the associated costs, profits, etc. After the conclusions and recommendations section, an appendix can be used to house technical information, computer output, calculations, and/or complete mathematical models.

## Executive Summary Example for Surfboard Inc.

The sample document below is an executive summary for the Surfboard Inc. model developed earlier in this chapter. The executive summary should be used by students of business decision modeling as a guide for future writing. It must be noted that it is only one example and executive summary style may change, depending on audience and content.

Since the executive summary is the only document presented it must both explain the problem facing Surfboard Inc. and provide recommendations in a limited amount of space.



### Executive Summary for Surfboard Inc. Break-Even Analysis

TO: Eddie

FROM: Business Decision Modeling Consulting Group

#### Introduction:

Surfboard Inc. is seeking a break-even analysis for its North Shore operations. The objective is to find Surfboard Inc.'s break-even point given its cost and pricing structure. We are assuming the firm can sell all surfboards produced.

#### Current Cost and Pricing Structure:

The current cost and pricing structure is summarized in Table 1:

**TABLE 1**  
Surfboard  
Manufacturing Firm  
Cost and Pricing  
Information

Cost Category	\$ Costs	\$ Price per Surfboard
Fixed cost	\$100,000	\$300
Variable cost per surfboard or average variable cost	\$ 100	

#### Profit Equation

On the basis of the above information, costs and pricing, a general profit equation can be established. This equation is listed below.

$$\text{Profit} = \$200 \times (\text{number of surfboards}) - \$100,000$$

The breakeven point quantity is equal to 500 surfboards. Hence, Surfboard Inc., at the current cost and pricing levels, must produce at least 500 surfboards to break even.

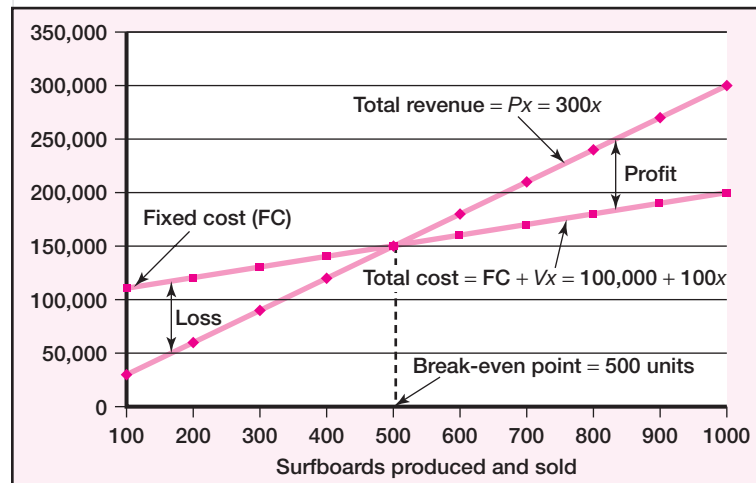
#### Break-Even Graph

To illustrate this point in relation to other production levels, a break-even graph has been constructed. The graph relates various levels of surfboard sales/production to the resultant levels of profit, revenue, and costs. Figure 1 displays the break-even graph.

#### Conclusions:

Figure 1 illustrates that the break-even point in number of surfboards is equal to 500 surfboards. Surfboard Inc. will incur a loss at sales/production levels of less than 500 surfboards and garner a profit at sales/production levels of greater than 500 surfboards. Total Revenue is defined on the graph as  $Px$  (price multiplied by quantity) and Total Cost is defined as  $FC + Vx$  (fixed cost + variable cost multiplied by units sold).

**FIGURE 1**  
Surfboard Inc.  
Breakeven Graph



## Optimal Information Area

Bricklin, Dan. "Dan Bricklin's Web Site," at <http://bricklin.com/history/sai.htm>

Decision Sciences Institute, at <http://dsi.gsu.edu>

Institute for Operations Research and Management Science, at <http://www.informs.org>

Mattessich, Richard. "Early History of the Spreadsheet," at <http://www.j-walk.com/history/spreadsh.htm>

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"VisiCalc '79," Dan Bricklin and Bob Frankston, *Creative Computing*, November 1984, vol. 10, pp. 122, 124.

"VisiCalc Production Ends," *PC Magazine*, August 6, 1985. vol. 4, p. 33.

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Beer, Stafford, *Management Sciences: The Business Use of Operations Research*, New York: Doubleday, 1967.

Hillier, F. S., and G. J. Lieberman, *Operations Research*, 4th ed., San Francisco: Holden-Day, 1987.

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Silk, David, *How to Communicate in Business: A Handbook for Engineers*, IEE Management of Technology Series 17, 1995.

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## Problems

- Rick Miles runs a CD-making business. He forecasts demand for his CDs at 5000 for the next year. He charges \$20 per CD sold. It costs him \$2000 in fixed costs a year to run his business and \$2 per CD in variable costs.
  - What are Rick's revenues?
  - What are Rick's costs?
  - Does Rick make a profit?
- The Scheinbach computer company manufactures computers wholesale. The company's fixed monthly cost is \$45,000, and its variable per computer cost is \$525. The company sells the computers for \$925. Determine the monthly break-even volume for the company.
- Kathy runs her own computer education business. She needs \$4000 a year to pay the leases on the computers she uses. She estimates she will have 400 pupils for the next year. Each pupil pays \$200 for the education. However, it costs Kathy \$20 to \$30 per pupil in supplies and overhead.
  - What are Kathy's yearly revenues?
  - What are Kathy's average total costs? What is the range of Kathy's costs?
  - Does Kathy make a profit? What is the range of Kathy's profit?
- Wayne owns a shaved ice stand. He sells 700 shaved ice cups per month at \$1.50 each, making the total revenue \$1050. Each shaved ice costs Wayne \$0.50 and he has fixed costs of \$750, making his

total costs \$1100. Therefore, he realizes a loss of \$50 a month. Help him determine what his break-even point is.

5. HPU Graduates is a start-up microbrewery in Pahoehoe, Hawaii. Its fixed costs to produce beer total \$8000 per month. The variable cost to produce their beer is \$3.00 per case of beer. It sells its beer to one hotel only, and that hotel has said it wants 550 cases this month. What price does HPU need to charge to break even?
6. The VA-TX Company is going to present a new product in Santa Clara, California. In this event, VA-TX will present a seminar with a coffee break. The auditorium's capacity is 500 people. The cost of renting the place is \$4000/day, utilities included. Moreover, the cost of the food and drinks is \$5 per person. After some other experiences, the company knows that 50 percent of the audience buys its product, which is priced at \$75. Is Santa Clara a profitable place to do this kind of campaign?
7. Eric runs a chiropractic center in Mililani. The annual fixed costs for operating Chiro-Care clinic is \$222,000. The variable cost per patient treated is \$55. The price billed for each visit is \$136. Currently, he has around 2500 visits a year.
  - a. Is he making a profit?
  - b. He doesn't think he can increase demand, so he is thinking about a cost-cutting measure for his variable costs. What would his variable costs need to be in order for him to break even at 2500 visits a year?
8. John is thinking about getting into the tourism business in Oahu. He will take visitors on a whole-day trip to the main tourist spots on the island in a new van he is planning to buy. He would like to know how many tourists he has to move daily to have a before-taxes profit of \$1000 per month so he can save that money. He will work 25 days per month.

His costs for the new business would be as follows:

Variable costs per day trip

Gasoline: \$ 30

Maintenance: \$ 5 (oil, tune-ups, wheels, repairs, etc.)

Fixed costs

Leasing and insurance: \$ 1000 per month

Personal expenses: \$1000 (the minimum amount he needs for living expenses) per month

He is planning to charge \$ 45 per visitor for a day trip.

Using the break-even formula, John will need how many daily travelers in order to achieve a profit of \$1000 per month?

9. The Thai Corporation has sales subsidiaries around the world. As a rule of thumb, each new established subsidiary should be able to reach its break-even point during year 2. After 18 months of business activity in Thailand, The Thai Corporation's Thai sales subsidiary generated a sales volume of 200,000 units. Its variable costs are \$5 per unit and fixed costs at this level equal \$750,000.
  - a. In year 2, at a sales price of \$17 per unit, how many units does the subsidiary need to sell in order to break even?
  - b. Do you think the company will make a profit if last year's sales are a good indicator of future sales?
10. The VA-TX Company has noticed when it advertises, it dramatically increases the amount of customers who buy its product at seminars. With advertising, VA-TX expects the audience to buy the product at a price of \$75. The cost of renting a place is \$4000/day, utilities included. Moreover, the cost of food and drinks is \$5/person. If VA-TX assumes at a minimum it will sell 124 units, what would be the upper bound on advertising dollars (i.e., where would the company break even?).
11. Bradley is a sales associate for VA-TX. He has suggested that if the company would provide an open bar at the end of the seminar, sales would rise. The open bar would increase the variable cost per customer from \$5 to \$7.50.
  - a. With the same fixed cost structure, how many sales would VA-TX have to make to break even?
  - b. How does this compare with the break-even point(s) in Problem 10?

12. Bernie Hsiao runs a lamp-making business. He has two lines of lamps: antler lamps and fishing rod lamps. It costs him \$10,000 a year to run his business (labor, materials, and overhead). The estimated demand for antler lamps is anywhere from 100 to 200 units. The estimated demand for fishing rod lamps is 300 to 400 units. He charges \$2000 for antler lamps and \$200 for fishing rod lamps. However, he incurs \$750 in variable costs per antler lamp sold and \$30 for each fishing rod lamp sold.
- What are Bernie's expected/average revenues from antler lamps? What are Bernie's expected/average revenues from fishing rod lamps? What is the total expected/average revenue Bernie's lamp business could generate? What is the range of total expected/average profit?
  - What are the expected/average costs associated with the lamp business? Identify the costs associated with antler lamps, fishing rod lamps, and costs associated with both.
  - Does Bernie make a profit in the case of low estimated demand for each lamp?
  - Does Bernie make a profit in the case of high estimated demand for each lamp?
  - If half of the fixed costs are attributable to antler lamps, how much do the antler lamps contribute to this profit? If half the fixed costs are attributable to fishing rod lamps, how much do the fishing rod lamps contribute to this profit?