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.)

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)
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)

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**.
Traditional Income Statement

Sales XXXX
Less Expenses (XXX)
= Net Income XXXX

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:

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 XXX
Total cost of goods sold (XXX)
= Gross Margin (or profit) XXXX
Less Selling and Admin:
  Variable S&A XXX
  Fixed S&A XXX
Total S&A expense (XXX)
= Net income XXXX
Contribution Income Statement:

Sales XXXX
Less Variable Costs (XXX)
= Contribution Margin XXXX
Less Fixed Costs (XXX)
= Net income XXXX

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

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
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  
\( a = \text{fixed costs} \)  
\( b = \text{unit variable cost} \)

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

Can use algebra to determine the breakeven point

Start with the following equality:

Total Revenues = Total Costs
pX = a + bX

and solve for X:

pX – bX = a
(p – b)X = a
X = a / (p – b)

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

Suppose the student union has a walk-up copy division where customers pay 5 cents per copy and the union receives ½ 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 ½ cent per copy combined. The university is charged $185 monthly rental per machine.

What is the breakeven point?

Solution

- First, what are the variable costs per copy?
  - Paper and toner: $0.005
  - Union rent: 0.005
  - Service ($90/30,000): 0.003
  - Total Variable Costs: $0.013
- What is the contribution margin per unit?
  - Price per copy: $0.050
  - Less VC/unit: (0.013)
  - Contribution margin: $0.037
- 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
**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:
  
  $ Sales = \frac{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

**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**
Example – E3-15 p. 93

- Determine the annual break-even dollar sales volume:
  - Sales $750,000
  - Variable costs $(412,500)
  - Contribution margin $337,500
  - Contribution margin ratio = $337,500/$750,000 = 0.45
  - Annual break-even dollar sales volume = $210,000/0.45 = $466,667

Example – E3-15 p. 93

- Determine the annual margin of safety:
  - Sales $750,000
  - Break-even sales dollars $(466,667)
  - Margin of safety $283,333
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.
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:
  \[
  \frac{(210,000 + 35,000)}{0.45} = 544,444
  \]

What about when costs and revenues are nonlinear?

May have multiple breakeven points
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.

Target Sales Volume:

- Target unit sales volume = (Fixed costs + Desired profit)/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.
(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.

Example with Taxes

- Suppose Pretty Tile, Inc. manufactures ceramic flooring tiles. PTI’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
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.

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.
Example – E3-25

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

Example – E3-25

- What would average order size be for the average customer’s breakeven point?
  - Average order size = $22,500/4 = $5,625
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** 60,000
- **Total costs** $ 240,000
- **Contribution margin ratio** $0.08$
- **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}) = $7,500

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.
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).

Suppose two internet retailers have the following data:

<table>
<thead>
<tr>
<th></th>
<th>BuyEverything.com</th>
<th>CheapSports.com</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sales</td>
<td>$120</td>
<td>$186</td>
</tr>
<tr>
<td>Variable Costs</td>
<td>70</td>
<td>150</td>
</tr>
<tr>
<td>Fixed Costs</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>Net Income</td>
<td>$10</td>
<td>$12</td>
</tr>
</tbody>
</table>
Which retailer has more operating leverage?

<table>
<thead>
<tr>
<th>(millions)</th>
<th>BuyEverything.com</th>
<th>CheapSports.com</th>
</tr>
</thead>
<tbody>
<tr>
<td>Contribution Margin</td>
<td>$50</td>
<td>$36</td>
</tr>
<tr>
<td>Net income</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>Degree of Operating</td>
<td>5.0</td>
<td>3.0</td>
</tr>
<tr>
<td>Leverage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>(millions)</th>
<th>BuyEverything.com</th>
<th>CheapSports.com</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fixed Costs</td>
<td>$40</td>
<td>$24</td>
</tr>
<tr>
<td>Total Costs</td>
<td>110</td>
<td>174</td>
</tr>
<tr>
<td>Operating Leverage</td>
<td>36%</td>
<td>14%</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>(millions)</th>
<th>BuyEverything.com</th>
<th>CheapSports.com</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Sales</td>
<td>$240</td>
<td>$372</td>
</tr>
<tr>
<td>Variable Costs</td>
<td>140</td>
<td>300</td>
</tr>
<tr>
<td>Fixed Costs</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>Net Income</td>
<td>60</td>
<td>48</td>
</tr>
<tr>
<td>Previous Net Income</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>% Change in Net Income</td>
<td>500%</td>
<td>300%</td>
</tr>
</tbody>
</table>

Thus, the firm with the highest operating leverage has the greatest net income sensitivity to changes in sales.
Repeat the analysis when sales fall by 50%:

<table>
<thead>
<tr>
<th>(millions)</th>
<th>BuyEverything.com</th>
<th>CheapSports.com</th>
</tr>
</thead>
<tbody>
<tr>
<td>New Sales</td>
<td>$60</td>
<td>$93</td>
</tr>
<tr>
<td>Variable Costs</td>
<td>35</td>
<td>75</td>
</tr>
<tr>
<td>Fixed Costs</td>
<td>40</td>
<td>24</td>
</tr>
<tr>
<td>Net Income</td>
<td>($15)</td>
<td>($6)</td>
</tr>
<tr>
<td>Previous Net Income</td>
<td>10</td>
<td>12</td>
</tr>
<tr>
<td>% Change in Net Income</td>
<td>-250%</td>
<td>-150%</td>
</tr>
</tbody>
</table>

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

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.