

EXHIBIT 11

Seventeenth Edition

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Microeconomics

Principles, Problems, and Policies

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Figure 8.2b is plotted halfway between the units of labor, since it applies to the addition of each labor unit.)

Note first in Figure 8.2a that total product, TP, goes through three phases: It rises initially at an increasing rate; then it increases, but at a diminishing rate; finally, after reaching a maximum, it declines.

Geometrically, marginal product—shown by the MP curve in Figure 8.2b—is the slope of the total-product curve. Marginal product measures the change in total product associated with each succeeding unit of labor. Thus, the three phases of total product are also reflected in marginal product. Where total product is increasing at an increasing rate, marginal product is rising. Here, extra units of labor are adding larger and larger amounts to total product. Similarly, where total product is increasing but at a decreasing rate, marginal product is positive but falling. Each additional unit of labor adds less to total product than did the previous unit. When total product is at a maximum, marginal product is zero. When total product declines, marginal product becomes negative.

Average product, AP (Figure 8.2b), displays the same tendencies as marginal product. It increases, reaches a maximum, and then decreases as more and more units of labor are added to the fixed plant. But note the relationship between marginal product and average product: Where marginal product exceeds average product, average product rises. And where marginal product is less than average product, average product declines. It follows that marginal product intersects average product where average product is at a maximum.

This relationship is a mathematical necessity. If you add a larger number to a total than the current average of that total, the average must rise. And if you add a smaller number to a total than the current average of that total, the average must fall. You raise your average examination grade only when your score on an additional (marginal) examination is greater than the average of all your past scores. You lower your average when your grade on an additional exam is below your current average. In our production example, when the amount an extra worker adds to total product exceeds the average product of all workers currently employed, average product will rise. Conversely, when an extra worker adds to total product an amount that is less than the current average product, then average product will decrease.

The law of diminishing returns is embodied in the shapes of all three curves. But, as our definition of the law of diminishing returns indicates, economists are most concerned with its effects on marginal product. The regions of increasing,

diminishing, and negative marginal product (returns) are shown in Figure 8.2b. (Key Question 4)

Short-Run Production Costs

Production information such as that provided in Table 8.1 and Figure 8.2a and 8.2b must be coupled with resource prices to determine the total and per-unit costs of producing various levels of output. We know that in the short run some resources, those associated with the firm's plant, are fixed. Other resources, however, are variable. So short-run costs are either fixed or variable.

Fixed, Variable, and Total Costs

Let's see what distinguishes fixed costs, variable costs, and total costs from one another.

Fixed Costs Fixed costs are those costs that in total do not vary with changes in output. Fixed costs are associated with the very existence of a firm's plant and therefore must be paid even if its output is zero. Such costs as rental payments, interest on a firm's debts, a portion of depreciation on equipment and buildings, and insurance premiums are generally fixed costs; they do not increase even if a firm produces more. In column 2 of Table 8.2 we assume that the firm's total fixed cost is \$100. By definition, this fixed cost is incurred at all levels of output, including zero. The firm cannot avoid paying fixed costs in the short run.

Variable Costs Variable costs are those costs that change with the level of output. They include payments for materials, fuel, power, transportation services, most labor, and similar variable resources. In column 3 of Table 8.2 we find that the total of variable costs changes directly with output. But note that the increases in variable cost associated with succeeding 1-unit increases in output are not equal. As production begins, variable cost will for a time increase by a decreasing amount; this is true through the fourth unit of output in Table 8.2. Beyond the fourth unit, however, variable cost rises by increasing amounts for succeeding units of output.

The reason lies in the shape of the marginal-product curve. At first, as in Figure 8.2b, marginal product is increasing, so smaller and smaller increases in the amounts of variable resources are needed to produce successive units of output. Hence the variable cost of successive units of output decreases. But when, as diminishing returns are encountered, marginal product begins to decline, larger and larger additional amounts of variable resources are needed to produce successive units of output. Total variable cost therefore increases by increasing amounts.

8.2

Production
relationship

TABLE 8.2 Total-, Average-, and Marginal-Cost Schedules for an Individual Firm in the Short Run

Total-Cost Data				Average-Cost Data			Marginal Cost
(1) Total Product (Q)	(2) Total Fixed Cost (TFC)	(3) Total Variable Cost (TVC)	(4) Total Cost (TC) TC = TFC + TVC	(5) Average Fixed Cost (AFC) $AFC = \frac{TFC}{Q}$	(6) Average Variable Cost (AVC) $AVC = \frac{TVC}{Q}$	(7) Average Total Cost (ATC) $ATC = \frac{TC}{Q}$	(8) Marginal Cost (MC) $MC = \frac{\text{change in TC}}{\text{change in Q}}$
0	\$100	\$ 0	\$ 100				\$ 90
1	100	90	190	100.00	90.00	190.00	80
2	100	170	270	50.00	85.00	135.00	70
3	100	240	340	33.33	80.00	113.33	60
4	100	300	400	25.00	75.00	100.00	70
5	100	370	470	20.00	74.00	94.00	80
6	100	450	550	16.67	75.00	91.67	90
7	100	540	640	14.29	77.14	91.43	110
8	100	650	750	12.50	81.25	93.75	130
9	100	780	880	11.11	86.67	97.78	150
10	100	930	1030	10.00	93.00	103.00	

Total Cost Total Cost is the sum of fixed cost and variable cost at each level of output:

$$TC = TFC + TVC$$

TC is shown in column 4 of Table 8.2. At zero units of output, total cost is equal to the firm's fixed cost. Then for each unit of the 10 units of production, total cost increases by the same amount as variable cost.

Figure 8.3 shows graphically the fixed-, variable-, and total-cost data given in Table 8.2. Observe that total variable cost, TVC, is measured vertically from the horizontal axis at each level of output. The amount of fixed cost, shown as TFC, is added vertically to the total-variable-cost curve to obtain the points on the total-cost curve TC.

The distinction between fixed and variable costs is significant to the business manager. Variable costs can be controlled or altered in the short run by changing production levels. Fixed costs are beyond the business manager's current control; they are incurred in the short run and must be paid regardless of output level.

Per-Unit, or Average, Costs

Producers are certainly interested in their total costs, but they are equally concerned with per-unit, or average, costs. In particular, average-cost data are more meaningful for making comparisons with product price, which is always stated on a per-unit basis. Average fixed cost, average variable cost, and average total cost are shown in columns 5 to 7, Table 8.2.

AFC Average fixed cost (AFC) for any output level is found by dividing total fixed cost (TFC) by that output (Q). That is,

$$AFC = \frac{TFC}{Q}$$

Because the total fixed cost is, by definition, the same regardless of output, AFC must decline as output increases.

FIGURE 8.3 Total cost is the sum of fixed cost and variable cost. Total variable cost (TVC) changes with output. Total fixed cost (TFC) is independent of the level of output. The total cost (TC) at any output is the vertical sum of the fixed cost and variable cost at that output.

