Chapter 5

Lecture Notes

Chapter theme: Cost-volume-profit (CVP) analysis helps managers understand the interrelationships among **cost, volume, and profit** by focusing their attention on the interactions among the **prices** of products, **volume** of activity, **per unit variable costs**, **total fixed costs**, and **mix** of products sold. It is a vital tool used in many business decisions such as deciding what products to manufacture or sell, what pricing policy to follow, what marketing strategy to employ, and what type of productive facilities to acquire.

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1. **The basics of cost-volume-profit (CVP) analysis**

*Learning Objective 1: Explain how changes in activity affect contribution margin and net operating income.*

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#### The contribution income statement is helpful to managers in judging the impact on profits of changes in selling price, cost, or volume. For example, let's look at a hypothetical contribution income statement for Racing Bicycle Company (RBC). Notice:

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* + 1. The **emphasis is on cost behavior**. Variable costs are separate from fixed costs.
    2. The **contribution margin** isdefined asthe amount remaining from sales revenue after variable expenses have been deducted.
    3. Contribution margin is used first to cover **fixed expenses**. Any remaining contribution margin contributes to **net operating** **income**.

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* + 1. Sales, variable expenses, and contribution margin can also be expressed on a **per unit basis**. Thus:

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* + - 1. For each additional unit RBC sells, $200 more in contribution margin will help to cover fixed expenses and provide a profit.
      2. Notice, each month RBC must generate at least $80,000 in total contribution margin to **break-even (which is the level of sales at which profit is zero)**.

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* + - 1. Therefore, if RBC sells **400 units** a month, it will be operating at the **break-even point**.

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* + - 1. If RBC sells one more bike (**401 bikes**), net operating income will increase by **$200**.

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v. You do not need to prepare an income statement to estimate profits at a particular sales volume. Simply multiply the number of units sold above break-even by the contribution margin per unit.

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1. For example, if RBC sells **430 bikes**, its net operating income will be **$6,000**.

#### CVP relationships in equation form (for those who prefer an algebraic approach to solving problems in the chapter)

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* + 1. The contribution format income statement can be expressed in equation form as shown on this slide.
       1. This equation can be used to show the profit RBC earns if it sells **401 bikes**. Notice, the answer of **$200** mirrors our earlier solution.

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* + 1. When a company has only **one product** we can further refine this equation as shown on this slide.

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* + - 1. This equation can also be used to show the $200 profit RBC earns if it sells **401 bikes**.

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* + 1. The profit equation can also be expressed in terms **unit contribution margin** as shown on this slide.

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* + - 1. This equation can also be used to compute RBC’s $200 profit if it sells **401 bikes**.

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*Learning Objective 2: Prepare and interpret a cost-volume-profit (CVP) graph and a profit graph.*

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* 1. **CVP relationships in graphic** **form**
     1. The relationships among revenue, cost, profit, and volume can be expressed graphically by preparing a cost-volume-profit (CVP) graph. To illustrate, we will use contribution income statements for RBC at 0, 200, 400, and 600 units sold.

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*Helpful Hint: Mention to students that the graphic form of CVP analysis may be preferable to them if they are uncomfortable with algebraic equations.*

* + 1. In a CVP graph, **unit volume** is represented on the **horizontal (X) axis** and **dollars** on the **vertical (Y) axis**. A CVP graph can be prepared in **three steps**.

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* + - 1. Draw a line parallel to the volume axis to represent total fixed expenses.

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* + - 1. Choose some sales volume (e.g., 400 units) and plot the point representing total expenses (e.g., fixed and variable) at that sales volume. Draw a line through the data point back to where the fixed expenses line intersects the dollar axis.

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* + - 1. Choose some sales volume (e.g., 400 units) and plot the point representing total sales dollars at the chosen activity level. Draw a line through the data point back to the origin.

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* + 1. **Interpreting** **the CVP graph**.
       1. The **break-even point** is where the total revenue and total expense lines intersect.

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* + - 1. The **profit or loss** at any given sales level is measured by the vertical distance between the total revenue and the total expense lines.

*Helpful Hint: Ask students what the CVP graph would look like for a public agency like a county hospital receiving a fixed budget each year and collecting fees less than its variable costs. It would look like this:*

Total

expenses

Total

revenue

*This is the reverse of the usual situation. If such an organization has volume above the break-even point, it will experience financial difficulties.*

* + 1. An even simpler form of the CVP graph is called the **profit graph**. The profit graph is based on the equation shown on this slide.

1. To plot the graph, compute the profit at two different sales volumes, plot the points, and then connect them with a straight line. This slide contains the profit graph for RBC. Notice:

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* + - * 1. The sales volumes plotted on this graph are **300** and **500** bikes.

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* + - * 1. The breakeven point is **400** bikes.

#### Contribution margin ratio (CM ratio)

*Learning Objective 3: Use the contribution margin ratio (CM ratio) to compute changes in contribution margin and net operating income resulting from changes in sales volume.*

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* + 1. The CM ratio is calculated by dividing the **total** contribution margin by **total** sales.

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* + - 1. For RBC, the CM ratio is 40%. Thus, each $1.00 increase in sales results in a total contribution margin increase of 40¢.
    1. The CM ratio can also be calculated by dividing the contribution margin **per unit** by the selling price **per unit**.

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* + - 1. For RBC the CM ratio is 40%.
      2. If RBC increases sales from 400 to 500 bikes, the increase in contribution margin (**$20,000**) can be calculated by multiplying the increase in sales (**$50,000**) by the CM ratio (**40%**).

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29-30

*Quick Check – contribution margin ratio*

* + 1. The relation between profit and the CM ratio can also be expressed in terms of the equation shown on this slide.

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* + - 1. For example, we can use this equation to calculate RBC’s profit of **$20,000** at a volume of **500 bikes**.

#### Applications of CVP concepts

*Learning Objective 4: Show the effects on net operating income of changes in variable costs, fixed costs, selling price, and volume.*

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*Helpful Hint: The five examples that are forthcoming should indicate to students the range of uses of CVP analysis. In addition to assisting management in determining the level of sales that is needed to break-even or generate a certain dollar amount of profit, the examples illustrate how the results of alternative decisions can be quickly determined.*

* + 1. The **variable expense ratio**
       1. Before proceeding with five examples that demonstrate various applications of CVP concepts, we need to define the variable expense ratio as **the ratio of variable expenses to sales**.

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* + 1. **Change in fixed cost and sales volume**
       1. What is the profit impact if RBC can increase unit sales from 500 to 540 by increasing the monthly advertising budget by $10,000?

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* + - * 1. Preparing a contribution income statement reveals a **$2,000 decrease** in profits.

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* + - * 1. A shortcut solution using **incremental analysis** also reveals a $2,000 decrease in profits.

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* + 1. **Change in variable costs and sales** **volume**.
       1. What is the profit impact if RBC can use higher quality raw materials, thus increasing variable costs per unit by $10, to generate an increase in unit sales from 500 to 580?

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* + - * 1. The contribution income statement reveals a **$10,200 increase** in profits.

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* + 1. **Change in fixed cost, sales price, and sales volume**.
       1. What is the profit impact if RBC: (1) cuts its selling price $20 per unit, (2) increases its advertising budget by $15,000 per month, and (3) increases unit sales from 500 to 650 units per month?

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* + - * 1. The contribution income statement reveals a **$2,000 increase** in profits.

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* + 1. **Change in variable cost, fixed cost, and sales volume**.
       1. What is the profit impact if RBC: (1) pays a $15 sales commission per bike sold instead of paying salespersons flat salaries that currently total $6,000 per month, and (2) increases unit sales from 500 to 575 bikes?

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* + - * 1. The contribution income statement reveals a **$12,375 increase** in profits.

42

* + 1. **Change in regular sales** **price.**
       1. If RBC has an opportunity to sell 150 bikes to a wholesaler without disturbing sales to other customers or fixed expenses, what price should it quote to the wholesaler if it wants to increase monthly profits by $3,000?

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* + - * 1. The price quote should be **$320 per bike**.

1. **Target profit analysis**

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*Learning Objective 5: Determine the level of sales needed to achieve a desired target profit.*

#### We can compute the number of units that must be sold to attain a target profit using either the equation method or the formula method.

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#### The equation method is summarized on this slide. Our goal is to solve for the unknown “Q” which represents the quantity of units that must be sold to attain the target profit. For example:

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* + - 1. Suppose RBC wants to know how many bikes must be sold to earn a target profit of $100,000.

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* + - * 1. The **equation method** can be used to determine that **900 bikes** must be sold to earn the desired target profit.

#### The formula method is summarized on this slide. It can also be used to compute the quantity of units that must be sold to attain a target profit. For example:

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* + - 1. Suppose RBC wants to know how many bikes must be sold to earn a target profit of $100,000.

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* + - * 1. The **formula method** can be used to determine that **900 bikes** must be sold to earn the desired target profit.

#### We can also compute the target profit in terms sales dollars using either the equation method or the formula method.

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#### The equation method is summarized on this slide. Our goal is to solve for the unknown “Sales,” which represents the dollar amount of sales that must be sold to attain the target profit. For example:

* + - 1. Suppose RBC wants to compute the sales dollars required to earn a **target profit of $100,000**.

52

* + - * 1. The **equation method** can be used to determine that sales must be **$450,000** to earn the desired target profit.

#### The formula method is summarized on this slide. It can also be used to compute the dollar sales needed to attain a target profit. For example:

* + - 1. Suppose RBC wants to compute the dollar sales required to earn a **target profit of $100,000**.

53

* + - * 1. The **formula method** can be used to determine that sales must be **$450,000** to earn the desired target profit.

54-57

*Quick Check – target profit calculations*

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#### Break-even analysis

*Learning Objective 6: Determine the break-even point.*

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* + 1. The equation and formula methods can be used to determine the unit sales and dollar sales needed to achieve a **target profit of zero**. For example, let’s revisit the information from RBC:

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* + - 1. Suppose RBC wants to know how many bikes must be sold to break-even (i.e. earn a target profit of $0). The equation shown on this slide can be used to answer this question.

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* + - * 1. The **equation method** reveals that **400 bikes** must be sold to breakeven.

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* + - * 1. The **formula method** can also be used to determine that **400 bikes** must be sold to breakeven.

62

* + - 1. Suppose RBC wants to compute the sales dollars required to break-even (i.e. earn a target profit of $0). The equation shown here can be used to answer this question.
         1. The **equation method** reveals that sales of **$200,000** will enable the company to break-even.

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* + - * 1. The **formula method** can also be used to determine that sales of **$200,000** will enable the company to break-even.

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66-69

*Quick Check – break-even calculations*

#### The margin of safety

*Learning Objective 7: Compute the margin of safety and explain its significance.*

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###### The margin of safety in dollars is the **excess of budgeted (or actual) sales over the break-even volume of sales**. For example:

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###### If we assume that RBC has actual sales of $250,000, given that we have already determined the break-even sales to be $200,000, the **margin of safety is $50,000**.

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* + - 1. The margin of safety can be expressed as a percent of sales. For example:

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* + - * 1. RBC’s **margin of safety is 20% of sales**.
      1. The margin of safety can be expressed in terms of the number of units sold. For example:

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* + - * 1. RBC’s **margin of safety is 100 bikes**.

*Quick Check – margin of safety calculations*

75-76

III. **CVP considerations in choosing a cost structure**

#### Cost structure and profit stability

1. **Cost structure** refers to the relative proportion of fixed and variable costs in an organization. Managers often have some latitude in determining their organization's cost structure.

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1. There are **advantages and disadvantages** to high fixed cost (or low variable cost) and low fixed cost (or high variable cost) structures.
   * + 1. An advantage of a high fixed cost structure is that income will be higher in good years compared to companies with a lower proportion of fixed costs.

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* + - 1. A disadvantage of a high fixed cost structure is that income will be lower in bad years compared to companies with a lower proportion of fixed costs.
      2. Companies with low fixed cost structures enjoy greater stability in income across good and bad years.

*Learning Objective 8: Compute the degree of operating leverage at a particular level of sales and explain how it can be used to predict changes in net operating income.*

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#### Operating leverage

1. Operating leverage is a measure of **how sensitive net operating income is to percentage changes in sales**.

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* + 1. The degree of operating leverage is a measure, at any given level of sales, of how a percentage change in sales volume will affect profits. It is computed as shown on this slide.
    2. To illustrate, let’s revisit the contribution income statement for RBC:

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* + - 1. RBC’s degree of operating leverage is **5 ($100,000/$20,000).**
      2. With an operating leverage of 5, if RBC increases its sales by 10%, net operating income would increase by 50%.

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* + - * 1. The 50% increase can be verified by preparing a contribution approach income statement.

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84-88

*Quick Check – operating leverage calculations*

*Helpful Hint: Emphasize that the degree of operating leverage is not a constant like unit variable cost or unit contribution margin that a manager can apply with confidence in a variety of situations. The degree of operating leverage depends on the level of sales and must be recomputed each time the sales level changes. Also, note that operating leverage is greatest at sales levels near the break-even point and it decreases as sales and profits rise.*

1. **Structuring sales** **commissions**

#### Companies generally compensate salespeople by paying them either a commission based on sales or a salary plus a sales commission. Commissions based on sales dollars can lead to lower profits in a company. Consider the following illustration:

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* + 1. Pipeline Unlimited produces two types of surfboards, the XR7 and the Turbo. The XR7 sells for $100 and generates a contribution margin per unit of $25. The Turbo sells for $150 and earns a contribution margin per unit of $18.

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* + 1. Salespeople compensated based on sales commission will push hard to sell the Turbo even-though the XR7 earns a higher contribution margin per unit.

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* + 1. To eliminate this type of conflict, **commissions can be based on contribution margin** rather than on selling price alone.

1. **The concept of sales mix**

*Learning Objective 9: Compute the break-even point for a multiproduct company and explain the effects of shifts in the sales mix on contribution margin and the break-even point.*

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#### The term sales mix refers to the relative proportions in which a company’s products are sold. Since different products have different selling prices, variable costs, and contribution margins, when a company sells more than one product, break-even analysis becomes more complex as the following example illustrates:

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*Helpful Hint: Mention that these calculations typically assume a constant sales mix. The rationale for this assumption can be explained as follows. To use simple break-even and target profit formulas, we must assume the firm has a single product. So we do just that – even for multi-product companies. The trick is to assume the company is really selling baskets of products and each* basket always contains the various products in the same proportions.

* + 1. Assume the RBC sells bikes and carts. The bikes comprise 45% of the company’s total sales revenue and the carts comprise the remaining 55%. **The contribution margin ratio for both products combined is 48.2%**.

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* + 1. The break-even point in sales would be **$352,697**. The bikes would account for 45% of this amount, or **$158,714**. The carts would account for 55% of the break-even sales, or **$193,983**.

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* + - 1. Notice a slight rounding error of $176.

1. **Assumptions of CVP analysis**

#### Four key assumptions underlie CVP analysis:

* + 1. Selling price is **constant**.
    2. Costs are **linear** and can be accurately divided into variable and fixed elements. The variable element is **constant** per unit, and the fixed element is **constant** in total over the entire relevant range.

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* + 1. In multiproduct companies, the sales mix is **constant**.
    2. In manufacturing companies, inventories **do not change**. The number of units produced equals the number of units sold.

*Helpful Hint: Point out that nothing is sacred about these assumptions. When violations of these assumptions are significant, managers can and do modify the basic CVP model. Spreadsheets allow practical models that incorporate more realistic assumptions. For example, nonlinear cost functions with step fixed costs can be modeled using “If…Then” functions.*