Determining How Costs Behave

Session 10
Learning Objectives

- Explain the two assumptions frequently used in cost-behavior estimation
- Describe linear cost functions and three common ways in which they behave
- Recognize various approaches to cost estimation
- Outline six steps in estimating a cost function on the basis of current or past cost relationships
- Describe three criteria to evaluate and choose cost drivers
- Explain and give examples of nonlinear cost functions
- Distinguish between the cumulative average-time learning model and incremental unit-time model
- Understand data problems encountered in estimating cost functions
Learning Objective 1

Explain the two assumptions frequently used in cost-behavior estimation
Assumptions in Cost-Behavior Estimation

- Changes in total costs can be explained by changes in the level of a single activity.
  - Variation in machine hours can explain variations in total cost.
  - Variation in labor hours can explain variations in total cost.

- Cost behavior can adequately be approximated by a linear function of the activity level within the relevant range.
  - A linear cost function is a cost function in which the graph of total cost versus the level of a single activity is a straight line.
Learning Objective 2

Describe linear cost functions and three common ways in which they behave
The Cost Function...

- is a mathematical expression describing how costs change with changes in the level of an activity.
  - Output produced
  - Direct manufacturing labor hours
  - Machine hours
  - Batches of production
Cost Function

- La Bella Hotel offers Happy Airline three alternative cost structures to accommodate its crew overnight:
  - $60 per night per room usage
    - Total room usage is the only factor whose change causes a change in total costs.
    - The cost is variable.
  - $8,000 per month
    - The total cost will be $8,000 per month regardless of room usage.
    - The cost is fixed, not variable.
  - $3,000 per month plus $24 per room
    - This is an example of a mixed cost.
- What are the cost functions?
Cost Classification and Estimation

- Choice of cost object
- Time span
- Relevant range
Choice of Cost Object

- Costs may be variable with respect to one cost item and fixed with respect to another.
- If the number of taxis owned by a taxi company is the cost object, annual taxi registration, and license costs would be a variable cost.
- If miles driven during a year on a particular taxi is the cost object, registration, and license costs for that taxi is a fixed cost.
Time Span

- Whether a cost is variable or fixed with respect to a particular activity depends on the time span.
- More costs are variable with longer time spans.
Variable and fixed cost behavior patterns are valid for linear cost functions only within the given relevant range.

Costs may behave nonlinear outside the range.
Cost Estimation...

– is the attempt to measure a past cost relationship between costs and the level of an activity.

- Managers are interested in estimating past cost-behavior functions primarily because these estimates can help them make more accurate cost predictions.
The Cause-and-Effect Criterion In Choosing Cost Drivers

– Physical relationship (materials costs)
– Contractual agreements (phone charges based on minutes)
– Implicitly established by logic (ordering costs driven by number of parts)
Learning Objective 3

Recognize various approaches to cost estimation
Cost Estimation Approaches

- Industrial engineering method
- Conference method
- Quantitative analysis methods
Industrial Engineering Method...

- is also called the *work-measurement method*.
- It estimates cost functions by analyzing the relationship between inputs and outputs in physical terms.
Conference Method...

- estimates cost functions on the basis of analysis and opinions about costs and their drivers gathered from various sources.
- This method involves the pooling of expert knowledge.
Quantitative Analysis Methods

- Quantitative analysis uses a formal mathematical method to fit linear cost functions to past data observations.
Learning Objective 4

Outline six steps in estimating a cost function on the basis of current or past cost relationships
Steps In Estimating A Cost Function

- Choose the dependent variable.
- Identify the independent variable cost driver(s).
- Collect data on the dependent variable and the cost driver(s).
- Plot the data.
- Estimate the cost function.
- Evaluate the estimated cost function.
Steps In Estimating A Cost Function

1. Choose the dependent variable.
   - Choice of the dependent variable (the cost to be predicted) will depend on the purpose for estimating a cost function.
Steps In Estimating A Cost Function

2 Identify the independent variable cost driver(s).

- The independent variable (level of activity or cost driver) is the factor used to predict the dependent variable (costs).

- Two important aspects when identifying a cost driver:
  - It should have an economically plausible relationship with the dependent variable.
  - It should be accurately measurable.
Steps In Estimating A Cost Function

3 Collect data on the dependent variable and the cost driver(s).
   - Cost analysts obtain data from company documents, from interviews with managers, and through special studies.
     - Time-series data
     - Cross-sectional data
Steps In Estimating A Cost Function

4 Plot the data.

- The general relationship between the cost driver and the dependent variable can readily be observed in a plot of the data.
- The plot highlights extreme observations that analysts should check.

Cost of activity

Fixed cost

Estimated cost function

Level of activity
Steps In Estimating A Cost Function

5 Estimate the cost function.
   – High-low method
   – Regression analysis
High-Low Method

- Choose the highest and lowest value of the cost driver and their respective costs.
- Cost function as a linear function:
  \[ \text{Cost} = a + b \times \text{value of cost driver} \]
- Determine \( a \) and \( b \) using algebra.
High-Low Method

High capacity December: 55,000 machine hours
  • Cost of electricity: $80,450

Low capacity September: 30,000 machine hours
  • Cost of electricity: $64,200

What is the variable rate?
  • \( \frac{($80,450 - $64,200)}{(55,000 - 30,000)} = $0.65 \)

What is the fixed cost?
  • \( $80,450 = \text{Fixed cost} + 55,000 \times $0.65 \)
    \[ \text{Fixed cost} = $80,450 - $35,750 = $44,700 \]
  • \( $64,200 = \text{Fixed cost} + 30,000 \times $0.65 \)
    \[ \text{Fixed cost} = $64,200 - $19,500 = $44,700 \]

\( \text{Cost} = $44,700 + ($0.65 \times \text{Machine-hours}) \)
Regression Analysis...

- is used to measure the average amount of change in a dependent variable, such as electricity, that is associated with unit increases in the amounts of one or more independent variables, such as machine hours.

- Regression analysis uses all available data to estimate the cost function.
  - Simple regression analysis estimates the relationship between the dependent variable and one independent variable.
  - Multiple regression analysis estimates the relationship between the dependent variable and multiple independent variables.
Regression Analysis

- The regression equation and regression line are derived using the **least-squares technique**.
- The vertical difference (residual term) measures the distance between the actual cost and the estimated cost for each observation.
- The regression method is more accurate than the high-low method.
- The objective of least-squares is to develop estimates of the parameters $a$ and $b$. 

Steps In Estimating A Cost Function

6 Evaluate the estimated cost function.

- A key aspect of estimating a cost function is choosing the appropriate cost driver.
Learning Objective 5

Describe three criteria to evaluate and choose cost drivers
Criteria to Evaluate and Choose Cost Drivers

1. Economic plausibility
2. Goodness of fit
3. Slope of the regression line
Goodness of Fit

- The **coefficient of determination** \((r^2)\) expresses the extent to which the changes in \((x)\) explain the variation in \((y)\).
- An \((r^2)\) of 0.80 indicates that 80 percent of the change in the dependent variable can be explained by the change in the independent variable.
Slope of Regression Line

- A relatively steep slope indicates a strong relationship between the cost driver and costs.
- A relatively flat regression line indicates a weak relationship between the cost driver and costs.
Slope of Regression Line

- The closer the value of the correlation coefficient \( r^2 \) to 1, the stronger the statistical relation between the variables.
- A positive \( r^2 \) predicts either a positive or a negative statistical relationship:
  - A positive relationship implies that the dependent variable \( y \) increases if the independent variable \( x \) increases.
  - A negative, or inverse, relationship implies, that the dependent variable \( y \) decreases as the independent variable \( x \) increases.
Learning Objective 6

Explain and give examples of nonlinear cost functions
Nonlinearity and Cost Functions

- A nonlinear cost function is a cost function in which the graph of total costs versus the level of a single activity is not a straight line within the relevant range.
  - Economies of scale
  - Quantity discounts
  - Step cost functions
Nonlinearity and Cost Functions

- **Economies of scale** in advertising may enable an advertising agency to double the number of advertisements for less than double the cost.
- **Quantity discounts** on direct materials purchases produce a lower cost per unit purchased with larger orders.
- **A step function** is a cost function in which the cost is constant over various ranges of the level of activity, but the cost increases by discrete amounts as the level of activity changes from one range to the next.
Learning Objective 7

Distinguish between the cumulative average-time learning model and incremental unit-time model
Learning Curves

- A learning curve is a function that shows how labor-hours per unit decline as units of output increase.
Experience Curve...

- is a function that shows how the costs per unit in various value chain areas decline as units produced and sold increase.
Cumulative Average-Time and Incremental Unit-Time Learning Model

- **Cumulative average time per unit** is reduced by a constant percentage each time the cumulative quantity of units produced is doubled.
- The **time needed to produce the last unit** is reduced by a constant percentage each time the cumulative quantity of units produced is doubled.
Cumulative Average-Time and Incremental Unit-Time Learning Model

- Underlying mathematical relationship:

  \[ y = aX^b \]

  - \( y \) = Cumulative average time (labor hours) per unit
  - \( X \) = Cumulative number of units produced
  - \( a \) = Time (labor hours) required to produce the first unit
  - \( b \) = Factor used to calculate cumulative average time to produce units
  - \( b = \log(\text{learning curve } \%) / \log 2 \)
**Cumulative Average-Time Learning Model**

- $a = 100$, learning rate = 80%, $X = 1, 2, 3, 4$

<table>
<thead>
<tr>
<th>Number of units</th>
<th>Cumulative average labor hours per unit</th>
<th>Cumulative total labor hours</th>
<th>Individual time for Xth unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>100</td>
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<tr>
<td>2</td>
<td>80</td>
<td>160</td>
<td>60</td>
</tr>
<tr>
<td>3</td>
<td>70.21</td>
<td>210.63</td>
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<td>4</td>
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<td>45.37</td>
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</table>
Incremental Unit-Time Learning Model

- \( a = 100 \), learning rate = 80%, \( X = 1, 2, 3, 4 \)

<table>
<thead>
<tr>
<th>Number of units</th>
<th>Individual time for Xth unit</th>
<th>Cumulative total labor hours</th>
<th>Cumulative average labor hours per unit</th>
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</thead>
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<tr>
<td>1</td>
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<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
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<tr>
<td>4</td>
<td>64</td>
<td>314.21</td>
<td>78.55</td>
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</tbody>
</table>

- Cumulative average-time learning model predicts lower overall production time
- Why? Which model is preferable?
Learning Objective 8

Understand data problems encountered in estimating cost functions
Data Collection and Adjustment Issues

- The ideal database for cost estimation has two characteristics:
  - It contains numerous reliably measured observations of the cost driver(s) and the cost that is the dependent variable.
  - It considers many values for the cost driver that span a wide range.
Data Collection and Adjustment Issues

- Time periods do not match.
- Fixed costs are allocated as if they were variable.
- Data are either not available or not reliable.
- Inflation may play a role.
- Extreme values of observations occur from errors in recording costs.
- Analysts should adjust or eliminate unusual observations before estimating a cost relationship.
- There is no homogeneous relationship.
- The relationship between the cost driver and the cost is not stationary.
- The most difficult task in cost estimation is collecting high-quality, reliably measured data on the dependent variable and the cost driver(s).
True or False???

- When estimating a cost function, cost behavior is approximated by a nonlinear cost function within the relevant range.
- A high correlation in the relationship between two variables means that one variable must cause the other.
- The simplest method of quantitative analysis is the simple regression method.
- The high-low method involves using the highest cost driver activity, the lowest cost driver activity, the highest cost incurred, and the lowest cost incurred, even if the highest and lowest costs were not incurred at the highest and lowest cost driver activity levels.
- When looking at the costs incurred, allocated fixed costs should be treated as variable costs.
YEP uses the cumulative average-time learning model. If the YEP has a 90% learning curve and the one unit would take 10 hours to produce, what would be the cumulative total time needed if the firm produces 4 units?

- 29.16 hours
- 32.4 hours
- 36 hours
- 40 hours
The following observations are available for Sum-it, an accounting services firm, for its printing costs for the past 4 months.

If Sum-it uses the high-low method, what is the slope coefficient for the month for printing? What is the constant for the month for printing?

<table>
<thead>
<tr>
<th>Month</th>
<th>Pages</th>
<th>Printing Cost</th>
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<tbody>
<tr>
<td>April</td>
<td>8,000</td>
<td>2,800</td>
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<tr>
<td>May</td>
<td>10,000</td>
<td>3,100</td>
</tr>
<tr>
<td>June</td>
<td>7,500</td>
<td>2,600</td>
</tr>
<tr>
<td>July</td>
<td>9,000</td>
<td>2,900</td>
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