CHAPTER SEVEN
THE THEORY AND ESTIMATION OF COST

✧ The production decision has to be based not only on the capacity to produce (the production function) but also on the costs of production (the cost function).
✧ Firms seeking profit maximization are concerned with both the short run and long run cost-output relationship.
✧ Understanding the short run cost-output relationship is essential for making decisions concerning the efficient use of variable input and the optimal output level.
✧ The long run cost-output relationship is important for decisions concerning choosing the right size of the firm, and new investments in the long run.

RELEVANT AND IRRELEVANT COSTS:
✧ A cost is considered to be relevant if it is affected by management decision.
✧ Costs that are independent of the firm decision or the firm has to bear irrespective of its decision are called irrelevant costs.
✧ The following are some examples of relevant and irrelevant costs.

Historical Versus Replacement Cost:
✧ **Historical cost** means the original monetary value or price of an economic item.
✧ **Replacement cost** refers to the current amount that an entity would have to pay, at the present time, to replace any one of its assets.
Suppose a construction firm has 50,000 tons of regular walls paint, which the firm has purchased five years ago at BD 25,000. A breakthrough in chemical industries has introduced “Super Paint”, a better quality washable paint that favored the regular paint especially in schools and public buildings. As a result, the current market value of the firm inventories of regular paints fell to BD 10,000.

If the firm wants to estimate its expected profits from a new project of a 10 stories office building in Manama, in which it can make use of its stock of regular paints, the relevant cost here is the replacement cost of BD 10,000, not the historical one, only because what is relevant is the opportunity cost of the input, which is the value of the input in its next alternative uses. The next alternative use of these quantities of the regular paints is to sell it in the market for BD 10,000, and if the firm decides to buy the regular paints from the market, it will only pay 10,000 for that quantity.

Opportunity Cost, Explicit and Implicit Costs:

- Every choice or decision by the firm involves giving up some other alternative, the opportunity cost.
- **Opportunity cost** is the best alternatives forgone or sacrificed in choosing one activity over the next best alternative.
- Opportunity cost highlights the consequences of making choices under conditions of scarcity. This allows division of cost into:
- **Explicit cost** (out of pocket cost): Monetary payments made to factors of production. These payments could have been spent on something else. When the firm buys an input from the market, it has to pay the price required to attract the quantity it buys from other alternative buyers or uses.
- **Implicit costs**: The value of resources used in production even though they have not received any direct monetary payments. Implicit costs are incurred when:
o Firm uses its own capital resources, which consists of
  a. Implicit rental rate of Capital: rental income forgone is the firm’s opportunity cost of using its own capital.
  b. Interest forgone: could also have used the funds used to purchase capital for another purpose, so return that they would have earned is also an opportunity cost.
  c. Economic depreciation: change in market value of capital over a given period (NOT based on tax or accounting standard rules)

o Firm uses owner’s time or financial resources: firm owner may provide entrepreneurial ability and labor services, which he could have used elsewhere. This consists of:
  a. Normal profit is the average return that an entrepreneur could obtain from running another business.
  b. Wages forgone: opportunity cost of owner’s labor = wage income they could have earned in their next best alternative job.

✧ Economic cost of production is the value of all resources used in producing a good or a service whether those resources receive monetary payments or not.

✧ In our previous example, as the firm uses its own stock of regular paints in its new project it will bear an implicit cost of BD 10,000 or the opportunity cost of using its inventory instead of selling it on the market. Suppose the firm needs an additional BD 20,000 worth of Super Paint, the firm will pay for this paints its opportunity cost of BD 20,000 to bid it away from other users, and that is the explicit cost. To sum, the total opportunity cost (economic cost) of the required paints is BD 30,000: BD 10,000 of implicit cost of paints owned by the firm and BD 20,000 of explicit or direct payment to suppliers of paints bought from the market.

✧ Economic profit is the profit over and above normal profit.
Incremental Cost versus Sunk Cost:

- **Incremental cost** is the cost that is affected by a current decision.
- It is measured by the change in cost relative to the change in a particular activity (e.g., construction of a new building, entry into the market with a new product, development of new software etc.)
- In decision-making, economists are concerned only with additional or incremental costs attributed to the decision.
- The difference between incremental cost and MC: incremental cost is $\Delta TVC$, while marginal cost is $\Delta TVC/\Delta Q$.
- **Sunk Cost** is the cost that incurred in the past and is not affected by a current decision. (except for purposes of taxes and possibly for the “full-cost” pricing of a product)
- In the previous example (of the regular paints), the difference between the opportunity cost of the paint and its historical value (BD 25,000 – BD 10,000) is a cost of BD 15,000 that the decision to use the paint or to sell it has nothing to do with it.

- In conclusion,
  - Sunk cost is not considered relevant because it is incurred in the past and therefore not affected by a current decision.
  - In the short run, fixed cost is also not considered to be relevant because a firm cannot change this amount regardless of its level of production or business activity.
  - In contrast, incremental cost, marginal cost, and variable cost are considered to be relevant because they are affected by a current decision.
THE SHORT RUN COST FUNCTION

- In the last chapter, we introduced three measures of production, TP, MP, and AP; here too, we are going to discuss the costs of production in short run:
- The main assumptions of the cost functions’ model are:
  1. The firm operates in a short run production function where labor is variable, capital is fixed.
  2. The firms operate at a given level of technology
  3. The firm operates efficiently at every level of output
  4. The firm operates in a perfectly competitive input and output markets. It is a “price taker” in the input markets.
  5. The firm’s production function is affected by the law of diminishing returns
- We describe the way a firm’s costs change as total product changes by using three cost concepts and three types of cost curve: total cost, marginal cost, and average cost

Total Cost

- **Total Cost** refers to the market value of all the resources used to produce a good or service.
- Since, in short run, some inputs are variable and some are fixed. Total cost contains both fixed cost and variable costs.
- **Fixed Costs** are the costs of production that do not change when the rate of output is altered, e.g., the cost of basic plant and equipment.
- Fixed costs cannot be avoided in the short run.
- **Variable Costs** are the costs of production that change when the rate of output is altered, e.g., labor and material costs.
- In short run, changes in total costs and marginal costs will result only from changes in variable costs
✧ In the short run, when output equals zero, total cost is equal to fixed cost (since variable cost equals zero)
✧ Therefore, in short run:

\[ \text{TC} = \text{TFC} + \text{TVC} \]

- TFC is a horizontal straight line since it does not change with output
- TC and TVC initially increase at a decreasing rate then eventually increase at an increasing rate
✧ The table below presents imaginary figures representing the relationship between production and cost in the short run assuming labor as the only variable input.
✧ As a matter of convenience, we have considered unit changes in output over the range of production ⇒ \( \Delta Q \) will always be equal to 1

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The Marginal Cost and the Average Cost Curves

We can derive per unit costs and marginal cost from total costs as the following

\[
MC = \frac{\Delta TC}{\Delta Q} = \frac{\Delta TC}{\Delta Q} = \frac{\Delta TVC}{\Delta Q}
\]

and

\[
TC = TFC + TVC
\]

\[
\frac{TC}{Q} = \frac{TFC}{Q} + \frac{TVC}{Q}
\]

\[
ATC = AFC + AVC
\]

Table 7.1 also presents marginal cost, and per unit costs which can be converted to a graphical presentation representing the averages and marginal cost curves and the relationship among them in the following figure.
From table 7.1 and the figure 7.2 we can reach to the following important economic relations.

- **Falling AFC**: As the rate of output increases, AFC decreases as the fixed cost is spread over more output. Note that AFC decreases at a decreasing rate. It approaches the X-axis but never equals to zero.

- **ATC, AVC and MC initially decrease with the increase in the output level, they reach the minimum and then start to increase**

- **ATC curve is always above AVC; the vertical distance between them is AFC. This vertical distance becomes narrower as output increases since AFC decreases**

- **Rising AVC and ATC**: As the rate of output increases, each unit of labor has less capital and land to work with. ⇒ AVC will eventually rise. AVC rises because of diminishing returns in the production process. In our example, AVC declines, reaches a minimum at 3 units of output, and then starts to increase.
In our example, ATC behaves in a similar fashion but reaches its minimum at 5 units of output.

**U-Shaped ATC**: The initial dominance of falling AFC, combined with the later resurgence of rising AVC, is what gives the ATC curve its characteristic U shape.

- Initially: \( \downarrow \text{AFC} \& \downarrow \text{AVC} \Rightarrow \text{ATC}\downarrow \),
- Later: \( \downarrow \text{AFC} > \uparrow \text{AVC} \Rightarrow \text{ATC}\downarrow \),
- Eventually: \( \downarrow \text{AFC} < \uparrow \text{AVC} \Rightarrow \text{ATC}\uparrow \)

Thus, The U-shape of the average cost curve arises from the influence of two forces:

1. Spreading total fixed cost over a larger output.
2. Increasing diminishing returns to variable inputs in the short run.

**Minimum Average Cost**: The bottom of the “U” is important as it represents the minimum average total costs.

- It represents the lowest possible opportunity costs to produce the product.
- However, the goal of producers is to maximize profit and that might not happen at this point.

**MC and ATC (and AVC) Curves**:

- MC starts below both ATC and AVC, but rises faster than both of them.
- In our example, MC declines, reaches the minimum at 2 and then starts to increase at 3 units of output.
- With regard to the relationship between MC and ATC (and AVC) we can reach the following conclusions:
  - The marginal cost curve intersects both the ATC curve and the AVC curve from below at their minimum points.
The marginal cost curve gives ATC and AVC their U-shape

- If MC < ATC, ATC is decreasing,
- If MC > ATC, ATC is increasing.
- If MC = ATC, ATC at minimum

Same thing is applied to AVC

- If MC < AVC, AVC is decreasing.
- If MC > AVC, AVC is increasing,
- If MC = AVC, AVC at minimum

**Shifts in the Cost curves:**

- The location of the firms short run cost curves will change only when things other than the output level changes especially the state of technology and the price of variable inputs.

**Technology Effect:**

- At a given level of input prices, if the firm uses a better technology that improves productivity, total product increases at each level of the variable input (shifts the TP curve upward). As a result, AVC shifts downward showing a lower per unit variable cost.
- Meanwhile, investment in new technology is an addition to total fixed cost of production that would show as an upward shift of the AFC. Therefore, the net effect of the acquisition of new cost saving on ATC depends on the level of output. At low level of output, the increase in AFC would be relatively more effective causing ATC to shift upward, while at high level of output the decrease in AVC would be relatively more effective, causing ATC to shift downward.
Input Price Effect:

- Changes in input prices have a direct effect on the cost of production, depending on the share of the input in the total cost of production. It also depends on which input prices are changed.
- A rise in the fixed cost items (rent, insurance, interest,..) would shift the AFC and the ATC curves upward leaving the AVC and the MC curves unchanged. While an increase in the price of a variable input (wages, price of: raw materials, energy, spare parts,..) would cause AVC, MC, and ATC, to shift upward leaving AFC curve unchanged.

USING CALCULS

- The general form of the short run production function is: \( TC = F(Q) \)
- There are three specific forms of this function are used in economic analysis: the cubic, the quadratic, and the linear.
- **Cubic function:** \( TC = 100 +60Q – 3Q^2 + 0.1Q^3 \)
  As output increases, total cost first increases at a decreasing rate, then increases at an increasing rate.
- **Quadratic relationship:** \( TC = 100 +60Q + 3Q^2 \)
  As output increases, total cost increases at an increasing rate. The quadratic form of the total cost function implies that only the law of diminishing returns affects the short run relationship between a firm’s output and its variable input.
- **Linear relationship:** \( TC = 100 +60Q \)
  As output increases, total cost increases at a constant rate. The linear form indicates that neither increasing nor diminishing returns to a factor take place in the short run as the firm uses additional units of its variable input.
Microeconomic theory relies mainly on cubic equation because it encompasses the possibility of increasing returns to a factor as well as diminishing returns.

Example:
Consider the following equation: \( TC = 100 + 60Q - 5Q^2 + 0.7Q^3 \)
1. This is a short run cost function with a TFC = 100, when \( Q = 0 \)
2. \( TVC = TC - TFC = 60Q - 5Q^2 + 0.7Q^3 \)
3. \( AFC = \frac{TFC}{Q} = \frac{100}{Q} \)
4. \( AVC = \frac{TVC}{Q} = 60 - 5Q + 0.7Q^2 \)
5. \( ATC = \frac{TC}{Q} = \frac{100}{Q} + 60 - 5Q + 0.7Q^2 \)
6. \( MC = \frac{dTC}{dQ} = 60 - 10Q + 2.1Q^2 \)
7. The range of \( Q \) for stage I is from \( Q = 0 \) to \( Q \) at maximum AP or minimum AVC. Differentiate \( AVC \), then set the result equal to zero and solve for \( Q \)
   \( AVC = 60 - 5Q + 0.7Q^2 \)
   \( \frac{dAVC}{dQ} = -5 + 1.4Q = 0 \)
   \( \Rightarrow Q^* = \frac{5}{1.4} = 3.57 \)
8. Diminishing returns starts when MP reaches its maximum or when \( MC \) reaches its minimum. Differentiate \( MC \), then set the result equal to zero and solve for \( Q \)
   \( MC = 60 - 10Q + 2.1Q^2 \)
   \( \frac{dMC}{dQ} = -10 + 4.2Q = 0 \Rightarrow Q^* = \frac{10}{4.2} = 2.38 \)
   Diminishing returns occur at \( Q = 2.38 \) (Min MC)
THE RELATIONSHIP BETWEEN PRODUCTION AND COST:

- The **cost of production** is the total value of all inputs used in the production of a specific good or service.
- It is easy to see the direct link between the cost function and the production function.
- Actually, one can say that the **cost function** used in economic analysis is simply the production function expressed in monetary rather than physical units.

The SR Relationship between MP and MC:

- The relationship between diminishing returns and increasing marginal cost can be illustrated algebraically.
- First, assume the variable input is the labor (L) and its unit cost is some given wage rate (W)

\[ MC = \frac{\Delta TVC}{\Delta Q} \]  

(1)

Since \( TVC = WL \), we can say that

\[ \Delta TVC = \Delta L \times W \]  

(2)

Substituting (2) in (1) gives us

\[ MC = \frac{\Delta L \times W}{\Delta Q} = \frac{\Delta L}{\Delta Q} \times W \]  

(3)

Recalling the definition of MP, we know that

\[ MP_L = \frac{\Delta Q}{\Delta L} \implies \]

\[ MC = \frac{1}{MP} \times W = \frac{W}{MP} \]  

(4)

- Equation (4) tells us that, assuming a constant wage rate,
  - When MP is rising, MC is falling
  - When MP is falling, MC is rising
  - When MP is at its maximum, MC is at its minimum
In economic theory, the relationship between diminishing returns and MC represents a key link between a firm’s SR production function and its SR cost function because it is the law of diminishing returns that gives the SR cost function its nonlinear form. All other costs are constructed according to this non-linearity.

The SR Relationship between AP and AVC:

- TVC is a mirror image of the TP curve
- When TP increases at increasing rate, TVC increases at decreasing rate
- When TP increases at decreasing rate, TVC increases at increasing rate
- Using the above-mentioned assumptions, the average total cost (ATC) may be written as follows:
  \[ \text{AVC} = \frac{\text{TVC}}{\text{TP}} = W \times \frac{L}{TP} = W \times \frac{1}{\text{AP}_L}, \]
- Then, the AVC is negatively related to the \( \text{AP}_L \). The AVC curve is expected to have a mirror image of the \( \text{AP}_L \) curve.
  - When \( \text{AP} \) is rising, \( \text{AVC} \) is falling
  - When \( \text{AP} \) is falling, \( \text{AVC} \) is rising
  - When \( \text{AP} \) is at its maximum, \( \text{AVC} \) is at its minimum
- Again, remember that the marginal cost leads the average cost, which means that the average cost will be falling as long as the marginal cost is less than the average cost, and will be rising when the marginal cost exceeds it.
- The following figure shows the relationship between the production curves and the cost curves in the short run with labor as the only variable input.
- The MC falls first to reach its minimum at \( \text{TP}_1 \) when the \( \text{MP}_L \) reaches its maximum, then the MC starts to rise from there on.
- Notice that the MC curve intersects the AVC curve at the latter minimum point where MC = AVC.
Also, notice that the relevant stage of production starts from the minimum point on the AVC curve.

Figure 7.1
THE LONG RUN COST FUNCTION

✧ In the long-run, all inputs are variable, the firm has enough time to change its labor as well as its capital input or to choose the production capacity that suite its product market demand.

✧ Because there are no fixed inputs, there are no fixed costs. All costs of production are variable in the long run.

✧ Since there is no fixed cost in the LR, the firm would incur no cost if it chooses not to produce any output.

✧ The table bellow presents LR production function or the relationship between the firm out put and different levels of its inputs: labor and capital.

<table>
<thead>
<tr>
<th>Production per day</th>
<th>Labor</th>
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<th>Plant2</th>
<th>Plant3</th>
<th>Plant4</th>
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</tbody>
</table>

✧ Notice how the MP_L eventually diminish as more workers are used with any fixed number of machines in each column. It is also true that MP_K diminishes as more labor are used with a fixed amount of capital in each raw.

✧ Recall from chapter 6 that LR production function may show IRTS, CRTS or DRTS. This implies that the firm will have decreasing cost when it has IRTS, and increasing cost when it has DRTS.

✧ Note that
  
  o SRMC is U-shaped because it is affected by diminishing returns to the variable input.
  
  o LRMC is U-shaped because of returns to scale (size)
In Figure 7.3 below, notice that:

1. In the short run (holding plant size fixed), each plant would have its U shaped ATC curve.
2. The larger the plant size is, the greater would be the output level at which average total cost reaches its minimum, and the lower would be the minimum ATC. That is because as the size of the plant increases, total fixed cost (cost of fixed assets) increases too, causing the range of production over which ATC declines to be longer. In other words, ATC of large size firms would be falling over a long range of its output than the case of smaller size firms. This fact allows large size firms to enjoy natural monopoly power, where it can always force smaller firms out of the market by selling at a price level lower than their minimum average cost, as you will learn in latter chapters.

Long Run Average Cost (LRAC)

- The long run average cost curve represents the long run relationship between the level of output and the minimum possible cost of production, when all inputs can be changed.
- The long run average cost curve is the envelope that contains the short run average cost curves.
- LRAC is constructed from the lowest attainable SR ATCs at each level of output.
- Notice here that points on the LRATC curve represent the lowest cost per unit at any level of output.
- The long-run average cost curve is a planning curve that tells the firm the plant size that minimizes the cost of producing a given output range.
- Once the firm has chosen that plant size, it incurs the costs that correspond to the ATC curve for that plant.
If we have a large number SRATC of different sizes of firms in the above graph, the resulted LRAC curve would have been a smooth U shaped curve quite similar to the SRATC curve introduced in the previous section.

However, the reason for the resulted U shaped LRAC curve is completely different from that of SRATC curve. In the long run, the U shaped LRAC is determined by the interaction of two opposing forces:

1. Productivity improvement through inputs specialization in large plant sizes, which pull average costs down, by generating economies of scale.
2. Managerial difficulties or inefficiencies associated with the growing size of the firm, including difficulty of monitoring and controlling production, wastes, and problems of communication between managers at different levels and divisions of the firm, which work together to generate diseconomies of scale, pushing LRAC upward.

Therefore, the LRAC is U-shaped because of returns to scale

- If LRAC decreases as output increases, the firm experiences **economies of scale (size)**
- If LRAC increases as output increases, the firm experiences **diseconomies of scale (size)**
- If LRAC remains constant as output increases, the firm experiences constant returns to scale

- Note also that
  - When LRMC < LRAC ⇒ economies of scale
  - When LRMC > LRAC ⇒ diseconomies of scale
  - This implies that LRMC intersects LRAC at its minimum from below

**Economies of Scale (IRTS):**

- Economies of scale refer to situation where a firm’s long-run average cost (LRAC) declines as output increases.

- If the firm experiences increasing return to scale in production, that implies a proportional increase in all input would lead to more than proportional increase in output.

- Economies of scale can be explained on base of productivity improvement attainable in large size firms through specialization of labor and capital (more specialized tools and machines and less of general ones), which dominates the negative effects of managerial difficulties associated with the growing size of the firm.
Constant Return to Scale:

✧ As production continues to expand and the firm experiences constant returns to scale in production, its LRAC would be at its minimum and the curve would have a horizontal segment with the average cost unaffected by the change in output over a certain range of production.

✧ In this phase, the positive impact of specialization is exactly equal to the negative effect of the managerial difficulties, or in other words, the two forces are offsetting each other.

Diseconomies of Scale (DRTS):

✧ The LATC would eventually start to rise or become positively sloped in the last phase, when the firm experiences decreasing return to scale in production.

✧ In this phase and as the firm size increases above its optimal size, the negative effect of the managerial difficulties of the growing size of the firm will dominate the positive impact of productivity improvements through specialization of input. The firm is said to experience diseconomies of scale.
Minimum efficient scale is the smallest quantity of output at which the long-run average cost reaches its lowest level.

Possible reasons for economies of scale:

1. Product-Specific Economies:
   a. large output allow greater specialization in the use of labor and capital which increases productivity and overcomes the negative effects of managerial difficulties associated with the growing size of the firm
   b. Indivisible nature of many types of capital equipment
   c. Learning –curve effect, as workers learn, the additional inputs required to produce additional output decreases.

2. Price of the Input: Large firms may be able to obtain discounts on raw materials (discount from bulk purchases). It might be able to buy more cost-effective machinery or use advanced technology, which cannot be used with small plants.

3. Financial Economies: Large firms are often able to obtain funds at cheaper cost than small firms do. (lower cost of raising funds)

4. Marketing Economies: Larger the output allows spreading of marketing and advertisement costs (spreading of promotional and research & development costs)

5. Management Economies: Larger firms can rely on specialized in-house talents rather than hiring more expensive outsider consultants.

6. Economies of Scope: Reduction of a firm’s unit cost by producing two or more goods or services jointly rather than separately. It is closely related to economies of scale.

The recently growing trend of acquisitions and merges by multinational enterprises is motivated largely by the expected privileges or advantages of economies of scale.
Possible reasons for diseconomies of scale:

1. **Transportation Diseconomies:** Disproportionate rise in transportation costs which include not only delivery of good, but also handling, insurance, security and inventory costs.

2. **Input market imperfections:** Large firms may affect the demand for inputs increasing its prices. It may not be able to hire all its labor locally, Disproportionate rise in staff and indirect labor.

3. **Management coordination and control problems:** The larger the plant size the more difficult to effectively manage it.

**The Learning Curve (Reading)**

- **Learning Curve:** is line showing the relationship between labor cost and additional units of output.
- Learning curve has a downward sloping curve indicates additional cost per unit declines as the level of output increases because workers improve with practice.
- Learning curve is measured in terms of percentage decrease in additional labor cost as output doubles.

\[ Y_x = Kx^n \]

- \( Y_x \) = Units of factor or cost to produce the \( X^{th} \) unit
- \( K \) = Factor units or cost to produce the \( K^{th} \) (usually first) unit
- \( x \) = Product unit (the \( x^{th} \) unit)
- \( n = \log S/\log 2 \)
- \( S \) = Slope parameter
Supply Chain Management (Reading)

- **Supply Chain Management (SCM):** refers to efforts by a firm to improve efficiencies through each link of a firm’s supply chain from supplier to customer.
- It includes all internal and external activities required to fulfill a customer’s demand.
- **Transaction costs** are incurred by using resources outside the firm.
- **Coordination costs** arise because of uncertainty and complexity of tasks.
- **Information costs** arise because information is essential to the proper coordination of activities between the firm and its suppliers.
- Ways to develop better supplier relationships
  - **Strategic alliance:** firm and outside supplier join together in some sharing of resources.
  - **Competitive tension:** firm uses two or more suppliers, thereby helping the firm keep its purchase prices under control

Ways Companies Have Cut Costs to Remain Competitive (Reading)

- The Strategic Use of Cost
- Reduction in Cost of Materials
- Using Information Technology to Reduce Costs
- Reduction of Process Costs
- Relocation to Lower-Wage Countries or Regions
- Mergers, Consolidation, and Subsequent Downsizing
- Layoffs and Plant Closings