Chapter 2:
Cost Behavior, Activity Analysis, and Cost Estimation

Agenda
- History of Cost Accounting
- Cost Formulas
- Cost Estimation Techniques
- New School – Nonunit-Level Data
Cost Accounting

- First developed by General Motors 80 years ago
- Postulates that the total manufacturing cost is the sum of the costs of individual operations
- We’ve come a long way since then ….

Why do we care about costs?

- To evaluate past performance
- To predict future performance
- Old-School:
  - Add up the costs
  - Add up the units produced
  - Determine the average cost/unit
What’s wrong with “old school”?

- It’s simple and you’ve included all possible costs into your analysis.
- But what if one type of product consumes a disproportionate share of the production function compared to other types?
- What if the plant is not running at full capacity?
- This method provides a starting point, however, we’ve greatly improved “cost” accounting in subsequent decades.

Uh-oh … here comes the math

- \( Y = \) Total Costs
- \( X = \) Total Activity
Hold on, ‘pardner’ … it’s about to get bumpy …

- But what if total costs \((Y)\) don’t vary proportionately with \((X)\)?
  - Costs that vary in proportion to activity are called “variable” costs
  - Costs that don’t vary with activity are called “fixed” costs
  - Costs that vary with activity, but not proportionately, are a mixture of the two

Variable Costs

*Total variable costs* increase in proportion to increases in unit level cost drivers.
Variable Costs

- Notice the intercept is always zero
- Costs vary proportionately with production
- The slope of the line (b) is the variable rate/unit
- Formula: \( Y = bX \)
- Examples: direct labor, direct materials

(Show me some numbers …)

- Consider the following data for Beverage Of Your Choice Corporation:

<table>
<thead>
<tr>
<th>Variable Costs:</th>
<th>Last Month</th>
<th>Per Unit</th>
<th>Current Month</th>
<th>Per Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Bottles</td>
<td>$120,000</td>
<td>$0.30</td>
<td>$144,000</td>
<td>$0.30</td>
</tr>
<tr>
<td>Ingredient Cost</td>
<td>$32,000</td>
<td>0.08</td>
<td>$38,400</td>
<td>0.08</td>
</tr>
<tr>
<td>Water</td>
<td>$12,000</td>
<td>0.03</td>
<td>$14,400</td>
<td>0.03</td>
</tr>
<tr>
<td>Labor Cost</td>
<td>$24,000</td>
<td>0.06</td>
<td>$28,800</td>
<td>0.06</td>
</tr>
<tr>
<td>Total Var. Cost</td>
<td>$188,000</td>
<td>$0.47</td>
<td>$225,600</td>
<td>$0.47</td>
</tr>
</tbody>
</table>
**Fixed Costs**

**Total fixed costs** do not respond to changes in unit-level cost drivers.

![Graph showing fixed costs](image)

- The intercept is the amount of fixed cost \(a\)
- The slope of the line is zero
  - Formula: \(Y = a\) (notice that \(X\) does not enter the equation)
  - Examples: fixed-rate debt, property taxes, corporate salaries and insurance (fixed in the short run)
(Less talk, more numbers …)

Consider the following data for Beverage Of Your Choice Corporation:

- Notice the unit cost of a fixed cost varies with production, but not the total.

<table>
<thead>
<tr>
<th></th>
<th>Last Month</th>
<th>Per Unit</th>
<th>Current Month</th>
<th>Per Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production</td>
<td>400,000 bottles</td>
<td></td>
<td>480,000 bottles</td>
<td></td>
</tr>
<tr>
<td>Fixed Costs:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rent</td>
<td>$5,000</td>
<td>$0.0125</td>
<td>$5,000</td>
<td>$0.0104</td>
</tr>
<tr>
<td>Depreciation</td>
<td>6,667</td>
<td>0.0167</td>
<td>6,667</td>
<td>0.0139</td>
</tr>
<tr>
<td>Other</td>
<td>8,333</td>
<td>0.0208</td>
<td>8,333</td>
<td>0.0174</td>
</tr>
<tr>
<td>Total Fix. Cost</td>
<td>$20,000</td>
<td>$0.0500</td>
<td>$20,000</td>
<td>$0.0417</td>
</tr>
</tbody>
</table>

Mixed Costs

**Total mixed costs** contain fixed and variable cost elements. They increase, but not in direct proportion to increases in unit level cost drivers.
Mixed Costs

- The intercept is the fixed portion of cost
- The slope is the variable rate/unit
  - Formula: \( Y = a + bX \) (note that this is the mathematical equation of a straight line)
  - Examples: utility bills, salesperson compensation (usually base plus commission)

Step Costs

**Total step costs** are constant over a range of activity for a unit-level cost driver but move to a different amount at different ranges.
Step Costs

- Costs are fixed for a narrow range of production, but the fixed levels vary with overall production.
- Can identify the fixed cost over a relevant range of production.
  - Note: Most fixed costs are actually step costs in the long run.
  - Formula: \( Y = a_i \) where \( i \) is the current level of activity.
- Examples: Wages (Fixed for 40 hours of work, steps up if paid overtime).
- Put our knowledge to the test … E2-14

Which type of cost would you prefer as manager?

**Variable!!!**

You’re not assessed a charge if you don’t produce.

What happens if you abandon a business segment that is made up of fixed costs? Those costs persist …
It’s all relevant …

- Relevant range: If you sufficiently *expand* your time horizon, there are no fixed costs (contracts expire, facilities can be constructed, etc.).
- This means that all costs are *variable* in the long run.

Hold the line ….

- The previous graphs were all linear (with the exception of the step costs).
- Is that descriptive of reality?
- Law of diminishing marginal returns states that as more of something becomes available, the less it will be in demand.
- This induces curvature into the mathematical function and this curvature is prevalent in almost every revenue or cost function.
(So what good were those goofy graphs?)

- Relevant range: If you sufficiently contract your time horizon, the segment of the nonlinear graph will be linear.

Not all costs are created equal …

- Suppose the total cost of producing machines is as follows:

<table>
<thead>
<tr>
<th>Number of Machines</th>
<th>Total Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$50,000</td>
</tr>
<tr>
<td>2</td>
<td>98,000</td>
</tr>
<tr>
<td>3</td>
<td>144,000</td>
</tr>
<tr>
<td>4</td>
<td>184,000</td>
</tr>
<tr>
<td>5</td>
<td>225,000</td>
</tr>
<tr>
<td>6</td>
<td>270,000</td>
</tr>
<tr>
<td>7</td>
<td>315,000</td>
</tr>
<tr>
<td>8</td>
<td>368,000</td>
</tr>
<tr>
<td>9</td>
<td>423,000</td>
</tr>
<tr>
<td>10</td>
<td>480,000</td>
</tr>
</tbody>
</table>
Total, Marginal and Average Cost

- Determine the Marginal and Average Cost at each Output Level:

<table>
<thead>
<tr>
<th>Number of Machines</th>
<th>Total Cost</th>
<th>Marginal Cost</th>
<th>Average Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$50,000</td>
<td>$50,000</td>
<td>$50,000</td>
</tr>
<tr>
<td>2</td>
<td>98,000</td>
<td>48,000</td>
<td>49,000</td>
</tr>
<tr>
<td>3</td>
<td>144,000</td>
<td>46,000</td>
<td>48,000</td>
</tr>
<tr>
<td>4</td>
<td>184,000</td>
<td>40,000</td>
<td>46,000</td>
</tr>
<tr>
<td>5</td>
<td>225,000</td>
<td>41,000</td>
<td>45,000</td>
</tr>
<tr>
<td>6</td>
<td>270,000</td>
<td>45,000</td>
<td>45,000</td>
</tr>
<tr>
<td>7</td>
<td>315,000</td>
<td>45,000</td>
<td>45,000</td>
</tr>
<tr>
<td>8</td>
<td>368,000</td>
<td>53,000</td>
<td>46,000</td>
</tr>
<tr>
<td>9</td>
<td>423,000</td>
<td>55,000</td>
<td>47,000</td>
</tr>
<tr>
<td>10</td>
<td>480,000</td>
<td>57,000</td>
<td>48,000</td>
</tr>
</tbody>
</table>

(Ey-yi-yi ... Too much information!)

- Which cost do I use?
  - Variable costs are usually the only relevant costs to determine marginal pricing
  - Average cost should be used for evaluation
  - Total costs should be used for prediction
(We need a drink ….)

- Return to Beverage of Your Choice Corp.
- Suppose that the company is approached by a potential customer who would like to buy 200,000 bottles for $0.75 per bottle. Should you accept or decline?

It’s a “marginal” thing …

| Incremental revenue ($0.75 x 200,000 bottles) | $150,000 |
| Incremental cost ($0.47 x 200,000 bottles)   | (94,000) |
| Incremental profit                           | $56,000 |

- Is it that simple?
- How does capacity level figure into this decision?
- Are there any other ramifications of this pricing policy?
- Cannibalization of other higher margin customers
Back to the machine example:

- The plant is currently making and selling eight machines per month.
- The company can sell another machine for $53,000.
- Should the company accept the offer? 
  \textit{No, because the offered price} < \textit{marginal cost; do not use average cost in this situation or you will lose money.}

Back to the future …

- Using cost information to predict future costs and/or profitability:
  - Total costs are best metric to use for prediction
  - How good is predictive accuracy when firm is nonstable (i.e., growing or contracting)?
Let’s recap

- Variable – total variable cost varies with number of units produced
- Fixed – total fixed cost remains constant regardless of number of units produced

Applying what we’ve learned:

- Labor – fixed or variable?
- Depends on where you are:
  - U.S. culture – treat labor as a variable cost
  - Some countries like Japan and Korea, labor is considered a fixed cost.
    - Japanese and Korean companies are hesitant to lay off workers when business decreases (just as they are hesitant to increase labor when business increases).
Cost Estimation Techniques:

- Relatively easy to identify strictly fixed and strictly variable costs.
- Mixed costs present a challenge:
  - High-Low Estimation
  - Scatter Diagrams
  - Least Squares Regression Analysis

[Sing: You say “high”, I say “low”]

- High-Low Estimation – estimates the fixed and variable components in a mixed cost:
  - Organize observations in order of activity level (production, etc.)
  - Choose a representative high and low activity point and gather the associated costs for each point
    - Absolute highest and lowest may not be representative due to extreme events such as equipment breakdowns, materials outages, labor strikes, interruption of production due to natural or manmade disasters, etc.
High-Low Estimation – Continued

- Estimate the variable portion of the mixed cost as:
  - Variable cost per unit = (High activity cost – low activity cost)/(High activity level – low activity level)
- Compute fixed costs based on the estimation of variable cost:
  - Fixed costs = Total costs – (variable cost per unit * activity level)
  - You can apply this formula to either the high or low point (assuming fixed costs are constant at both activity levels)

(Draw us a picture …)

- Scatter Diagrams – graph of historical data (cost versus activity level)
  - Graph points
  - Fit a straight line (visually)
  - Choose two points on the line and perform high-low cost analysis
(We’re paying tuition and you’re teaching us how to draw?)

- Least Squares Regression Analysis – produces a mathematically-derived line (not visual line-fitting) that minimizes the distance between the line and the data points.
- Uses more data points to produce the line (model will perform better if outliers are eliminated).
- The intercept of the line is the total fixed cost amount, and the slope of the line is the variable cost per unit.
  - Coefficient of determination ($R^2$) indicates the explanatory power of the fitted line (would like an $R^2$ close to 1.00)
  - Can extend simple regression to several activity drivers to arrive at a more complex cost and product function.

Complicating Factors in Analyzing Cost Data:

- Changing technology
- Changing input prices (goods used in production or delivery of services)
  - All prices are dynamic (i.e., changing frequently at different rates of change)
- Time lags between activity and cost [activity can precede cost (utility bills) or vice versa (operation of a machine)]
- Establishing causal links between activity and cost (i.e., units produced and cost of corporate legal department)
  - This becomes more difficult in complex organizations (multi-product, diversification into other industries or geographic areas, etc.)
The result …*[drum roll]*

- Inaccurate costs which may lead to faulty decisions.
- A possible solution:

*Using non-unit level data*

*(Say what?????)*

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**Manufacturing Cost Hierarchy:**

- Unit-level – an activity performed on each unit produced (Variable)
- Batch-level – an activity performed on each batch of units produced (machine setup, handling, inspection) (Variable); larger batch sizes generally result in smaller per unit costs.
- Product-level – an activity performed in support of a product (engineering and design, prototypes, testing) (Variable); product complexity generally increases per unit costs.
- Facility-level – an activity performed in support of the facility (management, maintenance, taxes, utilities) (Fixed)
Customer Cost Hierarchy:

- Unit-level
- Order-level – performed for each sales order
- Customer-level – performed to obtain and maintain each customer
- Facility-level