Unit III

Syllabus

Nature and types of cost, cost function – short run and long run, Economies, and diseconomies of scale.

Market structure and degree of competition, perfect competition, monopoly, monopolistic competition, oligopoly.

Types and nature of cost

1. **Opportunity (or economic) cost and accounting cost**
   The opportunity (or economic) cost of any decision is the value of the next best alternative that must be forgone. For example, the opportunity cost of buying a consumer product is not the amount of money paid but the dinner that was forgone. The opportunity cost of hiring an additional mathematics faculty is the forgone hiring of an additional clerk in the accounts department. The cost of adding another soldier in the army is not just the expense on that soldier and his salary but the forgone output that he could produce as a civilian. *The accounting costs to a firm are just the actual expenditures or explicit costs incurred to purchase or rent the inputs.* They are important for financial reports and tax purposes. But for managerial decision making based on cost benefit analysis, it is the economic costs that are relevant.
2. **Explicit cost and Implicit cost**
   Explicit costs are the actual payments of the firm to hire, rent or purchase the inputs required in production. These include the wages of hired labor, the rental price of capital, equipment and buildings, and the purchase price of raw materials and intermediate products. Implicit costs on the other hand refer to the value of forgone opportunities even when there is no actual payment. For example, consider a GTBIT pass out who decides to set up an office in one of the floors of his own house. He hires three employees at 2 lakhs rupees per month, furniture and equipment costing another 3 lakhs. His explicit costs are 5 lakhs at the end of the first month for starting up a business but there are implicit costs as well. First is the monthly rent forgone of that one floor of the house and second is the monthly salary forgone by not joining the placement job, and the interest or other return that could be earned in a month from investing 5 lakhs in most rewarding alternative. The implicit costs need to be added to explicit costs to arrive at the true extent of costs.
3. **Marginal cost, incremental cost, and sunk cost**
   Marginal cost refers to the addition in total cost because of producing one additional unit of output. Incremental cost refers to additional total cost because of implementing a particular management decision. For example, the cost of introducing a new product line, the cost of a new advertising campaign, the cost of acquiring a major competitor etc. Thus,

marginal cost is just a specific type incremental cost of taking a managerial decision of adding one unit of output. Sunk costs are the cost that must be made independent of the what decisions you make. In other word, they are irrelevant while making new decisions. These are the costs that cannot be recovered or reduced irrespective of choice in decisions. For example, for a firm, the costs of advertising will be sunk independent of whether it operates or shuts down.

4. **Fixed cost and variable cost**
   Fixed costs are incurred regardless of the level of output produced while variable costs change based on the level of output produced. Usually, the expenditure on buildings and machinery are fixed in nature while the expenditure on raw materials and labor are variable. The firm will have to pay the rent and interest payments if it stops production for some time but it need not hire any labor or buy raw materials during that time.
5. **Long run cost and short run cost**
   In the theory of production, the short run is the time horizon in which some input usually capital is available fixed quantity whereas the long run is the time horizon in which are inputs can be varied in any quantity. In the short run, capital is a fixed input while labor is variable input. In the long run, both labor and capital are variable input.
   The short run total cost of producing a given level of output Q to a firm is the minimum cost of producing that level of output with some fixed capital $\bar{K}$. The long run total cost of producing Q is the minimum cost of producing Q using any factor combination of labor and capital that is allowed by production technology (also called production function).

Before we discuss the short run and long run costs, let us discuss production a little bit. A firm produces some product using a technology blueprint known as production function. The quantity of output of product is denoted by Q, the quantity of input of labor by L and the quantity of input of capital (machinery) by K. The **production function** relates every possible combination or pair of quantities of labor and capital with the maximum level of output that can be produced using that pair. Mathematically, a production function is written as

$$Q = f\left(K, L\right)$$

Many specific forms of this production function are possible. For example, $Q = K + L$ or $Q = K^{1/2} L^{1/2}$ or $Q = K^2 L^3$.

But what is common in all these forms is the idea of substitution between the two inputs or factors. For example, in $Q = K + L$, 2 units of outputs can be produced using either (1,1) or (0,2) or (2,0) of input combination where the first number in the ordered pair is the quantity of labor and second number is the quantity of capital. Similarly, in $Q = K^{1/2} L^{1/2}$. 2 units of outputs can be produced using (4,1), (2,2) and (1,4) input combinations. Note that to produce the same output, if you reduce the use of one input then you need to increase the use of the other input.

The last two production functions given above in the multiplicative form are special cases of a function known as **Cobb-Douglas production function**. In general form, it is written as

$$Q = c\,K^{\alpha}L^{\beta}$$

Where $c > 0,\ \alpha > 0,\ \beta > 0$ are constants.

Any production function can be represented in the input space (L, K), as an **isoquant map**. An isoquant is a curve that combines all (L, K) combinations that produce same (iso) level of quantity (quant) of output. This is analogous to indifference curve of a consumer in commodity space. Example in Figure 1.

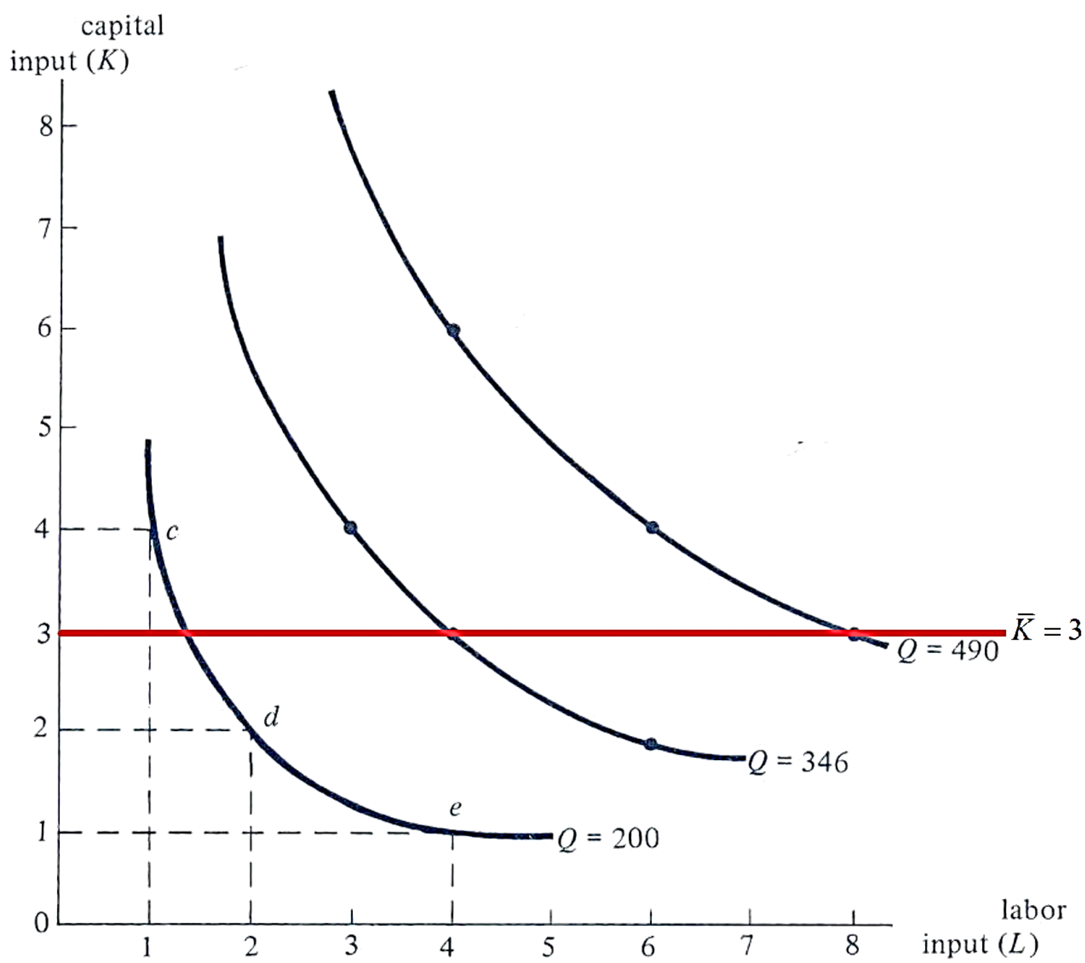


Figure 1

In the above isoquant map, Q=200 can be produced with (1,4), (2,2) and (1,4) input combinations. Ignore the red line for a while.

The slope of the isoquant is known as **marginal rate of technical substitution (MRTS)** and is equal to $-\frac{dK}{dL}$, negative of the amount of capital given up to substitute one more unit of labor, while producing same output.

In the short run, capital is fixed at some level $\bar{K}=3$ and any output can be produced using only factor combination that lies along the red line. If we plot the output on vertical against labor on horizontal axis then we get something called the **total product (TP) of labor** as shown in Figure 2.

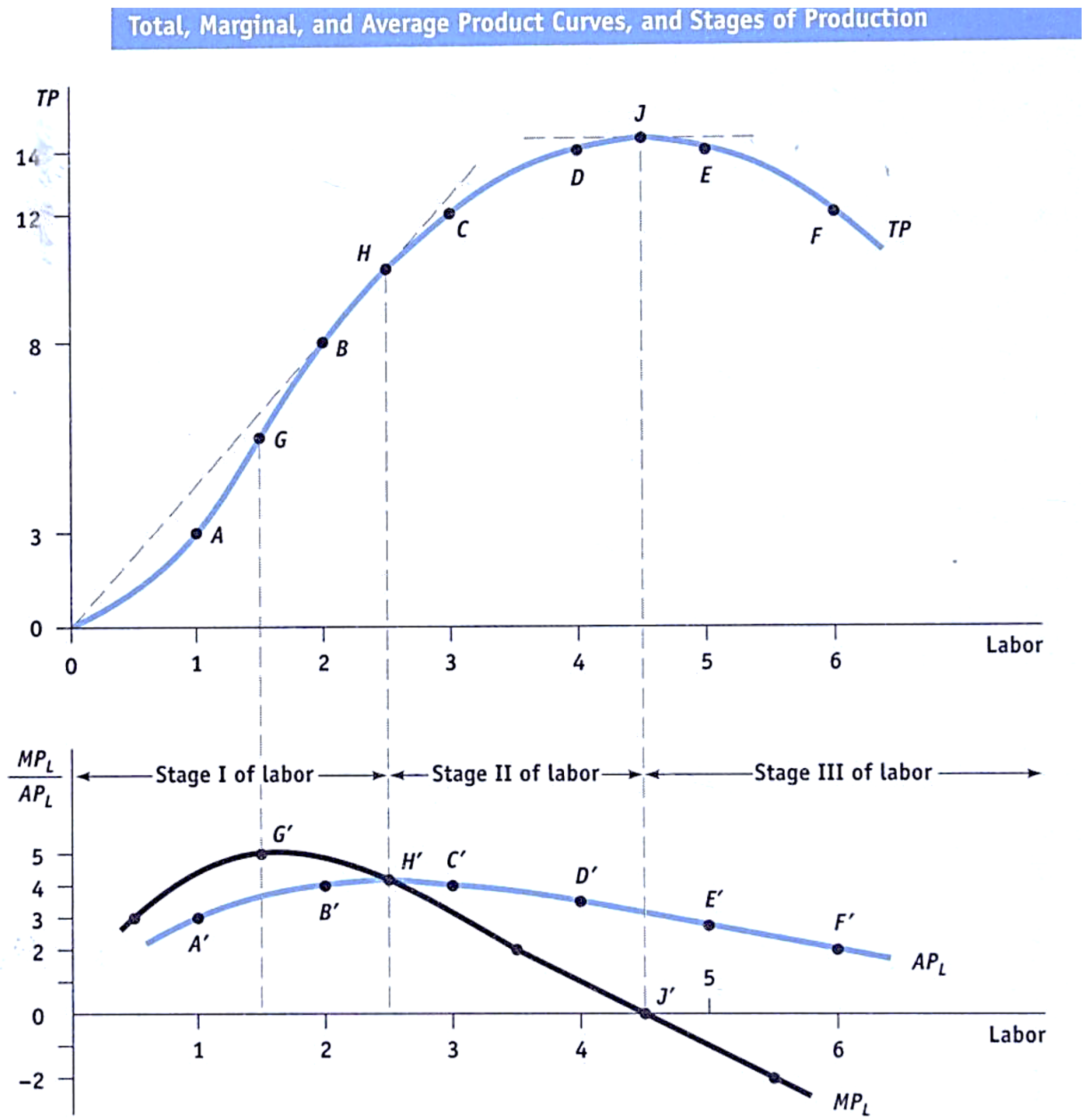


Figure 2

Carefully check the variables on the horizontal and vertical axis. It is quantity of labor on the horizontal and the quantity of product on the vertical axis. All the curves are drawn holding capital fixed at $K=\bar{K}$.

The slope of the TP_L curve (the tangent to the curve at that point) is known as the **marginal product of labor MP_L**. Note the shape of the total product curve. It is concave initially and then convex. Its slope or MP_L is increasing before point J when TP_L is rising, MP_L is 0 at J where TP_L reaches its maximum value and beyond J the MP_L is negative or TP_L is falling. The slope of the line joining origin to point on the TP_L curve is known as **average product of labor AP_L**. Mathematically,

$$AP_L = \frac{TP_L}{L} = \frac{Q\left(L,\bar{K}\right)}{L}$$

$$MP_L = \frac{d}{dL}\left(TP_L\right) = \frac{\Delta TP_L}{\Delta L}$$

Note that the tangent to the TP_L curve at H is the line OH. Hence, at point H on the curve, $AP_L = MP_L$. There are **three stages of production** with labor (or labor) in the short run. In the first stage of labor, the average product is increasing. For AP_L to rise as L increases, MP_L must be greater than AP_L to pull the latter up. In the second stage of labor, AP_L is falling but MP_L is positive. For AP_L to fall as L increases, MP_L must be smaller than AP_L to pull the latter down. In the third stage of labor, MP_L becomes negative or TP_L is falling. No profit maximizing perfectly competitive firm will operate in the third stage or the first stage. Why not in first stage? We will know later.

Let us discuss **short run costs** as this stage. As defined above, the **short run total cost (TC)** is the minimum cost to produce a given level of output Q when the capital is fixed at $K = \bar{K}$. Although capital is fixed but it is not free. The price per unit of capital is r and therefore the **total fixed cost (TFC)** is equal to $r\bar{K}$. The short run total cost also has a variable component depending on the amount of Q and is known as **total variable cost (TVC)**.

$$TC\left(Q\right) = TVC + TFC = wL + r\bar{K}$$

Where $Q = f\left(L,\bar{K}\right)$ is the maximum output, we can get from using L units of labor with fixed level of capital. Since Q output is maximum using L, the labor L is minimum labor needed to produce Q. What does TC look like? Look in figure 3. First check the variables on the horizontal and vertical axis. It is the quantity of output on the horizontal axis and costs in Rupees on the vertical axis. The TC curve as well as TVC curve are initially convex and later concave. G and G' respectively are the points of inflection. The TC curve is a parallel shift of the TVC curve upwards and the vertical distance at any level of output is the TFC. The TVC at Q=0 or no production is 0 but TC=TFC. The slope of the TC or TVC curve at any level of output is identical because the change in TC by adding labor is only equal to the change in TVC as TFC is constant. In fact,

$$\frac{d}{dQ}\left(TC\left(Q\right)\right) = \frac{d}{dQ}\left(TVC\right) + \frac{d}{dQ}\left(TFC\right) = \frac{d}{dQ}\left(wL\right) + \frac{d}{dQ}\left(r\bar{K}\right) = w\frac{dL}{dQ} = \frac{w}{\frac{dQ}{dL}} = \frac{w}{MP_L}$$

Short-Run Total and Per-Unit Cost Curves

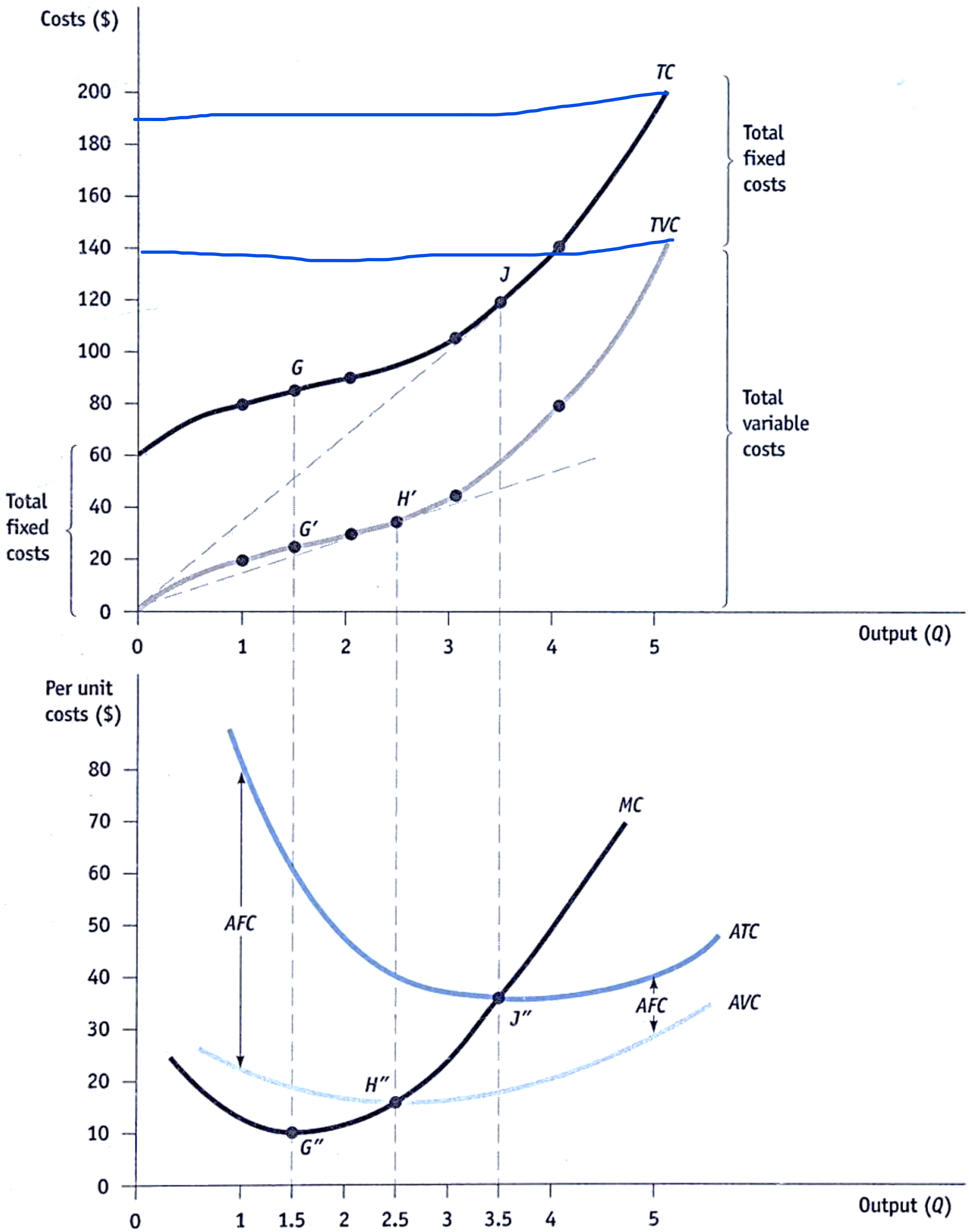


Figure 3

Note that the shape of the TVC curve is shaped reverse of the TP_L curve. This is because, the slope of TC curve is w divide by the slope of the TP_L curve. Hence if one is convex then the other must be concave and vice versa.

The change in total cost due to production of an additional unit of output is known as **short run marginal cost (MC)**. It is equal to the slope of the TC or TVC curve at any level of output.

$$MC = \frac{d}{dQ}\left(TC(Q)\right) = \frac{d}{dQ}(TVC) = \frac{\Delta TC}{\Delta Q} = \frac{\Delta TVC}{\Delta Q}$$

Since TC curve changes from convex to concave, the MC falls initially and then rises after reaching a minimum at output corresponding to G on TC curve. The shape of MC curve and MP_L curve reverse of each other. While the MP_L curve is inverted-J shaped, the short run MC curve is J-shaped.

The total cost divided by the amount of output is known as short run per unit or **average cost (ATC)**. The total fixed (variable) cost divided by the amount of output is known as short run average fixed cost (average variable cost).

$$ATC = \frac{TC}{Q} = \frac{TFC + TVC}{Q} = \frac{TFC}{Q} + \frac{TVC}{Q} = AFC + AVC$$

Since $TVC = wL$, $AVC = \frac{wL}{Q} = \frac{w}{\frac{Q}{L}} = \frac{w}{AP_L}$. Hence AVC and AP_L curve are reversely shaped. The short run AVC curve is U-shaped like a convex bowl.

Note that when AVC is falling up to output corresponding to point H”, the MC lies below AVC or is less than AC to pull it down and when AVC starts rising beyond H”, the MC lies above AVC or is more than AVC to pull AVC up. When AVC reaches its minimum, then MC=AVC. In other words, MC intersects AVC from below. Remember the first stage of labor when AP was rising with labor. In this stage, AC must be falling and hence MC must be below AC. We will see later that a profit maximizing firm produces that level of output where marginal revenue MR = MC. Under perfect competition, we will see that MR = AR = price of output. Since in the first stage, AVC > MC, if profits maximized somewhere in this stage, then AVC > MC=MR=AR=p. Multiply by Q on both sides and we get that Q.AVC = TVC > TR = p.Q. It means that for a perfectly competitive firm will get negative profits at the maximum in the first stage of labor. This is just a trivia.

Also note that $AFC = \frac{r\bar{K}}{Q}$ is a rectangular hyperbola curve and decreases as Q increases. In other words, average fixed cost is always declining as seen from the gap between ATC and AVC in figure 3. Moreover, since AFC is falling with Q, ATC can increase only if AVC increases. So, when ATC increases then AVC must be increasing. Hence the minimum point of ATC must never be on the left of minimum point of AVC. In fact, it is on the right at J". This can be seen geometrically in the TC and TVC figures. ATC (AVC) is the slope of the line joining point on the TC (TVC) curve to the origin. Since TVC lies parallelly below TC, the slope of the chord line is minimized at H' for TVC to the left of the corresponding minimum for TC at J. What is more important to see is that when MC < ATC then ATC is falling. We can show this with a bit of calculus (just for your understanding).

$$\frac{d}{dQ}(ATC)=\frac{d}{dQ}(AVC+AFC)=\frac{d}{dQ}(AVC)+\frac{d}{dQ}(AFC)=\frac{d}{dQ}\left(\frac{TVC}{Q}\right)+\frac{d}{dQ}\left(\frac{TFC}{Q}\right)$$

$$=\frac{MC}{Q}-\frac{TVC}{Q^2}-\frac{TFC}{Q^2}=\frac{MC}{Q}-\left(\frac{TVC}{Q^2}+\frac{TFC}{Q^2}\right)=\frac{MC}{Q}-\left(\frac{TC}{Q^2}\right)=\frac{MC}{Q}-\frac{ATC}{Q}=\frac{MC-ATC}{Q}$$

Hence the slope of ATC is positive or ATC is increasing only when MC> ATC. Therefore, ATC or AVC reaches its minimum when MC intersects it from below.

Before we talk about long run cost, let us revisit production. If all inputs are variable (as in the long run), a profit maximizing producer decides to produce any given level of output at the lowest cost possible. The factor combination that minimizes cost of production of any output level is that combination where the MRTS or slope of the isoquant = slope of the isocost line. The isocost line is analogous to the budget line for a consumer. Suppose the unit of labor and capital are w and r respectively then all factor combinations which cost 100 rupees are given by the line $wL+rK=100$. Here L and K are variables drawn on the horizontal and vertical axis respectively. The isocost line $wL+rK=100$ is shown in red color in figure 4. All the factor combinations lying along this line cost Rupees 100, given the per unit price of labor and capital at w and r respectively. The slope of this isocost line is –(w/r). The yellow line parallel to the red line includes factor combinations which all cost equal but less than 100. The green line parallel to the red line includes factor combinations which all cost equal but more than 100. These parallel lines make a family of isocost lines having the same slope. The further a line from origin, the more its cost.

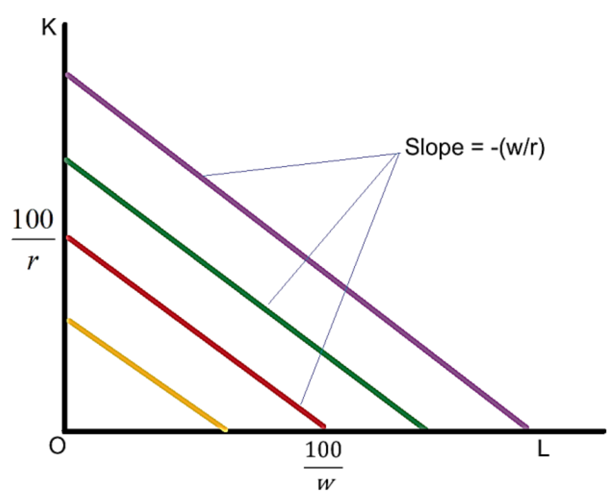


Figure 4

For a given output, our objective is to reach the lowest possible isocost line. In other words, we want to choose a factor combination that produces Q (or lies on the isoquant for Q) but lies on the lowest possible isocost. This is achieved when we reach an isocost which is tangent to the isoquant for Q as shown in figure 5.

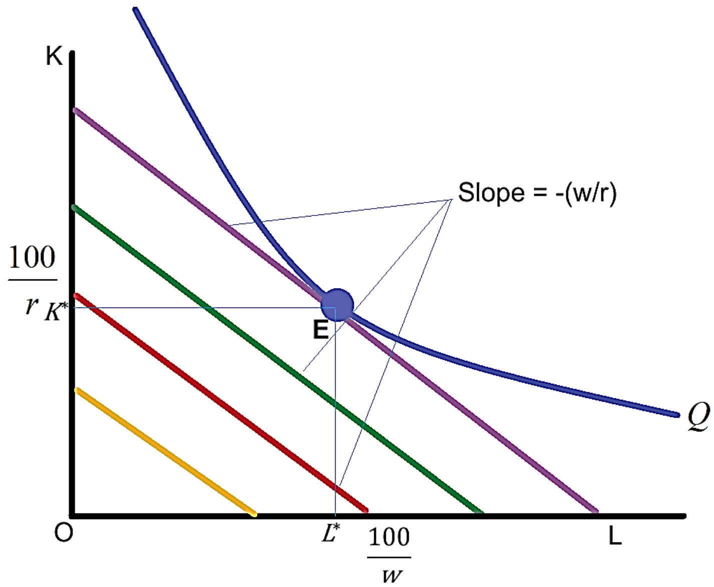


Figure 5

The condition for this cost minimization is that slope of isoquant for Q is equal to the slope of the isocost. Mathematically these conditions are,

$$Q = f(L, K)$$

$$MRTS = -\frac{MP_L}{MP_K} = -\frac{w}{r}$$

The last condition can also be rewritten as $\frac{MP_L}{w} = \frac{MP_K}{r}$. It means that at the optimal factor combination for any given output requires that the marginal product from one rupee spent on buying labor or capital is the same. The point E is known as producer's equilibrium. Note that $MRTS = -\frac{MP_L}{MP_K}$ just like $MRS = -\frac{MU_X}{MU_Y}$ for a consumer. This is because $MP_K = \frac{\partial Q(L,K)}{\partial K}$, holding L fixed and $MP_L = \frac{\partial Q(L,K)}{\partial L}$, holding K fixed.

Suppose that given w and r, L^* and K^* minimizes cost of producing Q, then the minimum cost or long run total cost of producing Q is given by

$$LTC(Q) = wL^* + rK^*$$

We can define long run marginal cost (LMC) and long run (unit cost or) average cost (LAC) as earlier. LMC is the change in LTC due to an increase in output by one unit. LAC for Q units of output is the LTC of Q divided by Q.

$$LMC(Q) = \frac{\Delta LTC}{\Delta Q} = \frac{d}{dQ}(LTC)$$

$$LAC(Q) = \frac{LTC(Q)}{Q}$$

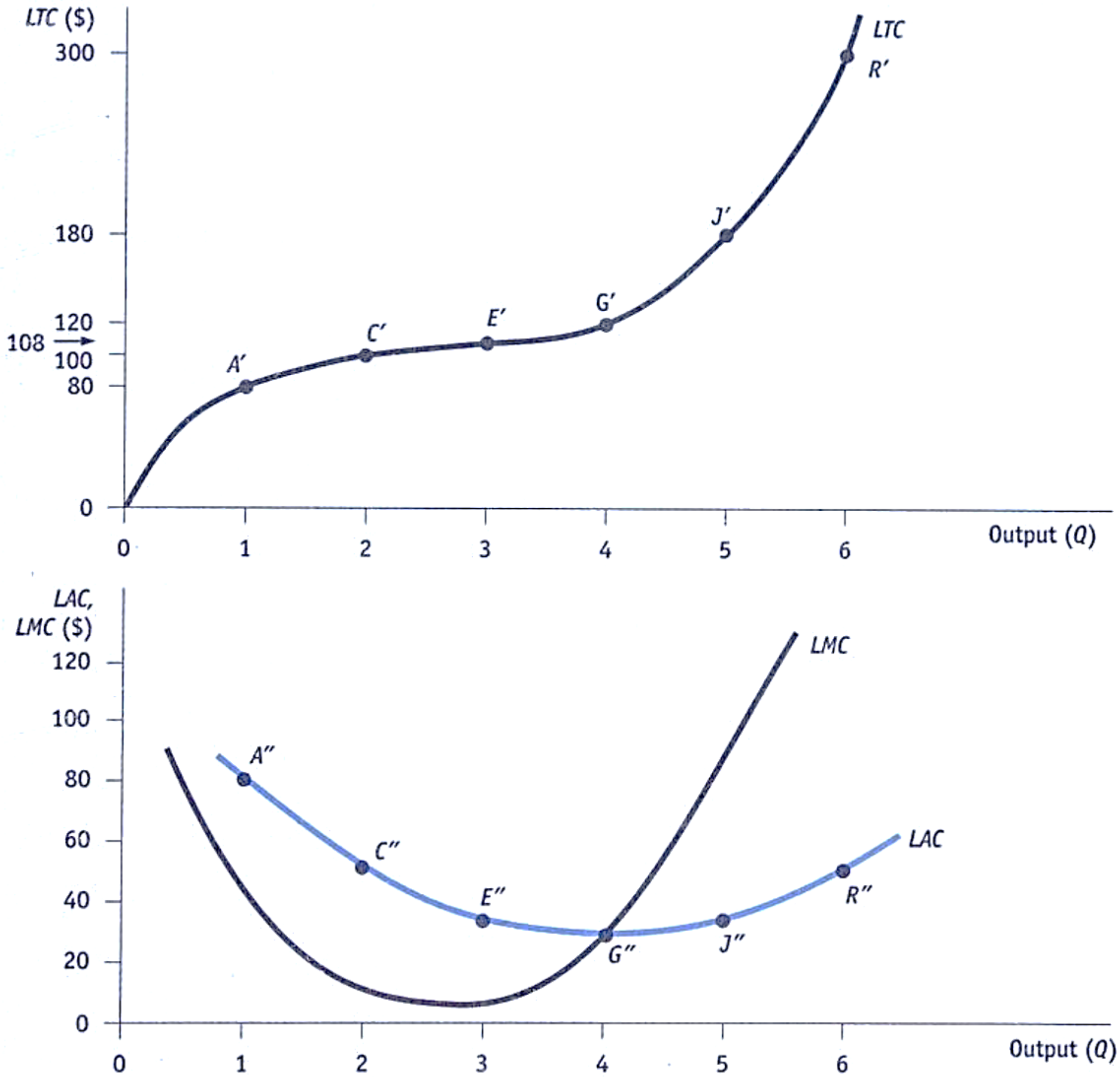


Figure 6

The shape of long run curves is exactly like short run curves except for that there is no fixed or variable cost in the long run. LTC changes from convex to concave. Note LTC=0 at Q=0 since there is no fixed cost now. No production means no cost in the long run. LMC has a J-shape and LAC has a (bowl or) U-shape. LAC minimizes when LMC=LAC.

We will denote the short run MC and AC as SMC and SAC hereafter. There is a **relation between the LAC and SACs**. The LAC curve envelopes the various SACs for different size of the fixed capital i.e. LAC is tangent to all the SACs.

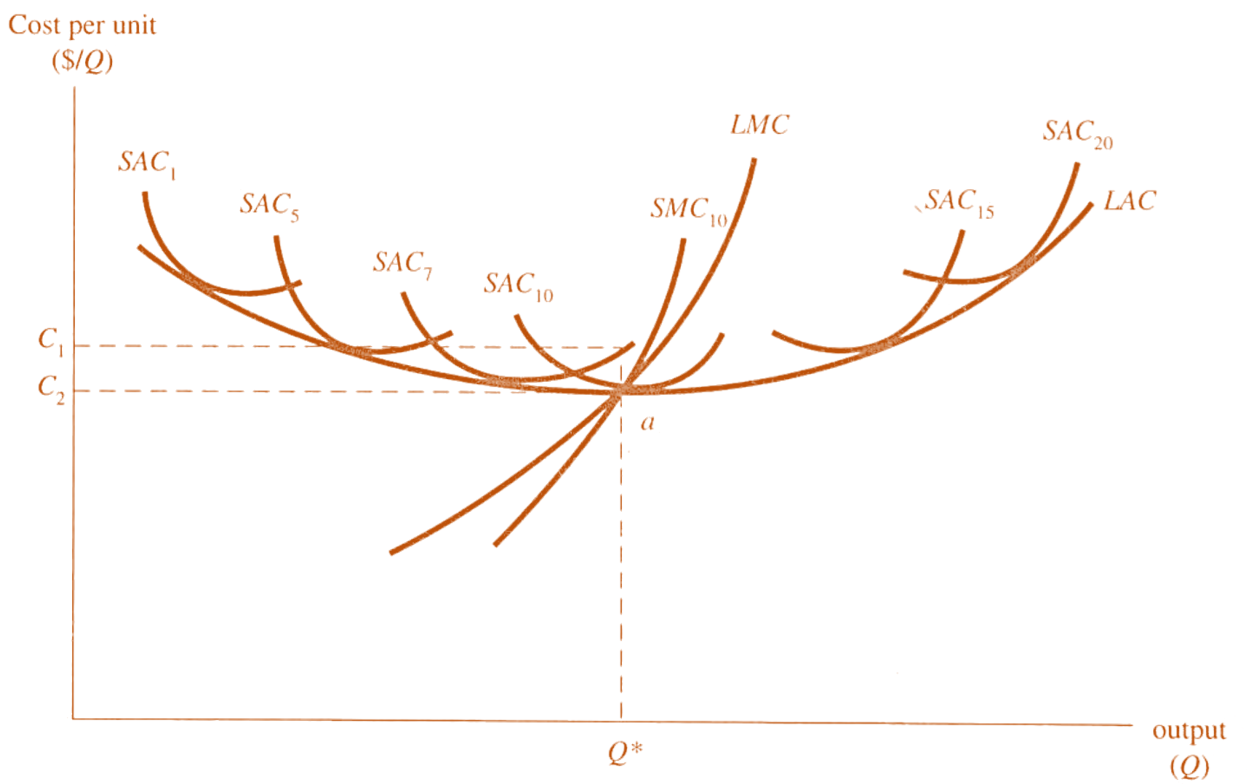


Figure 7

The firm's capital stock is fixed in the short run. So, if it wants to produce more output then it is stuck with a factory or plant of the fixed capital size. Given the market prospects, suppose the firm aims to produce output much below Q*, then it may choose to install a SAC_1 plant with lower capacity (or capital) and gets stuck with it for a while (short run). If it had aimed for producing a little bit more then it would have installed SAC_5 or SAC_7 plant. If it had aimed to produce Q* then it would install plant or SAC_{10} and so on. LAC can never be above any SAC at any level of output because the firm can do no worse by varying all inputs in the cost minimization exercise, since it always has the option of not varying capital at all. But why is it tangent to all SACs? If it is not tangent to any SAC then it will intersect that SAC and lie above it at some level of output which is logically not possible.

Moreover, at the minimum point of LAC i.e. Q*, where its slope is zero, it must be that slope of SAC (corresponding to optimal K* for Q* in firm's long run cost minimization) is also zero or SAC (corresponding to optimal K* for Q*) also has a minimum at Q*. As shown in the figure 7, at Q* we must have

$$SAC = SMC = LAC = LMC$$

Returns to Scale

Scaling up (down) means increasing (decreasing) all factor inputs (for our purpose L and K) in the same proportion. If output grows (or increases) proportionally more than the inputs, then the production function is said to have **increasing returns to scale** (IRS). If output grows (increases) proportionally less than the inputs, then the production function is said to have **decreasing returns to scale** (DRS). If the output grows (increases) proportionally as much as the inputs then the production function is said to have **constant returns to scale** (CRS). It means that if inputs are doubled then the output more than doubles, doubles and less than doubles if IRS, CRS, and DRS respectively.

Mathematically, if a firm was using some factor combination to begin with, say (L,K) then scaling up (down) would mean using (λL, λK) now where $\lambda>1$ ($\lambda<1$). Suppose a firm's output gets multiplied or scaled up by λ^{α} when inputs get multiplied or scaled up by λ. A firm is said to enjoy

1. Increasing returns to scale (IRS) if $\alpha>1$.
2. Constant returns to scale (CRS) if $\alpha=1$.
3. Decreasing returns to scale (DRS) if $\alpha<1$.

Consider the general Cobb-Doughlas production function $Q = c\,K^{\alpha}L^{\beta}$. If both inputs are scaled up by λ then new output $= c\left(\lambda K\right)^{\alpha}\left(\lambda L\right)^{\beta} = \lambda^{\alpha+\beta}c\,K^{\alpha}L^{\beta} = \lambda^{\alpha+\beta}Q$. Therefore, a Cobb-Doughlas production function has

1. IRS if $\alpha+\beta>1$
2. CRS if $\alpha+\beta=1$
3. DRS if $\alpha+\beta<1$

A production function usually does not enjoy IRS over entire range of output. In fact, normally a production function has IRS at lower levels of output, CRS in the middle and DRS at higher levels of output. If the prices of inputs are unchanged then over the range of output where production function

1. has IRS, the LAC is falling.
2. has CRS, the LAC is unchanging.
3. has DRS, the LAC is rising.

Hence IRS are reflected in falling LAC curve and DRS are reflected in rising LAC curve. On the output levels over where LAC is falling, the firm is said to have **economies of scale** and on the output levels over where LAC is rising, the firm is said to have **diseconomies of scale**. In figure 7, the firm has economies of scale before Q* and diseconomies of scale after Q*. At Q*, the forces causing economies of scale or IRS are balanced by the forces causing diseconomies of scale or DRS.

Sources of Economies of Scale or increasing returns to scale

1. Technological
    a. As the scale of operation increases, greater division of labor and specialization can happen. The increased specialization of workers on the same machines increases proficiency of use and saves time in going from one machine to another.
    b. At higher scale, more specialized and productive machinery can be used. For example, use of a conveyer belt may not be justified in a small factory but it increases efficiency in large factories.
    c. Geometrical relations also help increasing returns to scale. This is because volume increases faster than the surface area. For example, the construction cost of pipeline having a certain volume of flow per unit of time or dust proofing cost of a building with a certain storage capacity are dependent on the surface area which increases only by power of 2 whereas the volume increases by a power of 3, bringing the per unit cost down.
    d. Size also effects unit costs because large firms need not increase inventories or replacements parts of machines proportionally with size. For example, suppose a small firm has one machine with a probability of breakdown of 0.1 in a month. The small firm needs to buy or rent another machine to keep as back up just to prevent against that possibility. Its machine cost has just doubled. On the other hand, if a large firm has 5 machines, then the joint probability of all of them breaking down simultaneously is just 0.1x0.1x0.1x0.1x0.1=negligible. Even if the large firm gets another machine just to defend against this possibility, the extra machine cost is just $1/5^{th}$ of its existing machine cost. Hence a lower per unit cost for the larger firm.
2. Financial
    a. Because of bulk purchase of raw materials and other intermediate goods, the large firms get quantity discounts compared to the smaller firms.
    b. Large firms usually sell stocks more favorably and get loans from banks at lower interest rates than smaller firms.
    c. Large firms also achieve economies of scale in advertising and other promotional efforts.

Sources of diseconomies of Scale or decreasing returns to scale

1. Managerial (sources of DRS are primarily managerial)
   - As the scale gets larger, it becomes more difficult to manage the firm effectively and coordinate various operations and divisions of the firm.
   - The costs of gathering, organizing, and reviewing the information on all aspects of the firm increases rapidly than the scale.
   - The number of meetings, the paperwork and communication expenses increase proportionately more than to the increase in the scale of operations.
   - It becomes increasingly difficult for the top management to ensure that their directives and guidelines are properly carried out by their subordinates. All this decreases efficiency and increases per unit costs.
2. Transportation costs
   - If firm has two or more geographically separated units, then production costs may decline but this decline could be offset by the higher transportation costs from some unit.
3. Higher labor costs
   - If a large firm has already employed a large share of local labor force, then it will have to offer increased wage rates to attract new labor. This will lead to rising per unit costs.

<u>Break-Even analysis</u>

Th normal (or economic) profit is the difference between revenue and economic (opportunity) cost. The accounting profit is the difference between revenue and accounting cost. Suppose in a certain business you earn a 10% rate of return (or profit) but alternatively suppose you could put all that money in post office and earned an 8% rate of interest. Although your accounting profit is 10% but your economic profit is just 2% after deducting the opportunity cost of 8%.

A firm is said to ***break even*** *if it earns a zero normal profit.* The profit denoted by π is given by

$$\pi(Q) = R(Q) - C(Q) = \underbrace{\left[Q \times P(Q)\right]}_{revenue} - C(Q)$$

To break even, the firm choses the output level where profits are zero. Break even is a special case of profit analysis where the required profit is zero. Suppose required profit is denoted by π_R. Suppose a manger wants to cover all the fixed cost TFC and get a profit level of π_R. What Q will achieve that objective if we assume that both price per unit of output P and average variable cost AVC are constant?

$$P \times Q - \left[TFC + \left(\underbrace{Q \times AVC}_{\text{total variable cost}} \right) \right] = \pi_R$$
revenue

$$\Rightarrow \quad Q_R = \frac{\pi_R + TFC}{P - AVC}$$

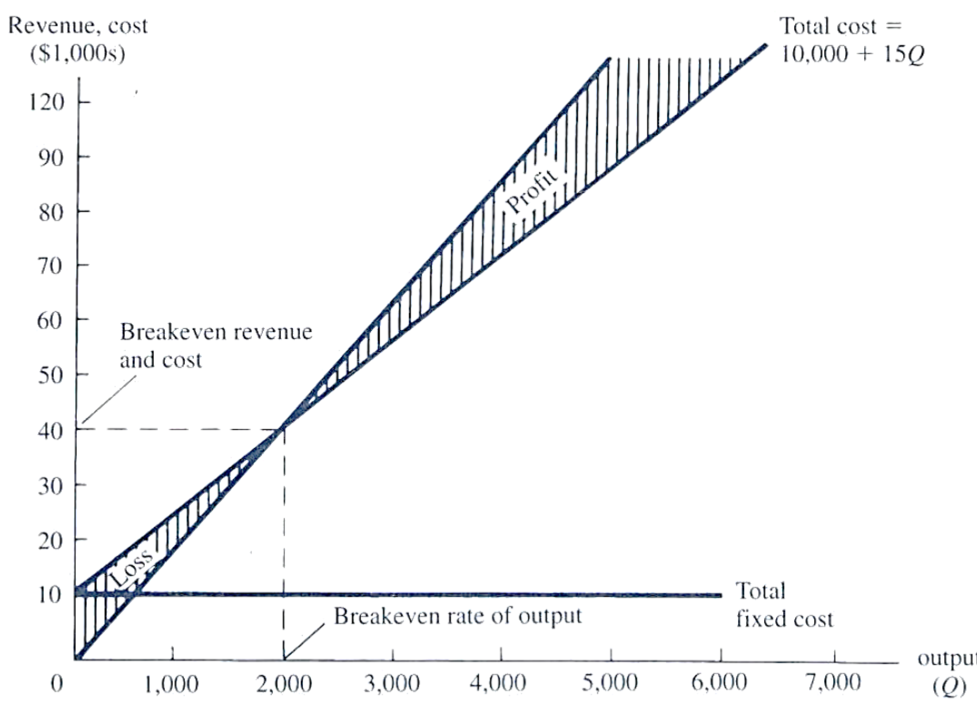
If $\pi_R = 0$ then $Q_e = \dfrac{TFC}{P - AVC}$ is known as the **break-even** (level of) **output**.

The denominator in the equation of Q_e i.e. $P - AVC$ is known as **contribution margin per unit** because it represents the portion of the selling price that can be applied to cover the fixed costs of the firm and provide profits.

Example from Peterson on linear break-even analysis

A linear break-even analysis assumes revenue and cost function to be linear functions of output. This is because both price per unit of output and average variable cost are assumed to be constant.

FIGURE 7.6 Linear Breakeven Analysis



For example, suppose that $FC = \$10{,}000$, $P = \$20$, $AVC = \$15$, and that the firm has set a required profit target of \$20,000. To generate this profit, an output rate of 6,000 units is required; that is,

$$Q_R = \frac{\$10{,}000 + \$20{,}000}{20 - 15} = 6{,}000$$

A special case of this equation is where the required economic profit is zero, that is, $\pi_R = 0$. This output rate is called the breakeven point for the firm. (Recall that a zero economic profit means that normal returns are being earned by capital and other factors of production.) The breakeven rate of output, Q_e, is given by the equation

$$Q_e = \frac{FC}{P - AVC} \tag{7-8}$$

Using the data just given, it is seen that the breakeven rate of output is 2,000; that is,

$$Q_e = \frac{\$10{,}000}{20 - 15} = 2{,}000$$

This example of breakeven analysis is shown graphically in Figure 7.6. Fixed cost is shown as the horizontal line at \$10,000. Total cost is given by the equation

$$TC = FC + TVC$$

Because $FC = 10{,}000$ and variable cost per unit is 15, the total cost function is

$$TC = 10{,}000 + 15Q$$

Since price is constant, the total revenue function is

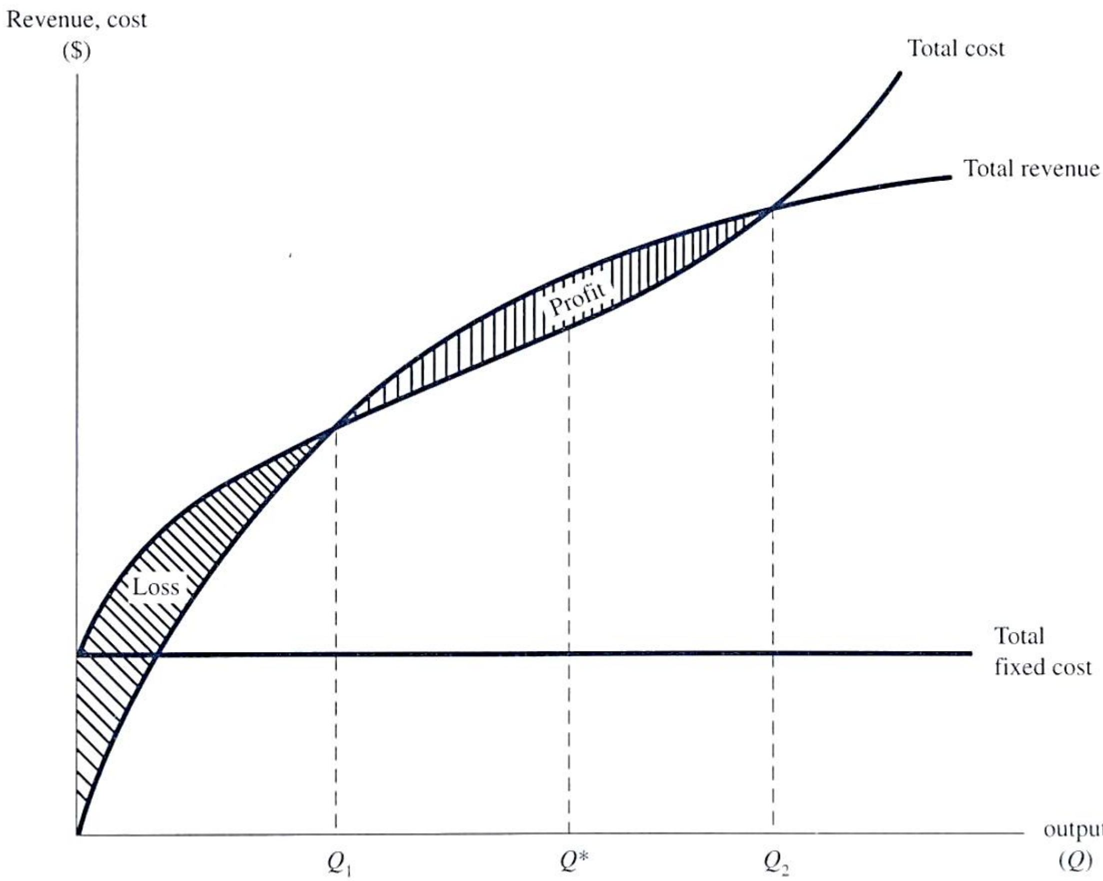
$$TR = 20Q$$

which is shown as a straight line through the origin having a slope of 20. The breakeven point occurs at an output rate of 2,000, which is at the intersection of the total revenue and total cost functions. At this point, both total revenue and total cost are \$40,000.

Criticisms of linear breakeven analysis

In the real world, per unit costs are U-shaped and if firm is not selling in a perfectly competitive market, then it must reduce price to sell more. In the figure 7.7 below, we have a TC function which goes from concave to concave as output increases. TVC starts from origin and is just a vertically parallel shift downward by the amount of TFC, giving us a U-shaped AVC curve. You may see in the figure that revenue equals cost i.e. profits are zero at Q_1 and Q_2. To break-even, the manager would want to get to the output level Q_1 as quickly as possible and then move on profit maximizing output level Q^*. The manager will never then decrease his profits and produce Q_2. Hence only Q_1 is the relevant break-even level of output.

FIGURE 7.7 Nonlinear Breakeven Analysis



Operating leverage refers to the ratio of fixed cost to variable costs. A firm is said to be highly leveraged if its fixed costs are large relative to its variable costs. The degree of operating leverage is given by the elasticity of profits with respect to sales.

$$E_\pi = \frac{\%\Delta\pi}{\%\Delta Q} = \frac{\frac{\Delta\pi}{\pi}}{\frac{\Delta Q}{Q}} = \frac{\Delta\pi}{\Delta Q} \times \frac{Q}{\pi} = \frac{d\pi}{dQ} \times \frac{Q}{\pi}$$

If P and AVC are constant then $\pi(Q) = P.Q - TFC - Q.AVC$ and $\frac{d\pi}{dQ} = P - AVC$. Therefore

$$E_\pi = \frac{d\pi}{dQ} \times \frac{Q}{\pi} = \frac{Q(P-AVC)}{Q(P-AVC)-TFC}$$

If profits are positive, a higher TFC will reduce the denominator and increase the value of elasticity. It means that profits will increase much faster than sales.