

# **Chapter 3:**

## **Cost-Volume-Profit Analysis and Planning**

### **Agenda**

- Direct Materials, Direct Labor, and Overhead
- Traditional vs. Contribution Margin Income Statements
- Cost-Volume-Profit (CVP) Analysis
- Profit Planning
- Nonunit-Level CVP (a customer profitability example)
- Effect of Operating Leverage on Profitability

## Direct Costs

- Direct materials – raw materials used in production or in the delivery of a service (variable cost)
- Direct labor – wages earned in converting direct materials to finished goods or in delivery of a service (variable cost, at least in U.S.)

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## Components of Costs - Overhead

- Manufacturing overhead – all other costs associated with production that are not direct materials or direct labor.
  - Variable manufacturing overhead – overhead costs that vary with the level of production
    - (i.e., supplies, electricity, materials handling)
  - Fixed manufacturing overhead – overhead costs that do not vary with the level of production
    - (i.e., depreciation on facilities, property taxes, insurance, salaries of supervisors, fixed portion of utilities)

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## Selling and Administrative Costs

- Selling and Administrative costs – all costs other than those associated with the production of goods or direct delivery of services.
  - Variable selling and administrative costs – costs that vary with level of production (i.e., sales commissions, transportation of finished goods to customers or wholesalers)
  - Fixed selling and administrative costs – costs that do not vary with level of production (i.e., executive staff, accounting, legal department, marketing and communications, and any fixed costs associated with sales or administrative facilities)

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## Putting it Together

- ***Product costs*** generally refer to direct materials, direct labor, and manufacturing overhead.
- ***Conversion costs*** generally refer to direct labor and manufacturing overhead.
- Selling and administrative (sometimes referred to as SG&A) are ***period costs***.

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## Traditional Income Statement

Sales	XXXX
Less Expenses	<u>(XXX)</u>
= Net Income	<u>XXXX</u>

- We use income statements in managerial accounting also, but we tailor them to planning and decision-making. We would like to know how much income we earn on different products to cover our fixed costs:

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## Traditional (or Functional) Income Statement:

Sales	XXXX
Less Cost of Goods Sold:	
Direct materials	XXX
Direct labor	XXX
Variable mfg overhead	XXX
Fixed mfg overhead	<u>XXX</u>
Total cost of goods sold	<u>(XXX)</u>
= Gross Margin (or profit)	XXXX
Less Selling and Admin:	
Variable S&A	XXX
Fixed S&A	<u>XXX</u>
Total S&A expense	<u>(XXX)</u>
= Net income	<u>XXXX</u>

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## Contribution Income Statement:

Sales	XXXX
Less Variable Costs	<u>(XXX)</u>
= Contribution Margin	XXXX
Less Fixed Costs	<u>(XXX)</u>
= Net income	<u>XXXX</u>

The contribution margin represents the amount that *contributes* to covering fixed costs.

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## Cost-Volume-Profit Analysis

- Facilitates planning through breakeven or desired profit (or activity) analysis.
- Assumptions of CVP Analysis:
  - All costs can be classified as fixed or variable
  - The cost function is linear (within the relevant range)
  - The revenue function is linear (within the relevant range)
    - Implies pure competition
  - Sales mix of multiple products is constant (not an issue for single product production)
  - Only one activity driver: unit or \$ sales volume

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**Profit Formula (*Hmm ... we like profits*):**

$$\pi = R - Y$$

where  $\pi$  = profit  
R = total revenue  
Y = total costs

**Revenue Formula**

$$R = pX$$

where  $p$  = unit selling price  
X = unit sales

## Cost Formula:

$$Y = a + bX$$

where  $a$  = fixed costs  
 $b$  = unit variable cost

Can then rewrite the profit formula  
as:

$$\pi = pX - (a + bX)$$

Can use this formula for a given price, cost and activity level to predict future profits.

## Breakeven Analysis:

Breakeven point = the sales volume necessary  
to cover all costs  
= Total revenues - Total  
Costs  
= Profit = 0

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## Can use algebra to determine the breakeven point

Start with the following equality:

$$\begin{aligned} \text{Total Revenues} &= \text{Total Costs} \\ pX &= a + bX \end{aligned}$$

and solve for X:

$$\begin{aligned} pX - bX &= a \\ (p - b)X &= a \\ X &= a / (p - b) \end{aligned}$$

In other words, the breakeven point (in units) is equal to total fixed costs divided by the contribution margin per unit.

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## Example

Suppose the student union has a walk-up copy division where customers pay 5 cents per copy and the union receives  $\frac{1}{2}$  cent per copy to cover the rent of the space. The university provides the machine, paper, toner, and service. Machines are serviced every 30,000 copies at an average cost of \$90 per service call. Paper and toner cost  $\frac{1}{2}$  cent per copy combined. The university is charged \$185 monthly rental per machine.

What is the breakeven point?

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## Solution

- First, what are the variable costs per copy?

Paper and toner	\$0.005
Union rent	0.005
Service (\$90/30,000)	<u>0.003</u>
Total Variable Costs	<u>\$0.013</u>
- What is the contribution margin per unit?

Price per copy	\$0.050
Less VC/unit	<u>(0.013)</u>
Contribution margin	<u>\$0.037</u>
- What are the fixed costs?

\$185 rental of machine
- How many copies are needed each month to breakeven?

Breakeven Point	=	\$185 / \$0.037
	=	5,000 copies per month

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## Breakeven point in \$

- If you want the breakeven point in sales dollars, just multiply X by the unit selling price (p).
- Or another method is the following:  
$$\text{\$ Sales} = a / \text{Contribution margin ratio}$$

where:

- Contribution margin ratio – expresses contribution margin as a % of sales price:
- Contribution margin ratio = contribution margin per unit/ unit selling price

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## Guess which firm has the highest contribution margin ratio:

- McDonald's versus UAL (United Airlines)
  - *UAL*
- Ford Motor Company versus Kroger
  - *Ford Motor Company*
- Oracle versus Sears
  - *Oracle*
- Nordstrom versus E\*Trade
  - *E\*Trade*
- Coca-Cola versus Wal-Mart
  - *Coca-Cola*

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## Example – E3-15 p. 93

- Determine the annual break-even dollar sales volume:

■ Sales	\$750,000
Variable costs	<u>(412,500)</u>
Contribution margin	<u>\$337,500</u>

- Contribution margin ratio =  
 $\$337,500 / \$750,000 = 0.45$
- Annual break-even dollar sales volume =  
 $\$210,000 / 0.45 = \underline{\$466,667}$

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## Example – E3-15 p. 93

- Determine the annual margin of safety:

■ Sales	\$750,000
Break-even sales dollars	<u>(466,667)</u>
Margin of safety	<u>\$283,333</u>

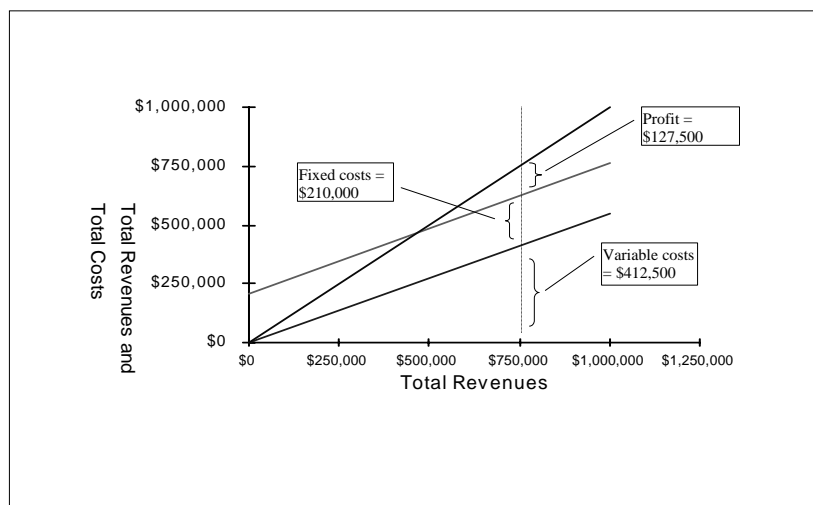
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## Example – E3-15 p. 93

- Prepare a CVP graph:
- To determine the variable and total costs lines, it is necessary to compute the variable cost ratio:
  - Variable cost ratio =  $\frac{\text{variable costs}}{\text{sales}} = \frac{\$412,500}{\$750,000} = 0.55$
- At a volume of \$1,000,000 sales dollars, variable costs are \$550,000.

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## CVP Graph



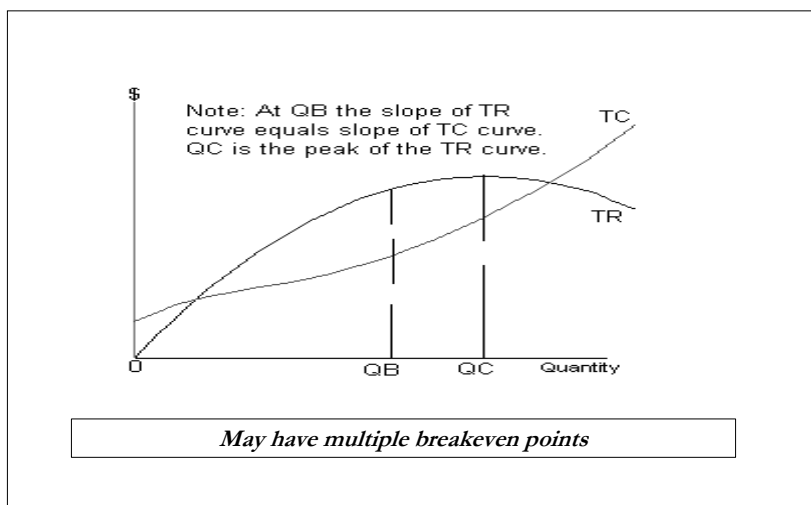
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## Example – E3-15 p. 93

- If fixed costs increase by \$35,000, what is new break-even dollar sales volume?
- Revised annual break-even dollar sales:  
 $(\$210,000 + \$35,000)/0.45 = \underline{\$544,444}$

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## What about when costs and revenues are nonlinear?



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## Profit Planning:

- Can establish a plan to reach a specific profit target.
- Can state profit in numerous ways:
  - % of last year's income
  - % of assets (ROA)
  - % of sales (Profit margin)
  - % of equity (ROE)
- CVP provides a rough and quick method for scenario planning (feasibility analysis).
  - Must consider demand and supply conditions in conjunction with assessing feasibility.
- Next step after CVP would be a full-out budget.

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## Target Sales Volume:

- Target unit sales volume =  $(\text{Fixed costs} + \text{Desired profit}) / \text{Unit contribution margin}$
- Notice this is the same as the breakeven formula, only we've added desired profit to fixed costs (a) in the numerator.

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## *(Uncle Sam Gets his Due)*

- To incorporate the effect of income taxes (we assume that taxable income = accounting income which isn't true due to deferred taxes.
  - You maybe covered this in the last module with Dr. Tucker.
  - This assumption, however, suffices for basic CVP analysis.
  - Tax-to-book differences may be incorporated into finer levels of budgeting and planning).
- Before tax profit = After-tax Profit / (1 – Tax Rate)
- Then use the before tax profit in place of the “Desired Profit” in the formula on the previous slide.

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## Example with Taxes

- Suppose Pretty Tile, Inc. manufactures ceramic flooring tiles. PTT's annual fixed costs are \$740,000. The variable cost of each tile is \$0.25, and tiles are sold for \$6.50 each. PTI has a combined state and federal tax rate of 45%.
- How many tiles does PTI need to make and sell each year to earn an after-tax profit of \$85,000?
- First, convert the desired after-tax profit to before-tax:
  - Before-tax profit =  $\$85,000 / (1 - .45)$   
= \$154,545
- Now, use the desired before-tax profit in the target profit calculation:
  - Target sales volume =  $(\$740,000 + \$154,545) / (\$6.50 - \$0.25)$   
= 143,127 tiles

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## Multiple Products - CVP Analysis:

- Depends on homogeneity of products:
  - Baskin Robbins could probably use traditional CVP by lumping their products together.
  - Sears would benefit from a weighted average approach:
- Recall that the \$ Breakeven point = Fixed costs/Contribution margin ratio
- For more detailed analyses at the product level, the analyses can be performed separately for each product line or division within the company.

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## What if costs do not vary by unit-level production?

- If that is the case, substantial errors in the analysis could ensue.
- Could we expand the analysis to non-unit level cost drivers?
  - Yes, by breaking our costs down by activity and computing the amount of each activity that was used in the estimation period.
- Need to prepare a multi-level contribution income statement [Exhibit 3-6, p. 85]:
  - Can answer many important questions such as:
    - What minimum order size is needed to break even (in units)?
    - What minimum order size is needed to break even (in dollars)?
    - Both of these questions can evaluate customer-level profitability. The same can be performed at the division or facility level to determine what the production volume should be at each facility to breakeven.

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## Example – E3-25

- Minimum order size (in sales \$) to break even on an order:
- Minimum order size =  $\frac{\$200}{(0.10 - 0.02)} = \underline{\$2,500}$   
to break even on order
- Annual sales \$ to break even on a customer (assuming 4 orders per year are placed):
- Annual sales to break-even on average customer =  $\frac{(\$200 \times 4 \text{ orders}) + \$1,000}{(0.10 - 0.02)} = \underline{\$22,500}$

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## Example – E3-25

- What would average order size be for the average customer's breakeven point?
- Average order size =  $\$22,500 / 4 = \underline{\$5,625}$

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## Example – E3-25

- Assuming 100 customers are currently served, with each placing 4 orders per year, what is minimum annual sales to breakeven?
- |  |               |
|--|---------------|
| Order level costs ( $\$200 \times 4 \text{ orders} \times 100 \text{ customers}$ ) | \$ 80,000     |
| Customer level costs ( $\$1,000 \times 100 \text{ customers}$ )                    | 100,000       |
| Facility level costs   | <u>60,000</u> |
| Total costs  | \$ 240,000    |
| Contribution margin ratio  | $\div$ 0.08   |
| Minimum annual sales to break even   | \$3,000,000   |
- What is average order size per customer?
- Average order size =  $\$3,000,000 / (4 \text{ orders} \times 100 \text{ customers}) = \underline{\$7,500}$

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## Example – E3-25

- Explain the differences in the answers to (a), (c), and (e).
  - Part (a) considers only order level costs while part (c) also considers customer level costs, and part (e) adds facility level costs. In order for a company to break even on an order, it need only cover order level costs. To break even on a customer, the company must cover order level and customer level costs. Finally, to achieve true break-even, all costs must be covered.

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## Effect of Operating Leverage:

- Operating leverage represents the degree to which an organization's costs are fixed:
- Degree of operating leverage = Contribution Margin / Before-Tax Profit
- Would a firm rather have a higher or lower degree of operating leverage?
  - Higher may be desirable because additional sales have an increasing effect on profit (the fixed costs are spread across more units and overall profitability goes up).
  - Lower may be desirable because it allows a firm more financial flexibility (remember only the variable costs are relevant in on-going operations). Also, a decrease in sales has a more severe effect on profitability the higher the operating leverage (the mirror condition of point 1 above).

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Suppose two internet retailers have the following data:

<i>(millions)</i>	BuyEverything.com	CheapSports.com
Sales	\$120	\$186
Variable Costs	70	150
Fixed Costs	<u>40</u>	<u>24</u>
Net Income	<u>\$ 10</u>	<u>\$ 12</u>

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## Which retailer has more operating leverage?

<i>(millions)</i>	<b>BuyEverything.com</b>	<b>CheapSports.com</b>
Contribution Margin	\$50	\$36
Net income	10	12
Degree of Operating Leverage	<u>5.0</u>	<u>3.0</u>

Operating leverage is also frequently computed as:  
 Operating Leverage = Fixed costs / Total Costs

<i>(millions)</i>	<b>BuyEverything.com</b>	<b>CheapSports.com</b>
Fixed Costs	\$40	\$24
Total Costs	110	174
Operating Leverage	<u>36%</u>	<u>14%</u>

Using both measures, BuyEverything.com has more operating leverage.

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## Suppose both retailers double their sales. Which one's net income shows the greatest percentage increase?

<i>(millions)</i>	<b>BuyEverything.com</b>	<b>CheapSports.com</b>
New Sales	\$240	\$372
Variable Costs	140	300
Fixed Costs	<u>40</u>	<u>24</u>
Net Income	<u>\$ 60</u>	<u>\$ 48</u>
Previous Net Income	10	12
% Change in Net Income	500%	300%

Thus, the firm with the highest operating leverage has the greatest net income sensitivity to changes in sales.

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## Repeat the analysis when sales fall by 50%:

<i>(millions)</i>	<b>BuyEverything.com</b>	<b>CheapSports.com</b>
New Sales	\$60	\$93
Variable Costs	35	75
Fixed Costs	<u>40</u>	<u>24</u>
Net Income	<u>(\$15)</u>	<u>(\$ 6)</u>
Previous Net Income	10	12
% Change in Net Income	-250%	-150%

Again, the firm with the highest operating leverage has the greatest net income sensitivity to changes in sales.

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## Further Application:

- Suppose your company is operating at a loss. What are some things you can do to get closer to your breakeven point?
  - Reduce labor costs (manufacturing and executive)
  - Consolidate operations into fewer facilities
  - Shutting down plants or eliminating products that do not break even
- Those of you with a marketing focus are encouraged to review Appendix 3A.

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