**Essentials of CVP Analysis**

In Chapter 2, we discussed total revenues, total costs, and income. Cost-volume-profit (CVP) analysis studies the behavior and relationship among these elements as changes occur in the units sold, the selling price, the variable cost per unit, or the fixed costs of a product. Let’s consider an example to illustrate CVP analysis. Example: Emma Frost is considering selling GMAT Success, a test prep book and software package for the business school admission test, at a college fair in Chicago. Emma knows she can purchase this package from a wholesaler at $120 per package, with the privilege of returning all unsold packages and receiving a full $120 refund per package. She also knows that she must pay $2,000 to the organizers for the booth rental at the fair. She will incur no other costs. She must decide whether she should rent a booth. Emma, like most managers who face such a situation, works through a series of steps.

1. Identify the problem and uncertainties. The decision to rent the booth hinges critically on how Emma resolves two important uncertainties—the price she can charge and the number of packages she can sell at that price. Every decision deals with selecting a course of action. Emma must decide knowing that the outcome of the chosen action is uncertain and will only be known in the future. The more confident Emma is about selling a large number of packages at a good price, the more willing she will be to rent the booth.

2. Obtain information. When faced with uncertainty, managers obtain information that might help them understand the uncertainties better. For example, Emma gathers information about the type of individuals likely to attend the fair and other test-prep packages that might be sold at the fair. She also gathers data on her past experiences selling GMAT Success at fairs very much like the Chicago fair. `

3. Make predictions about the future. Using all the information available to them, managers make predictions. Emma predicts that she can charge a price of $200 for GMAT Success. At that price she is reasonably confident that she will be able to sell at least 30 packages and possibly as many as 60. In making these predictions, Emma like most managers, must be realistic and exercise careful judgment. If her predictions are excessively optimistic, Emma will rent the booth when she should not. If they are unduly pessimistic, Emma will not rent the booth when she should. Emma’s predictions rest on the belief that her experience at the Chicago fair will be similar to her experience at the Boston fair four months earlier. Yet, Emma is uncertain about several aspects of her prediction. Is the comparison between Boston and Chicago appropriate? Have conditions and circumstances changed over the last four months? Are there any biases creeping into her thinking? She is keen on selling at the Chicago fair because sales in the last couple of months have been lower than expected. Is this experience making her predictions overly optimistic? Has she ignored some of the competitive risks? Will the other test prep vendors at the fair reduce their prices? Emma reviews her thinking. She retests her assumptions. She also explores these questions with John Mills, a close friend, who has extensive experience selling test prep packages like GMAT Success. In the end, she feels quite confident that her predictions are reasonable, accurate, and carefully thought through.

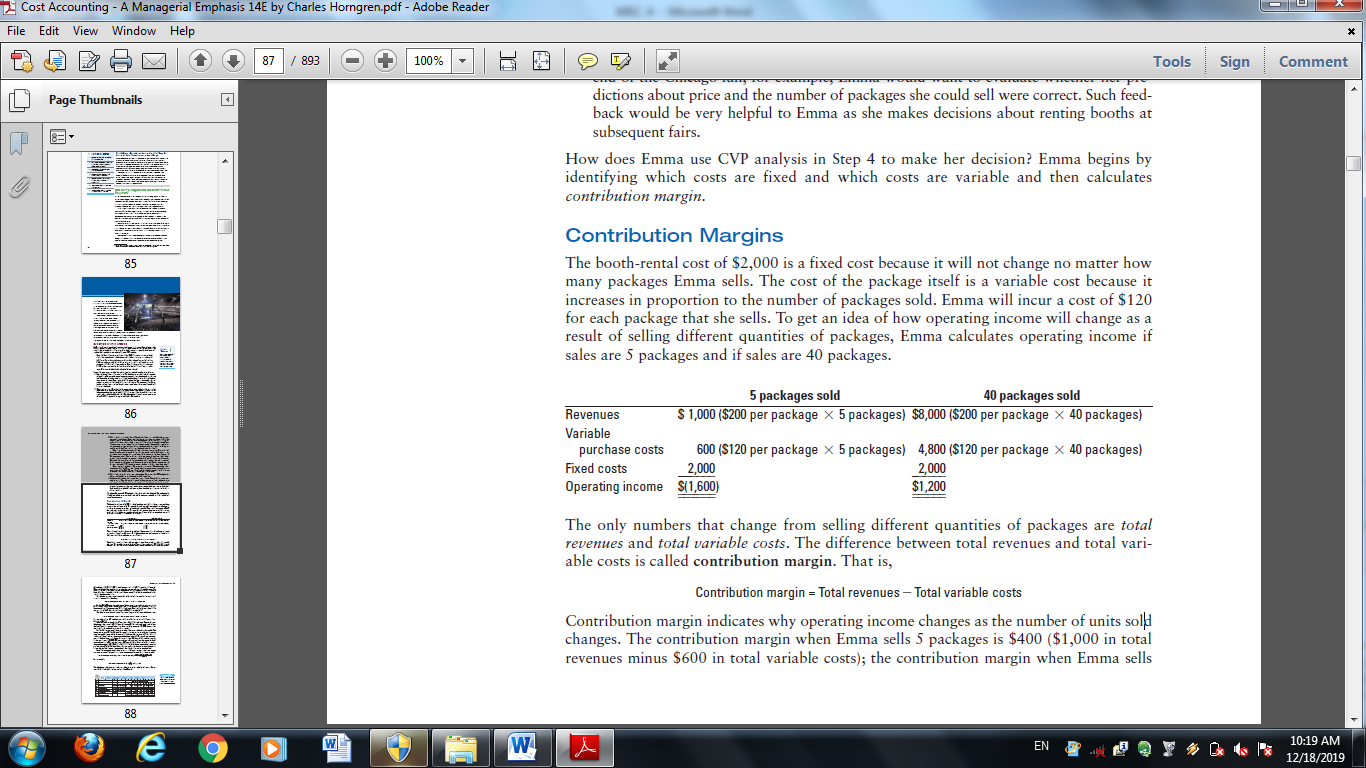
4. Make decisions by choosing among alternatives. Emma uses the CVP analysis that follows, and decides to rent the booth at the Chicago fair.

5. Implement the decision, evaluate performance, and learn. Thoughtful managers never stop learning. They compare their actual performance to predicted performance to understand why things worked out the way they did and what they might learn. At the end of the Chicago fair, for example, Emma would want to evaluate whether her predictions about price and the number of packages she could sell were correct. Such feedback would be very helpful to Emma as she makes decisions about renting booths at subsequent fairs.

How does Emma use CVP analysis in Step 4 to make her decision? Emma begins by identifying which costs are fixed and which costs are variable and then calculates contribution margin.

**Contribution Margins**

The booth-rental cost of $2,000 is a fixed cost because it will not change no matter how many packages Emma sells. The cost of the package itself is a variable cost because it increases in proportion to the number of packages sold. Emma will incur a cost of $120 for each package that she sells. To get an idea of how operating income will change as a result of selling different quantities of packages, Emma calculates operating income if sales are 5 packages and if sales are 40 packages.



The only numbers that change from selling different quantities of packages are total revenues and total variable costs. The difference between total revenues and total variable costs is called contribution margin. That is,

Contribution margin = Total revenues - Total variable costs

Contribution margin indicates why operating income changes as the number of units sold changes. The contribution margin when Emma sells 5 packages is $400 ($1,000 in total revenues minus $600 in total variable costs); the contribution margin when Emma sells 40 packages is $3,200 ($8,000 in total revenues minus $4,800 in total variable costs).

When calculating the contribution margin, be sure to subtract all variable costs. For example, if Emma had variable selling costs because she paid a commission to salespeople for each package they sold at the fair, variable costs would include the cost of each package plus the sales commission.

Contribution margin per unit is a useful tool for calculating contribution margin and operating income. It is defined as,

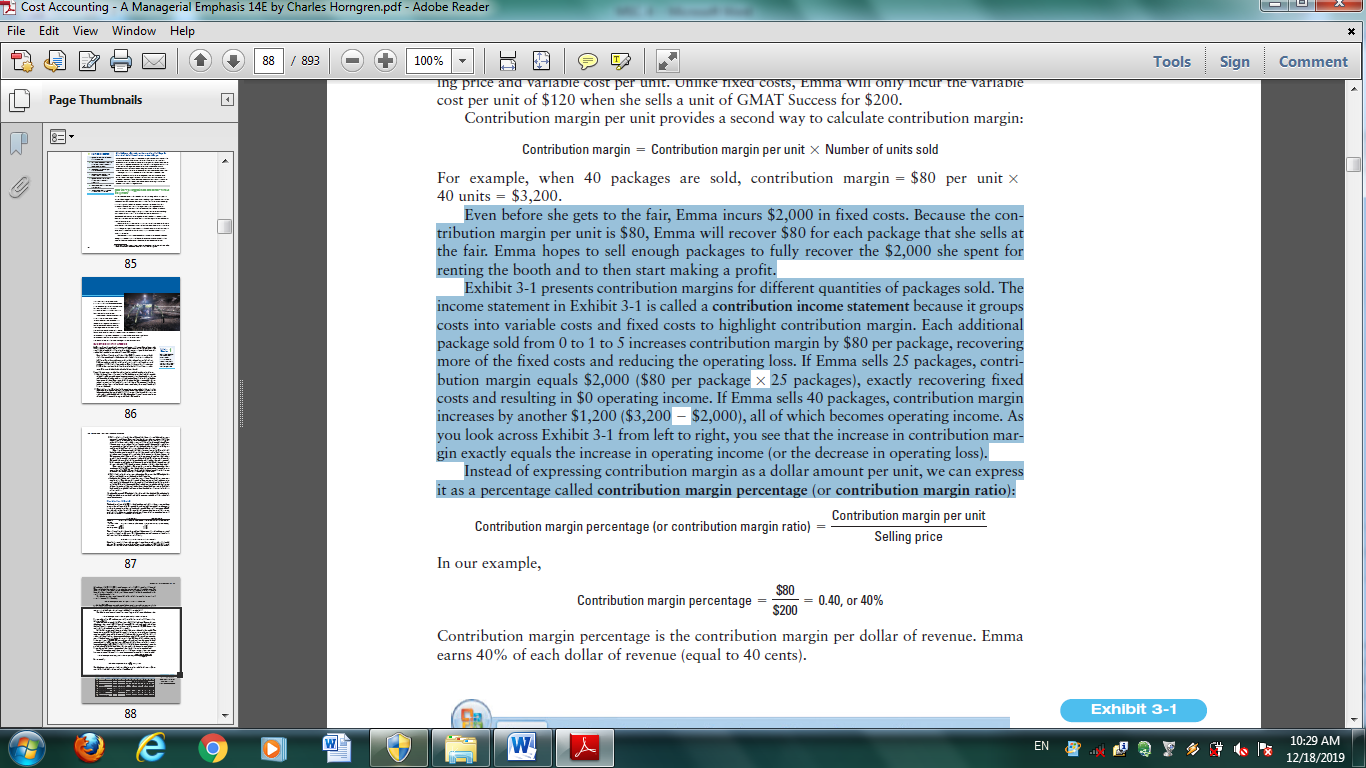
Contribution margin per unit = Selling price - Variable cost per unit

In the GMAT Success example, contribution margin per package, or per unit, is $200- $120= $80. Contribution margin per unit recognizes the tight coupling of selling price and variable cost per unit. Unlike fixed costs, Emma will only incur the variable cost per unit of $120 when she sells a unit of GMAT Success for $200. Contribution margin per unit provides a second way to calculate contribution margin:

Contribution margin = Contribution margin per unit \* Number of units sold

For example, when 40 packages are sold, contribution margin= $80 per unit\* 40 units = $3,200.

Even before she gets to the fair, Emma incurs $2,000 in fixed costs. Because the contribution margin per unit is $80, Emma will recover $80 for each package that she sells at the fair. Emma hopes to sell enough packages to fully recover the $2,000 she spent for renting the booth and to then start making a profit. Exhibit 3-1 presents contribution margins for different quantities of packages sold. The income statement in Exhibit 3-1 is called a contribution income statement because it groups costs into variable costs and fixed costs to highlight contribution margin. Each additional package sold from 0 to 1 to 5 increases contribution margin by $80 per package, recovering more of the fixed costs and reducing the operating loss. If Emma sells 25 packages, contribution margin equals $2,000 ($80 per package\* 25 packages), exactly recovering fixed costs and resulting in $0 operating income. If Emma sells 40 packages, contribution margin increases by another $1,200 ($3,200 - $2,000), all of which becomes operating income. As you look across Exhibit 3-1 from left to right, you see that the increase in contribution margin exactly equals the increase in operating income (or the decrease in operating loss). Instead of expressing contribution margin as a dollar amount per unit, we can express it as a percentage called contribution margin percentage (or contribution margin ratio):



Contribution margin percentage is the contribution margin per dollar of revenue. Emma earns 40% of each dollar of revenue (equal to 40 cents).



Most companies have multiple products. As we shall see later in this chapter, calculating contribution margin per unit when there are multiple products is more cumbersome. In practice, companies routinely use contribution margin percentage as a handy way to calculate contribution margin for different dollar amounts of revenue:

Contribution margin = Contribution margin percentage \* Revenues (in dollars)

For example, in Exhibit 3-1, if Emma sells 40 packages, revenues will be $8,000 and contribution margin will equal 40% of $8,000, or 0.40\* $8,000 =$3,200. Emma earns operating income of $1,200 ($3,200 - Fixed costs, $2,000) by selling 40 packages for $8,000.

**Expressing CVP Relationships**

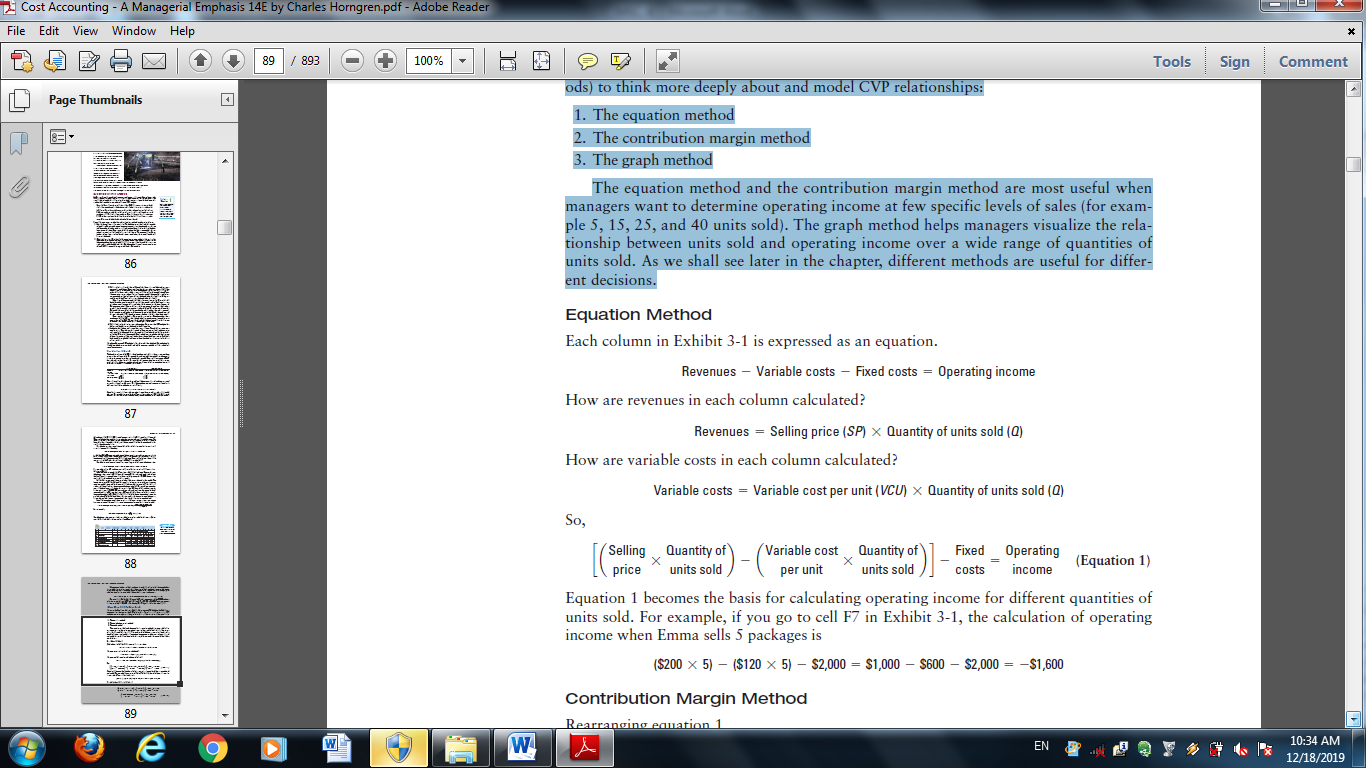
How was the Excel spreadsheet in Exhibit 3-1 constructed? Underlying the Exhibit are some equations that express the CVP relationships. To make good decisions using CVP analysis, we must understand these relationships and the structure of the contribution income statement in Exhibit 3-1. There are three related ways (we will call them methods) to think more deeply about and model CVP relationships:

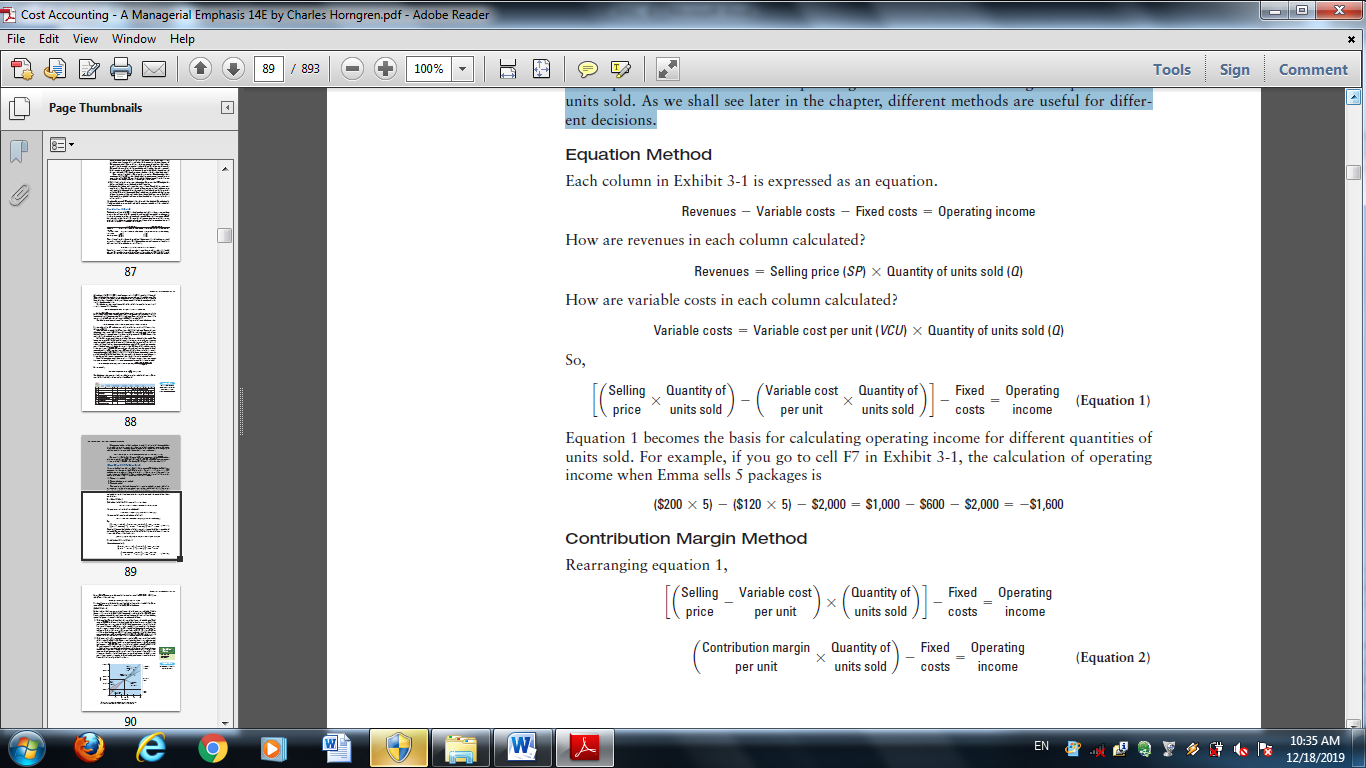
1. The equation method

2. The contribution margin method

3. The graph method

The equation method and the contribution margin method are most useful when managers want to determine operating income at few specific levels of sales (for example 5, 15, 25, and 40 units sold). The graph method helps managers visualize the relationship between units sold and operating income over a wide range of quantities of units sold. As we shall see later in the chapter, different methods are useful for different decisions.





In our GMAT Success example, contribution margin per unit is $80 ($200 -$120), so when Emma sells 5 packages,

Operating income = ($80 \* 5) - $2,000 = -$1,600

Equation 2 expresses the basic idea we described earlier—each unit sold helps Emma recover $80 (in contribution margin) of the $2,000 in fixed costs.

**Graph Method**

In the graph method, we represent total costs and total revenues graphically. Each is shown as a line on a graph. Exhibit 3-2 illustrates the graph method for GMAT Success. Because we have assumed that total costs and total revenues behave in a linear fashion, we need only two points to plot the line representing each of them.

1. Total costs line. The total costs line is the sum of fixed costs and variable costs. Fixed costs are $2,000 for all quantities of units sold within the relevant range. To plot the total costs line, use as one point the $2,000 fixed costs at zero units sold (point A) because variable costs are $0 when no units are sold. Select a second point by choosing any other convenient output level (say, 40 units sold) and determine the corresponding total costs. Total variable costs at this output level are $4,800 (40 units\* $120 per unit). Remember, fixed costs are $2,000 at all quantities of units sold within the relevant range, so total costs at 40 units sold equal $6,800 ($2,000 + $4,800), which is point B in Exhibit 3-2. The total costs line is the straight line from point A through point B.

2. Total revenues line. One convenient starting point is $0 revenues at 0 units sold, which is point C in Exhibit 3-2. Select a second point by choosing any other convenient output level and determining the corresponding total revenues. At 40 units sold, total revenues are $8,000 ($200 per unit\* 40 units), which is point D in Exhibit 3-2. The total revenues line is the straight line from point C through point D. Profit or loss at any sales level can be determined by the vertical distance between the two lines at that level in Exhibit 3-2. For quantities fewer than 25 units sold, total costs exceed total revenues, and the purple area indicates operating losses. For quantities greater than 25 units sold, total revenues exceed total costs, and the blue-green area indicates operating incomes. At 25 units sold, total revenues equal total costs. Emma will break even by selling 25 packages.

