The Cost of Production

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Announcements

• We are only going to cover the first four sections of chapter 7 (really only up to page 236).
• Midterm on Thursday, February 23 in class. The exam will cover material through Thursday’s lecture.

Opportunity Costs

• *Opportunity cost* is the value of the next best alternative that is forgone when another alternative is chosen.
• So if a business firm must choose among a set of mutually exclusive alternatives, the opportunity cost of a particular alternative is the payoff associated with the best of the alternatives that are not chosen.
• The opportunity cost includes both explicit and implicit costs.
  – *explicit costs* are costs that involve a direct monetary outlay.
  – *implicit costs* are costs that do not involve an outlay of cash.
• Suppose you are the owner of an airline and are deciding whether to stay in business. The explicit costs of staying in business included the wages of the workers and payments for fuel. The implicit cost is the forgone income from leasing the jets you own.
• Does it matter whether you own or lease the jets? No. If you continue to operate the airline
  – and you own the jets, you forego the income from leasing them to someone else.
  – and you lease the jets from someone else, you must pay the leasing fees.
Either way, the cost of the jets is included in the cost of operating the firm.
Economic Costs versus Accounting Costs

- Accounting costs – the costs that appear on firm accounting statements
  - are explicit costs that have incurred in the past.
  - Since these costs are used to pay taxes and to assess the financial health of the firm to outsiders, the costs must be objectively verifiable.
  - Usually backward-looking
- Economic costs are the sum of the explicit and implicit opportunity costs.
  - Includes all the decision-relevant costs.
  - Usually forward-looking.
  - May not be objectively verifiable.

Sunk (Unavoidable) versus Nonsunk (Avoidable) Costs

- We want to distinguish between
  - sunk costs – costs that have already been incurred and cannot be recovered, and
  - nonsunk costs – costs that are incurred if a particular decision is made.
- When evaluating a decision, sunk costs should be ignored.
- Suppose you pay $9 to go to a movie.
- Ten minutes into it you realize it is painfully dull and will last another 2 hours.
- What is the cost of staying? Just your time. The $9 you paid to get into the movie is sunk. It is incurred whether you watch the or walk out.
- Prior to walking up to the ticket booth, the ticket price is a nonsunk cost. Once you buy the ticket, the cost is sunk. Timing matters.

Total, Fixed, and Variable Costs

- The book defines total costs (TC) as the total economic cost of production, consisting of fixed and variable costs. So what are fixed a variable costs?
- A fixed cost (FC) is a cost that does not vary with the level of output and that can be eliminated only by shutting down.
- A variable cost (VC) is a cost that varies with the level of output.
- The only way a firm can eliminate a fixed cost is by shutting down.
- So what are the cost of going to class?
  - Fixed costs – getting out of bed, getting dressed, walking to and from your dorm room to the classroom. You incur these costs whether class is 2 minutes long or 200 minutes long.
  - Variable costs – your time spent in lecture.

Fixed versus Sunk Costs

- In general, variable costs are nonsunk.
  - However fixed costs are not necessarily sunk. It depends on the timing.
  - In your decision to go to class, while you are lying in bed, the fixed costs to attending class are nonsunk.
  - Once you incur the fixed costs, they are sunk.
**Average and Marginal Costs**

- The marginal cost is the increase in cost resulting from the production of one extra unit of output.

\[ MC = \frac{\Delta TC}{\Delta q} \]

- Since fixed costs do not depend on the level of output, the marginal cost is the incremental increase in variable costs from producing one extra unit of output.

\[ MC = \frac{\Delta TC}{\Delta q} = \frac{\Delta VC}{\Delta q} \]

**Average Total Cost**

- Average total cost is the firm’s total cost divided by its level of output

\[ ATC = \frac{TC}{q} \]

- We can decompose average total cost into average fixed cost and average variable cost

\[ AFC = \frac{FC}{q} \]
\[ AVC = \frac{VC}{q} \]

- In the short-run at least one of the firm’s input quantities cannot be changed (and its associated costs are fixed).
- In the very long-run all costs are variable.

**Cost in the Short Run**

- Diminishing marginal returns imply increasing marginal costs at some point.
- Assume labor is the only input. So to produce more output, the firm must hire more labor.

\[ MC = \frac{\Delta TC}{\Delta q} = \frac{\Delta VC}{\Delta q} \]

- Recall

\[ MPL = \frac{\Delta q}{\Delta L} \]

- So

\[ MC = \frac{w}{MPL} \]

As the firm increase output, it hires more workers. Since each additional work is less productive than the previous one, the marginal product of labor decreases and the marginal cost increases.
Total cost is the vertical sum of the fixed cost and the variable cost.

Marginal cost is slope of total cost curve as well as the slope of the variable cost curve.

Marginal cost crosses the average variable cost curve and average total cost curve at their minimum points.

The average total cost curve is initially downward sloping as the fixed cost is spread out over more units of output. But eventually this effect is dominated by rising average variable costs as diminishing returns (and rising marginal costs) kick in.

For a U-shaped total cost curve, average total cost is at the bottom of the U.

We call the quantity that corresponds to the minimum average total cost, the minimum efficient scale.

- At the minimum efficient scale, average total cost equals marginal cost.
- When the firm operates below its MES, marginal cost is less than average total cost, and average total cost is falling.
- When the firm operates above its MES, marginal cost is greater than average total cost, and average total cost is rising.

The Short-Run Costs of Automobile Assembly

- Automobile assembly plants rarely change the speed of the line (the rate of production), the number of shifts run.
- If the open for the week, they rarely operate fewer than 5 days a week.
- They also use overtime quite often and the shutdown for week at time quite frequently.
- Consider a single assembly plant.
- Firm wishes to minimize costs for a given level of output.
- Weekly production function is linear:
  cars per week = days open per week x shifts per day x hours per shift x cars per

While the production function is linear, the firm faces a peculiar cost function due to its labor contract.

- Workers on the second (evening) shift receive a 5 percent premium.
- Any work in excess of eight hours in a day and all Saturday work is paid at a rate of time and an half.
- Employees working fewer than 40 hours per week must be paid 85 percent of their hourly wage times the difference between 40 and the number of hours worked.
- This “short-week compensation” is in addition to the wages the worker receives for the hours s/he actually worked.
Cost in the Long Run

- In the long-run the firm can change all of its inputs.
- We will focus on two costs: labor cost and capital costs.

The User Cost of Capital

- The user cost of capital is cost of owning and using a capital asset. It is equal to the sum of the economic depreciation and the forgone interest.
- What is a capital asset? An assets is something that maintain value over time. A capital asset is either a structure (e.g. a building, a house) or equipment (e.g. machines, furniture).
- So consider Yale’s decision to buy an AV system. Let’s say it cost $20,000.
- What is Yale’s annual cost of using this capital?

Yale incurs two costs.

1. The value of the this AV system falls or depreciates each year for two reasons.
   (a) The more the AV system is used, the more it wears out.
   (b) As it gets older, the equipment becomes out of date.
2. Yale could have invested the $20,000 used to purchase the AV system and received the interest income of Interest rate \times $20,000 each year. This is the opportunity cost of buying the AV system.

- So

User cost of capital = Economic Depreciation + (Interest Rate) \times (Value of Capital)

- We often divide both sides of this equation by the value of capital to express the user cost of capital as a rate per dollar of capital

\[ r = \text{Depreciation rate} + (\text{Interest Rate}) \]

- We often assume capital depreciates at a rate of 7.5 percent per year. The rate is higher for computers, lower for buildings.

Cost Minimization

- Suppose the firm want to produced a given level of output. It wants to find the quantities of capital and labor that produce this much output at the minimum cost.
- Assume the pool of workers is large enough and the firm is small enough that anything the firm does will not affect the going wage rate. Let’s say that the firm take the going wage rate \( w \) as given.
- Let’s assume the firm rents its capital (i.e. its office space, computers, machines, ...) at the user cost of capital \( r \).
  - The owner of the capital will need to be compensated for the rate of return she could have earned investing her money elsewhere and for the depreciation of her capital.
- So we write the total cost as

\[ C = w \times L + r \times K \]
• We can write this as an isocost line
  \[ K = \frac{C}{r} - \left(\frac{w}{r}\right)L \]
  An isocost line is the set of combinations of labor and capital that yield the same total cost to the firm.
• The slope of each one of these isocost lines is \(-\frac{w}{r}\). That is, if the firm gave up one unit of labor (and thus saved \(w\) dollars in cost) to rent \(\frac{w}{r}\) unit of capital at a cost of \(r\) dollars per unit, its total cost of production would remain unchanged.
• Suppose the firm wishes to produce \(q_1\) of output. What is the cost minimizing combination of capital and labor?
• Add an isoquant for \(q_1\)
• Figure 7.3

\[ \text{slope of isoquant} = \text{slope of isocost line} \]
\[ -\frac{MRTS}{w} = -\frac{w}{r} \]
\[ \frac{MPL}{MPK} = \frac{w}{r} \]

\(\text{ratio of marginal products} = \text{ratio of input prices}\)

• We can rewrite this optimality condition as:
\[ \frac{MPL}{w} = \frac{MPK}{r} \]

• This condition tells us that at the cost minimizing input combination, the additional output per dollar spent on labor equals the additional output per dollar spent on capital. Thus the firm is getting equal “bang for the buck” from each input.

Changes in Input Prices

• Suppose we increase the price of one of the two inputs.
• Isoquant stays fixed.
• Slope of the isocost curve changes and total cost changes.
• Firm substitutes away from the more now relatively more expensive input.
• Figure 7.4

• To see why this must be, consider a non-cost-minimizing point such that the slope of the isoquant is more negative than the slope of the isocost line. Therefore:
\[ \frac{MPL}{MPK} < -\frac{w}{r} \]
and thus
\[ \frac{MPL}{w} > \frac{MPK}{r} \]
This condition implies that a firm operating at this point could spend an additional dollar on labor and save more than one dollar by reducing capital and still keep output constant. Since this would reduce total cost, it cannot be an cost-minimizing.
Changes in Output

- Plot the firm’s expansion path and the long-run (fully flexible) cost curve.
- Figure 7.6
- In the short run we assume at least one factor is fixed cost so the short-run expansion path is either horizontal or vertical. (We usually assume capital is fixed and labor is variable in the short run)
- Figure 7.7

Long-Run versus Short Run Average Cost Curves

- Short-run average cost curve relates average cost of production to output when the level of capital is fixed.
- Of course, over time all costs become variable.
- The long run average cost curve (LAC) relates average cost of production to output when all inputs, including capital are variable.
- Consider three cases:
  1. Increasing returns to scale: In this case a doubling of the inputs leads to a more than doubling of output. If the prices of capital and labor (i.e. user cost of capital and wages) do not depend on the size of the firm, then average cost must be decreasing with output.
  2. Constant returns to scale: In this case a doubling of the inputs leads to exactly a doubling of output. In this case, average cost must be independent of the level of output.
  3. Decreasing returns to scale: In this case a doubling of the inputs leads to a less than doubling of output. In this case, average cost must be increasing with output.

- The long-run marginal cost curve (LMC) can be determined from the long-run average cost curve.
  - When
    $$ LMC < LAC $$  LAC is decreasing
  - When
    $$ LMC > LAC $$  LAC is increasing