Chapter 8
Profit Maximization and Competitive Supply

■ Review Questions

1. **Why would a firm that incurs losses choose to produce rather than shut down?**

   Losses occur when revenues do not cover total costs. If revenues are greater than variable costs, but not total costs, the firm is better off producing in the short run rather than shutting down, even though it is incurring a loss. The reason is that the firm will be stuck will all its fixed cost and have no revenue if it shuts down, so its loss will equal its fixed cost. If it continues to produce, however, and revenue is greater than variable costs, the firm can pay for some of its fixed cost, so its loss is less than it would be if it shut down. In the long run, all costs are variable, and thus all costs must be covered if the firm is to remain in business.

2. **Explain why the industry supply curve is not the long-run industry marginal cost curve.**

   In the short run, a change in the market price induces the profit-maximizing firm to change its optimal level of output. This optimal output occurs where price is equal to marginal cost, as long as marginal cost exceeds average variable cost. Therefore, the short-run supply curve of the firm is its marginal cost curve, above average variable cost. (When the price falls below average variable cost, the firm will shut down.)

   In the long run, a change in the market price induces entry into or exit from the industry and may induce existing firms to change their optimal outputs as well. As a result, the prices firms pay for inputs can change, and these will cause the firms' marginal costs to shift up or down. Therefore, long-run supply is not the sum of the existing firms' long-run marginal cost curves. The long-run supply curve depends on the number of firms in the market and on how their costs change due to any changes in input costs.

   As a simple example, consider a constant-cost industry where each firm has a U-shaped *LAC* curve. Here the input prices do not change, only the number of firms changes when industry price changes. Each firm has an increasing *LMC*, but the industry long-run supply is horizontal because any change in industry output comes about by firms entering or leaving the industry, not by existing firms moving up or down their *LMC* curves.

3. **In long-run equilibrium, all firms in the industry earn zero economic profit. Why is this true?**

   The theory of perfect competition explicitly assumes that there are no entry or exit barriers to new participants in an industry. With free entry, positive economic profits induce new entrants. As these firms enter, the supply curve shifts to the right, causing a fall in the equilibrium price of the product. Entry will stop, and equilibrium will be achieved, when economic profits have fallen to zero.

   Some firms may earn greater *accounting* profits than others because, for example, they own a superior source of an important input, but their *economic* profits will be the same. To be more concrete, suppose one firm can mine a critical input for $2 per pound while all other firms in the industry have to pay $3 per pound. The one firm will have an accounting cost advantage and will report higher accounting

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profits than other firms in the industry. But there is an opportunity cost associated with the company's input use, because other firms would be willing to pay up to $3 per pound to buy the input from the firm with the superior mine. Therefore, the company should include a $1 per pound opportunity cost for using its own input rather than selling it to other firms. Then, that firm's economic costs and economic profit will be the same as all the other firms in the industry. So all firms will earn zero economic profit in the long run.

4. **What is the difference between economic profit and producer surplus?**

   Economic profit is the difference between total revenue and total cost. Producer surplus is the difference between total revenue and total variable cost. So fixed cost is subtracted to find profit but not producer surplus, and thus profit equals producer surplus minus fixed cost (or producer surplus equals profit plus fixed cost).

5. **Why do firms enter an industry when they know that in the long run economic profit will be zero?**

   Firms enter an industry when they expect to earn economic profit, even if the profit will be short-lived. These short-run economic profits are enough to encourage entry because there is no cost to entering the industry, and some economic profit is better than none. Zero economic profit in the long run implies *normal* returns to the factors of production, including the labor and capital of the owner of the firm. So even when economic profit falls to zero, the firm will be doing as well as it could in any other industry, and then the owner will be indifferent to staying in the industry or exiting.

6. **At the beginning of the twentieth century, there were many small American automobile manufacturers. At the end of the century, there were only three large ones. Suppose that this situation is not the result of lax federal enforcement of antimonopoly laws. How do you explain the decrease in the number of manufacturers? (*Hint*: What is the inherent cost structure of the automobile industry?)**

   Automobile plants are highly capital-intensive, and consequently there are substantial economies of scale in production. So, over time, the automobile companies that produced larger quantities of cars were able to produce at lower average cost. They then sold their cars for less and eventually drove smaller (higher cost) companies out of business, or bought them to become even larger and more efficient. At very large levels of production, the economies of scale diminish, and diseconomies of scale may even occur. This would explain why more than one manufacturer remains.

7. **Because industry *X* is characterized by perfect competition, every firm in the industry is earning zero economic profit. If the product price falls, no firms can survive. Do you agree or disagree? Discuss.**

   Disagree. If the market price falls, all firms will suffer economic losses. They will cut production in the short run but continue in business as long as price is above average variable cost. In the long run, however, if price stays below average total cost, some firms will exit the industry. As firms leave industry *X*, the market supply decreases (i.e., shifts to the left). This causes the market price to increase. Eventually enough firms exit so that price increases to the point where profits return to zero for those firms still in the industry, and those firms will continue to survive and produce product *X*.

8. **An increase in the demand for movies also increases the salaries of actors and actresses. Is the long-run supply curve for films likely to be horizontal or upward sloping? Explain.**

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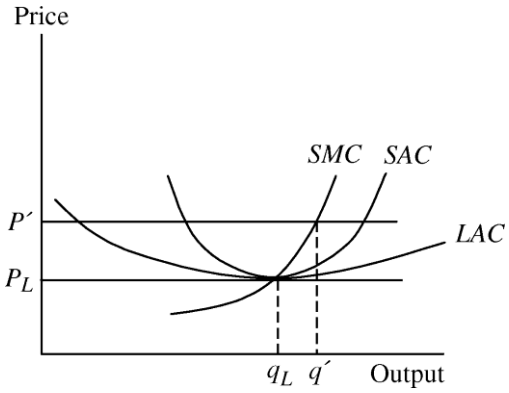
The long-run supply curve depends on the cost structure of the industry. Assuming there is a relatively fixed supply of actors and actresses, as more films are produced, higher salaries must be offered. Therefore the industry experiences increasing costs. In an increasing-cost industry, the long-run supply curve is upward sloping. Thus the supply curve for films would be upward sloping.

9. True or false: A firm should always produce at an output at which long-run average cost is minimized. Explain.

False. In the long run, under perfect competition, firms will produce where long-run average cost is minimized. In the short run, however, it may be optimal to produce at a different level. For example, if price is above the long-run equilibrium price, the firm will maximize short-run profit by producing a greater amount of output than the level at which *LAC* is minimized as illustrated in the diagram. P_L is the long-run equilibrium price, and q_L is the output level that minimizes *LAC*. If price increases to P' in the short run, the firm maximizes profit by producing q', which is greater than q_L, because that is the output level at which *SMC* (short-run marginal cost) equals price.



10. Can there be constant returns to scale in an industry with an upward-sloping supply curve? Explain.

Yes. Constant returns to scale means that proportional increases in all inputs yield the same proportional increase in output. However, when all firms increase their input use, the prices of some inputs may rise, because their supply curves are upward sloping. For example, production that uses rare or depleting inputs will see higher input costs as production increases. Doubling inputs will still yield double output, but because of rising input prices, production costs will more than double. In this case the industry is an increasing-cost industry, and it will have an upward-sloping long-run supply curve. Therefore, an industry can have both constant returns to scale and an upward-sloping industry supply curve.

11. What assumptions are necessary for a market to be perfectly competitive? In light of what you have learned in this chapter, why is each of these assumptions important?

The three primary assumptions of perfect competition are (1) all firms in the industry are price takers, (2) all firms produce identical products, and (3) there is free entry and exit of firms to and from the market. The first two assumptions are important because they imply that no firm has any market power and that each faces a horizontal demand curve. As a result, firms produce where price equals marginal cost, which defines their supply curves. With free entry and exit, positive (negative) economic profits encourage firms to enter (exit) the industry. Entry and exit affect industry supply and price. In the long run, entry or exit continues until price equals long-run average cost and firms earn zero economic profit.

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12. Suppose a competitive industry faces an increase in demand (i.e., the demand curve shifts upward). What are the steps by which a competitive market insures increased output? Will your answer change if the government imposes a price ceiling?

If demand increases, price and profits increase in the short run. The price increase causes existing firms to increase output, and the positive profits induce new firms to enter the industry in the long run, shifting the supply curve to the right. This results in a new equilibrium with a higher quantity and a price (less than the short-run price) that earns all firms zero economic profit. With an effective price ceiling, price will not increase when demand increases, and firms will therefore not increase output. Also, without an increase in economic profit, no new firms enter, and there is no shift in the supply curve. So the result is very different with a price ceiling. Output does not increase as a result of the increase in demand. Instead there is a shortage of the product.

13. The government passes a law that allows a substantial subsidy for every acre of land used to grow tobacco. How does this program affect the long-run supply curve for tobacco?

A subsidy on land used to grow tobacco decreases every farmer's average cost of producing tobacco and will lead existing tobacco growers to increase output. In addition, tobacco farmers will make positive economic profits that will encourage other firms to enter tobacco production. The result is that both the short-run and long-run supply curves for the industry will shift down and to the right.

14. A certain brand of vacuum cleaners can be purchased from several local stores as well as from several catalogues or websites.

a. If all sellers charge the same price for the vacuum cleaner, will they all earn zero economic profit in the long run?

Yes, all earn zero economic profit in the long run. If economic profit were greater than zero for, say, online sellers, then firms would enter the online industry and eventually drive economic profit for online sellers to zero. If economic profit were negative for catalogue sellers, some catalogue firms would exit the industry until economic profit returned to zero. So all must earn zero economic profit in the long run. Anything else will generate entry or exit until economic profit returns to zero.

b. If all sellers charge the same price and one local seller owns the building in which he does business, paying no rent, is this seller earning a positive economic profit?

No this seller would still earn zero economic profit. If he pays no rent then the accounting cost of using the building is zero, but there is still an opportunity cost, which represents the value of the building in its best alternative use.

c. Does the seller who pays no rent have an incentive to lower the price that he charges for the vacuum cleaner?

No he has no incentive to charge a lower price because he can sell as many units as he wants at the current market price. Lowering his price will only reduce his economic profit. Since all firms sell the identical good, they will all charge the same price for that good.

■ Exercises

1. The data in the table below give information about the price (in dollars) for which a firm can sell a unit of output and the total cost of production.

a. Fill in the blanks in the table.

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b. Show what happens to the firm's output choice and profit if the price of the product falls from $60 to $50.

q	P	R $P=60$	C	π $P=60$	MC $P=60$	MR $P=60$	R $P=50$	MR $P=50$	π $P=50$
0	**60**		**100**						
1	**60**		**150**						
2	**60**		**178**						
3	**60**		**198**						
4	**60**		**212**						
5	**60**		**230**						
6	**60**		**250**						
7	**60**		**272**						
8	**60**		**310**						
9	**60**		**355**						
10	**60**		**410**						
11	**60**		**475**						

The table below shows the firm's revenue and cost for the two prices.

q	P	R $P=60$	C	π $P=60$	MC $P=60$	MR $P=60$	R $P=50$	MR $P=50$	π $P=50$
0	60	0	100	–100	—	—	0	—	–100
1	60	60	150	–90	50	60	50	50	–100
2	60	120	178	–58	28	60	100	50	–78
3	60	180	198	–18	20	60	150	50	–48
4	60	240	212	28	14	60	200	50	–12
5	60	300	230	70	18	60	250	50	20
6	60	360	250	110	20	60	300	50	50
7	60	420	272	148	22	60	350	50	78
8	60	480	310	170	38	60	400	50	90
9	60	540	355	185	45	60	450	50	95
10	60	600	410	190	55	60	500	50	90
11	60	660	475	185	65	60	550	50	75

At a price of $60, the firm should produce ten units of output to maximize profit, which is $190 when $q = 10$. This is also the point closest to where price equals marginal cost without having marginal cost exceed price. At a price of $50, the firm should produce nine units to maximize

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profit, which will be \$95. Thus when price falls from \$60 to \$50, the firm's output drops from 10 to 9 units and profit falls from \$190 to \$95.

2. Using the data in the table, show what happens to the firm's output choice and profit if the fixed cost of production increases from \$100 to \$150 and then to \$200. Assume that the price of the output remains at \$60 per unit. What general conclusion can you reach about the effects of fixed costs on the firm's output choice?

The table below shows the firm's revenue and cost information for fixed cost (F) of 100, 150, and 200.

In all three cases, with fixed cost equal to 100, then 150, and then 200, the firm will produce 10 units of output because this is the point closest to where price equals marginal cost without having marginal cost exceed price. Fixed costs do not influence the optimal quantity, because they do not influence marginal cost. Higher fixed costs result in lower profits, but the highest profit always occurs at the same level of output, which is 10 units in this example.

q	P	R	C $F = 100$	π $F = 100$	MC	C $F = 150$	π $F = 150$	C $F = 200$	π $F = 200$
0	60	0	100	–100	—	150	–150	200	–200
1	60	60	150	–90	50	200	–140	250	–190
2	60	120	178	–58	28	228	–108	278	–158
3	60	180	198	–18	20	248	–68	298	–118
4	60	240	212	28	14	262	–22	312	–72
5	60	300	230	70	18	280	20	330	–30
6	60	360	250	110	20	300	60	350	10
7	60	420	272	148	22	322	98	372	48
8	60	480	310	170	38	360	120	410	70
9	60	540	355	185	45	405	135	455	85
10	60	600	410	190	55	460	140	510	90
11	60	660	475	185	65	525	135	575	85

3. Use the same information as in Exercise 1.

a. Derive the firm's short-run supply curve. (*Hint*: You may want to plot the appropriate cost curves.)

The firm's short-run supply curve is its marginal cost curve above average variable cost. The table below lists marginal cost, total cost, variable cost, fixed cost, and average variable cost. The firm will produce 8 or more units depending on the market price and will not produce in the 0 – 7 units of output range because in this range MC is less than AVC. When MC is below AVC, the firm minimizes losses by shutting down and producing nothing in the short run. The points on the firm's supply curve are therefore (38,8), (45,9), (55,10) and (65,11), where the first number inside the parentheses is price and the second is output q.

q	C	MC	TVC	TFC	AVC

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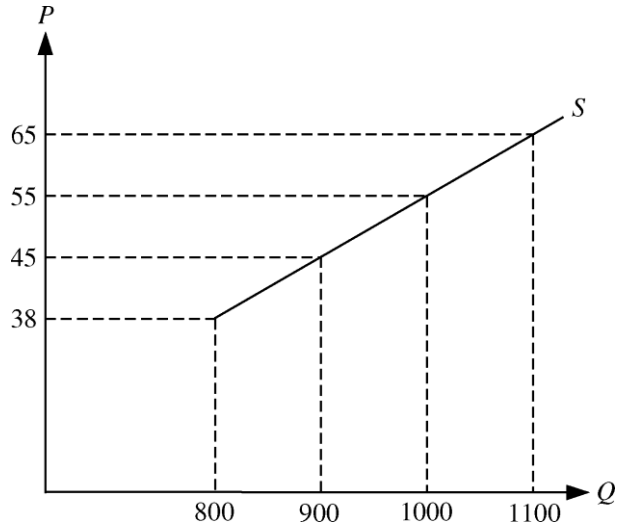
0	100	—	0	100	—
1	150	50	50	100	50.0
2	178	28	78	100	39.0
3	198	20	98	100	32.7
4	212	14	112	100	28.0
5	230	18	130	100	26.0
6	250	20	150	100	25.0
7	272	22	172	100	24.6
8	310	38	210	100	26.3
9	355	45	255	100	28.3
10	410	55	310	100	31.0
11	475	65	375	100	34.1

b. If 100 identical firms are in the market, what is the industry supply curve?

For 100 firms with identical cost structures, the market supply curve is the horizontal summation of each firm's output at each price. From the table above we know that when $P = 38$, each firm will produce 8 units, because $MC = 38$ at an output of 8 units. Therefore, when $P = 38$, $Q = 800$ units would be supplied by all the firms in the industry. The other points we know are: $P = 45$ and $Q = 900$, $P = 55$ and $Q = 1000$, and $P = 65$ and $Q = 1100$. The industry supply curve is shown in the diagram below.



4. Suppose you are the manager of a watchmaking firm operating in a competitive market. Your cost of production is given by $C = 200 + 2q^2$, where q is the level of output and C is total cost. (The marginal cost of production is $4q$; the fixed cost is \$200.)

a. If the price of watches is \$100, how many watches should you produce to maximize profit?

Profits are maximized where price equals marginal cost. Therefore,

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$$100 = 4q, \text{ or } q = 25.$$

b. What will the profit level be?

Profit is equal to total revenue minus total cost: $\pi = Pq - (200 + 2q^2)$. Thus,

$$\pi = (100)(25) - (200 + 2(25)^2) = \$1050.$$

c. At what minimum price will the firm produce a positive output?

The firm will produce in the short run if its revenues are greater than its total variable costs. The firm's short-run supply curve is its *MC* curve above minimum *AVC*. Here, $AVC = \frac{VC}{q} = \frac{2q^2}{q} = 2q$.

Also, $MC = 4q$. So, *MC* is greater than *AVC* for any quantity greater than 0. This means that the firm produces in the short run as long as price is positive.

5. Suppose that a competitive firm's marginal cost of producing output q is given by $MC(q) = 3 + 2q$. Assume that the market price of the firm's product is \$9.

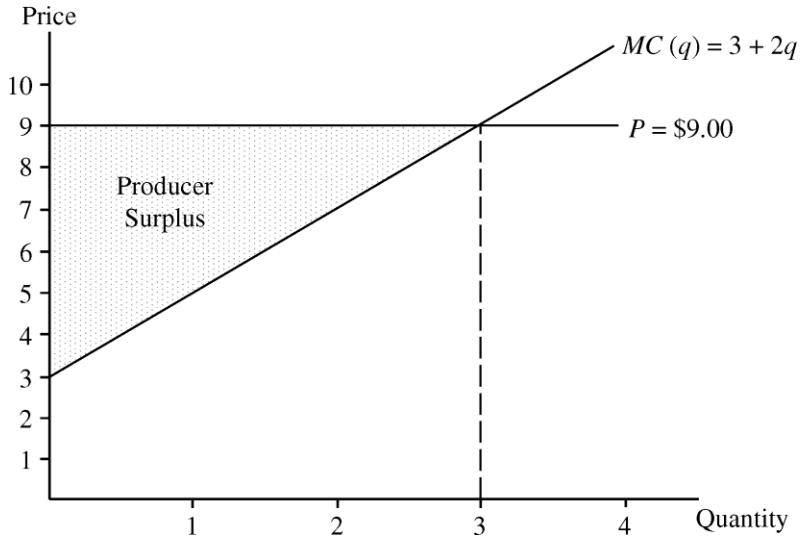
a. What level of output will the firm produce?

The firm should set the market price equal to marginal cost to maximize its profits:

$$9 = 3 + 2q, \text{ or } q = 3.$$

b. What is the firm's producer surplus?

Producer surplus is equal to the area below the market price, i.e., \$9.00, and above the marginal cost curve, i.e., $3 + 2q$. Because *MC* is linear, producer surplus is a triangle with a base equal to 3 (since $q = 3$) and a height of \$6 ($9 - 3 = 6$). The area of a triangle is (1/2) × (base) × (height). Therefore, producer surplus is (0.5)(3)(6) = \$9.



c. Suppose that the average variable cost of the firm is given by $AVC(q) = 3 + q$. Suppose that the firm's fixed costs are known to be \$3. Will the firm be earning a positive, negative, or zero profit in the short run?

Profit is equal to total revenue minus total cost. Total cost is equal to total variable cost plus fixed cost. Total variable cost is equal to $AVC(q) \times q$. At $q = 3$, $AVC(q) = 3 + 3 = 6$, and therefore

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$$TVC = (6)(3) = \$18.$$

Fixed cost is equal to \$3. Therefore, total cost equals *TVC* plus *TFC*, or

$$C = \$18 + 3 = \$21.$$

Total revenue is price times quantity:

$$R = (\$9)(3) = \$27.$$

Profit is total revenue minus total cost:

$$\pi = \$27 - 21 = \$6.$$

Therefore, the firm is earning positive economic profits. More easily, you might recall that profit equals producer surplus minus fixed cost. Since we found that producer surplus was \$9 in part b, profit equals 9 – 3 or \$6.

6. A firm produces a product in a competitive industry and has a total cost function $C = 50 + 4q + 2q^2$ and a marginal cost function $MC = 4 + 4q$. At the given market price of \$20, the firm is producing 5 units of output. Is the firm maximizing its profit? What quantity of output should the firm produce in the long run?

If the firm is maximizing profit, then price will be equal to marginal cost. $P = MC$ results in $20 = 4 + 4q$, or $q = 4$. The firm is not maximizing profit; it is producing too much output. The current level of profit is

$$\pi = Pq - C = 20(5) - (50 + 4(5) + 2(5)^2) = -20,$$

and the profit maximizing level is

$$\pi = 20(4) - (50 + 4(4) + 2(4)^2) = -18.$$

Given no change in the price of the product or the cost structure of the firm, the firm should produce $q = 0$ units of output in the long run since economic profit is negative at the quantity where price equals marginal cost. The firm should exit the industry.

7. Suppose the same firm's cost function is $C(q) = 4q^2 + 16$.

a. Find variable cost, fixed cost, average cost, average variable cost, and average fixed cost. (*Hint*: Marginal cost is given by $MC = 8q$.)

Variable cost is that part of total cost that depends on q (so $VC = 4q^2$) and fixed cost is that part of total cost that does not depend on q (so $FC = 16$).

$$VC = 4q^2$$

$$FC = 16$$

$$AC = \frac{C(q)}{q} = 4q + \frac{16}{q}$$

$$AVC = \frac{VC}{q} = 4q$$

$$AFC = \frac{FC}{q} = \frac{16}{q}$$

b. Show the average cost, marginal cost, and average variable cost curves on a graph.

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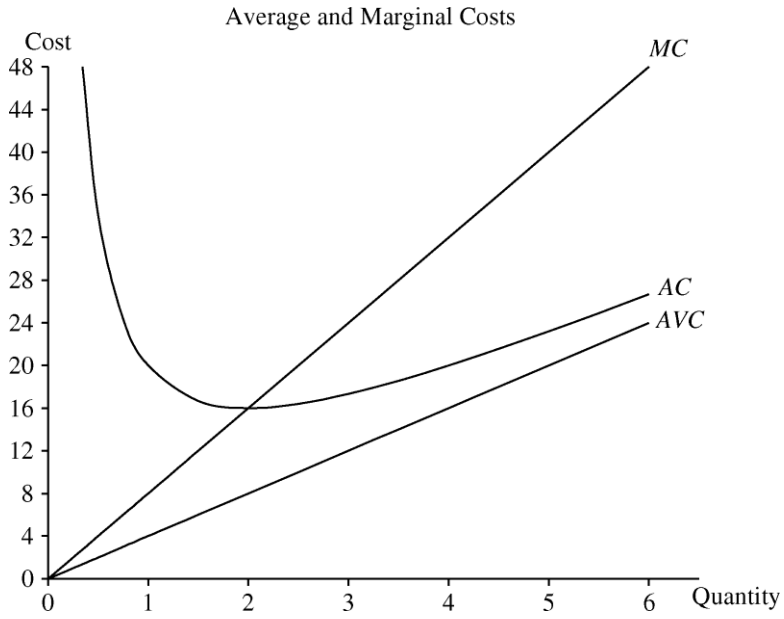
Average cost is U-shaped. Average cost is relatively large at first because the firm is not able to spread the fixed cost over very many units of output. As output increases, average fixed cost falls quickly, leading to a rapid decline in average cost. Average cost will increase at some point because the average fixed cost will become very small and average variable cost is increasing as q increases. MC and AVC are linear in this example, and both pass through the origin. Average variable cost is everywhere below average cost. Marginal cost is everywhere above average

variable cost. If the average is rising, then the marginal must be above the average. Marginal cost intersects average cost at its minimum point, which occurs at a quantity of 2 where MC and AC both equal \$16.



c. Find the output that minimizes average cost.

Minimum average cost occurs at the quantity where MC is equal to AC:

$$AC = 4q + \frac{16}{q} = 8q = MC$$

$$\frac{16}{q} = 4q$$

$$16 = 4q^2$$

$$4 = q^2$$

$$2 = q.$$

d. At what range of prices will the firm produce a positive output?

The firm will supply positive levels of output in the short run as long as $P = MC > AVC$, or as long as the firm is covering its variable costs of production. In this case, marginal cost is above

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average variable cost at all output levels, so the firm will supply positive output at any positive price.

e. At what range of prices will the firm earn a negative profit?

The firm will earn negative profit when $P = MC < AC$, or at any price below minimum average cost. In part c we found that the minimum average cost occurs where $q = 2$. Plug $q = 2$ into the average cost function to find $AC = 16$. The firm will therefore earn negative profit if price is below 16.

f. At what range of prices will the firm earn a positive profit?

In part e we found that the firm would earn negative profit at any price below 16. The firm therefore earns positive profit as long as price is above 16.

8. A competitive firm has the following short-run cost function:

$$C(q) = q^3 - 8q^2 + 30q + 5.$$

a. Find *MC*, *AC*, and *AVC* and sketch them on a graph.

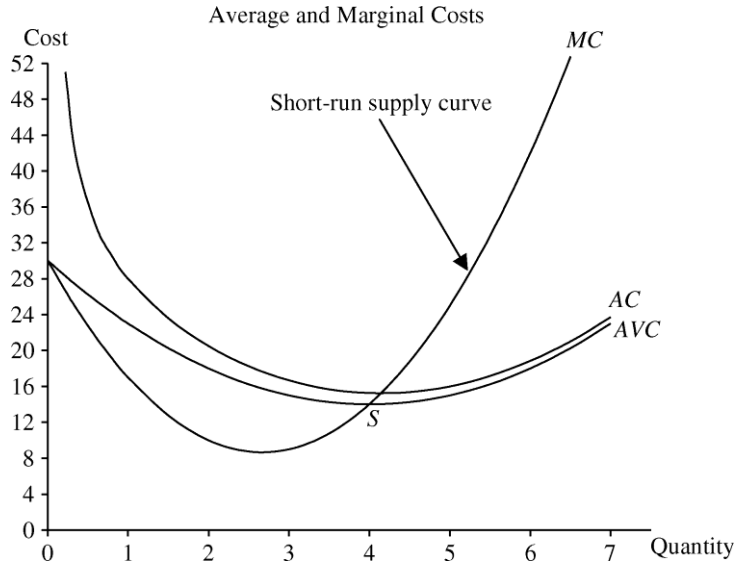
The functions can be calculated as follows:

$$MC = \frac{dC}{dq} = 3q^2 - 16q + 30$$

$$AC = \frac{C}{q} = q^2 - 8q + 30 + \frac{5}{q}$$

$$AVC = \frac{VC}{q} = q^2 - 8q + 30.$$

Graphically, all three cost functions are U-shaped in that cost initially declines as q increases, and then increases as q increases. Average variable cost is below average cost everywhere. Marginal cost is initially below AVC and then increases to intersect AVC at its minimum point, S. MC is also initially below AC and then intersects AC at its minimum point.



b. At what range of prices will the firm supply zero output?

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The firm will find it profitable to produce in the short run as long as price is greater than or equal to average variable cost. If price is less than average variable cost then the firm will be better off shutting down in the short run, as it will only lose its fixed cost and not fixed plus some variable cost. Here we need to find the minimum average variable cost, which can be done in two different ways. You can either set marginal cost equal to average variable cost, or you can differentiate average variable cost with respect to q and set this equal to zero. In both cases, you can solve for q and then plug into AVC to find the minimum AVC. Here we will set AVC equal to MC:

$$AVC = q^2 - 8q + 30 = 3q^2 - 16q + 30 = MC$$
$$2q^2 = 8q$$
$$q = 4$$
$$AVC(q = 4) = 4^2 - 8 * 4 + 30 = 14.$$

This is point S on the graph. Hence the firm supplies zero output if $P < \$14$.

c. Identify the firm's supply curve on your graph.

The firm's supply curve is the MC curve above the point where $MC = AVC$. The firm will produce at the point where price equals MC as long as MC is greater than or equal to AVC. This point is labeled S on the graph, so the short-run supply curve is the portion of MC that lies above point S.

d. At what price would the firm supply exactly 6 units of output?

The firm maximizes profit by choosing the level of output such that $P = MC$. To find the price where the firm would supply 6 units of output, set q equal to 6 and solve for MC:

$$P = MC = 3q^2 - 16q + 30 = 3(6^2) - 16(6) + 30 = 42.$$

9. a. Suppose that a firm's production function is $q = 9x^{\frac{1}{2}}$ in the short run, where there are fixed costs of \$1000, and x is the variable input whose cost is \$4000 per unit. What is the total cost of producing a level of output q? In other words, identify the total cost function $C(q)$.

Since the variable input costs \$4000 per unit, total variable cost is 4000 times the number of units used, or $4000x$. Therefore, the total cost of the inputs used is $C(x)$ = variable cost + fixed cost = $4000x + 1000$. Now rewrite the production function to express x in terms of q: $x = \frac{q^2}{81}$. We can then substitute this into the above cost function to find $C(q)$:

$$C(q) = \frac{4000q^2}{81} + 1000,$$

or $C(q) = 49.3827q^2 + 1000$.

b. Write down the equation for the supply curve.

The firm supplies output where $P = MC$ as long as $MC > AVC$. In this example, $MC = 98.7654q$ is always greater than $AVC = 49.3827q$, so the entire marginal cost curve is the supply curve. Therefore $P = 98.7654q$, or $q = .010125P$, is the firm's short-run supply curve.

c. If price is \$1000, how many units will the firm produce? What is the level of profit? Illustrate your answer on a cost curve graph.

Use the supply curve from part b: $q = 0.010125(1000) = 10.125$.

Profit $\pi = R - C = 1000(10.125) - [(4000(10.125)^2/81) + 1000] = \$4062.50$. Graphically, the firm produces where the price line hits the MC curve. Since profit is positive, this occurs at a

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quantity where price is greater than average cost. To find profit on the graph, take the difference between the revenue rectangle (price times quantity) and the cost rectangle (average cost times quantity). The area of the resulting rectangle is the firm's profit.

10. Suppose you are given the following information about a particular industry:

$$Q^D = 6500 - 100P \quad \text{Market demand}$$

$$Q^S = 1200P \quad \text{Market supply}$$

$$C(q) = 722 + \frac{q^2}{200} \quad \text{Firm total cost function}$$

$$MC(q) = \frac{2q}{200} \quad \text{Firm marginal cost function.}$$

Assume that all firms are identical, and that the market is characterized by perfect competition.

a. Find the equilibrium price, the equilibrium quantity, the output supplied by the firm, and the profit of each firm.

Equilibrium price and quantity are found by setting market demand equal to market supply: $6500 - 100P = 1200P$. Solve to find $P = \$5$ and substitute into either equation to find $Q = 6000$. To find the output for the firm set price equal to marginal cost: $5 = \frac{2q}{200}$ so $q = 500$. Profit is total revenue minus total cost or $\pi = Pq - \left(722 + \frac{q^2}{200}\right) = 5(500) - \left(722 + \frac{500^2}{200}\right) = \$528$. Notice that since the total output in the market is 6000, and each firm's output is 500, there must be 6000/500 = 12 firms in the industry.

b. Would you expect to see entry into or exit from the industry in the long run? Explain. What effect will entry or exit have on market equilibrium?

We would expect entry because firms in the industry are making positive economic profits. As new firms enter, market supply will increase (i.e., the market supply curve will shift down and to the right), which will cause the market equilibrium price to fall, all else the same. This, in turn, will reduce each firm's optimal output and profit. When profit falls to zero, no further entry will occur.

c. What is the lowest price at which each firm would sell its output in the long run? Is profit positive, negative, or zero at this price? Explain.

In the long run profit falls to zero, which means price falls to the minimum value of *AC*. To find the minimum average cost, set marginal cost equal to average cost and solve for *q*:

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$$\frac{2q}{200} = \frac{722}{q} + \frac{q}{200}$$
$$\frac{q}{200} = \frac{722}{q}$$
$$q^2 = 722(200)$$
$$q = 380$$
$$AC(q = 380) = 3.8.$$

Therefore, the firm will not sell for any price less than \$3.80 in the long run. The long-run equilibrium price is therefore \$3.80, and at a price of \$3.80, each firm sells 380 units and earns an economic profit of zero because $P = AC$.

d. What is the lowest price at which each firm would sell its output in the short run? Is profit positive, negative, or zero at this price? Explain.

The firm will sell its output at any price above zero in the short run, because marginal cost is above average variable cost ($MC = q/100 > AVC = q/200$) for all positive prices. Profit is negative if price is just above zero.

11. Suppose that a competitive firm has a total cost function $C(q) = 450 + 15q + 2q^2$ and a marginal cost function $MC(q) = 15 + 4q$. If the market price is $P = \$115$ per unit, find the level of output produced by the firm. Find the level of profit and the level of producer surplus.

The firm should produce where price is equal to marginal cost so that $115 = 15 + 4q$, and therefore $q = 25$. Profit is $\pi = R - C = 115(25) - [450 + 15(25) + 2(25)^2] = \$800$.

Producer surplus is profit plus fixed cost, so $PS = 800 + 450 = \$1250$. Producer surplus can also be found graphically by calculating the area below price and above the marginal cost (supply) curve: $PS = (1/2)(25)(115 - 15) = \$1250$.

12. A number of stores offer film developing as a service to their customers. Suppose that each store offering this service has a cost function $C(q) = 50 + 0.5q + 0.08q^2$ and a marginal cost $MC = 0.5 + 0.16q$.

a. If the going rate for developing a roll of film is \$8.50, is the industry in long-run equilibrium? If not, find the price associated with long-run equilibrium.

Each firm's profit-maximizing quantity is where price equals marginal cost: $8.50 = 0.5 + 0.16q$. Thus $q = 50$. Profit is then $8.50(50) - [50 + 0.5(50) + 0.08(50)^2] = \$150$. The industry is not in long-run equilibrium because profit is greater than zero. In long-run equilibrium, firms produce where price is equal to minimum average cost and there is no incentive for entry or exit. To find the minimum average cost point, set marginal cost equal to average cost and solve for q:

$$MC = 0.5 + 0.16q = \frac{50}{q} + 0.5 + 0.08q = AC$$
$$0.08q^2 = 50$$
$$q = 25.$$

To find the long-run equilibrium price in the market, substitute $q = 25$ into either marginal cost or average cost to get $P = \$4.50$.

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b. Suppose now that a new technology is developed which will reduce the cost of film developing by 25%. Assuming that the industry is in long-run equilibrium, how much would any one store be willing to pay to purchase this new technology?

The new total cost function and marginal cost function can be found by multiplying the old functions by 0.75 (or 75%). The new functions are:

$$C_{new}(q) = 0.75(50 + 0.5q + 0.08q^2) = 37.5 + 0.375q + 0.06q^2$$

$$MC_{new}(q) = 0.375 + 0.12q.$$

The firm will set marginal cost equal to price, which is \$4.50 in the long-run equilibrium. Solve for q to find that the firm will develop approximately 34 rolls of film (rounding down). If $q = 34$ then profit is \$33.39. This is the most the firm would be willing to pay per year for the new technology. It will pay this amount only if no other firms can adopt the new technology, because if all firms adopt the new technology, the long-run equilibrium price will fall to the minimum average cost of the new technology and profits will be driven to zero.

13. Consider a city that has a number of hot dog stands operating throughout the downtown area. Suppose that each vendor has a marginal cost of \$1.50 per hot dog sold and no fixed cost. Suppose the maximum number of hot dogs that any one vendor can sell is 100 per day.

a. If the price of a hot dog is \$2, how may hot dogs does each vendor want to sell?

Since marginal cost is equal to \$1.50 and the price is \$2, each hot dog vendor will want to sell as many hot dogs as possible, which is 100 per day.

b. If the industry is perfectly competitive, will the price remain at \$2 for a hot dog? If not, what will the price be?

Each hot dog vendor is making a profit of \$0.50 per hot dog at the current \$2 price: a total profit of \$50. Therefore, the price will not remain at \$2, because these positive economic profits will encourage new vendors to enter the market. As new firms start selling hot dogs, market supply will increase and price will drop until economic profits are driven to zero. That will happen when price falls to \$1.50, where price equals average cost. (Note that $AC = MC = \$1.50$ for firms in this industry because fixed cost is zero and MC is constant at \$1.50).

c. If each vendor sells exactly 100 hot dogs a day and the demand for hot dogs from vendors in the city is $Q = 4400 - 1200P$, how many vendors are there?

At the current price of \$2, the total number of hot dogs demanded is $Q = 4400 - 1200(2) = 2000$, so there are 2000/100 = 20 vendors. In the long run, price will fall to \$1.50, and the number of hot dogs demanded will increase to $Q = 2600$. If each vendor sells 100 hot dogs, there will be 26 vendors in the long run.

d. Suppose the city decides to regulate hot dog vendors by issuing permits. If the city issues only 20 permits and if each vendor continues to sell 100 hot dogs a day, what price will a hot dog sell for?

If there are 20 vendors selling 100 hot dogs each, then the total number sold is 2000. If $Q = 2000$ then $P = \$2$, from the demand curve.

e. Suppose the city decides to sell the permits. What is the highest price a vendor would pay for a permit?

At the price of \$2, each vendor is making a profit of \$50 per day as noted in part b. This is the most a vendor would pay per day for a permit.

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14. A sales tax of $1 per unit of output is placed on a particular firm whose product sells for $5 in a competitive industry with many firms.

a. How will this tax affect the cost curves for the firm?

With a tax of $1 per unit, all the firm's cost curves (except those based solely on fixed costs) shift up. Total cost becomes $TC + tq$, or $TC + q$ since the tax rate $t = 1$. Average variable cost becomes $AVC + 1$, Average cost is now $AC + 1$, and marginal cost becomes $MC + 1$. Average fixed cost does not change.

b. What will happen to the firm's price, output, and profit?

Because the firm is a price-taker in a competitive market, the imposition of the tax on only one firm does not change the market price. Since the firm's short-run supply curve is its marginal cost curve (above average variable cost), and the marginal cost curve has shifted up (and to the left), the firm supplies less to the market at every price. Profits are lower at every quantity.

c. Will there be entry or exit in the industry?

If the tax is placed on a single firm, that firm will go out of business in the long run because price will be below the firm's minimum average cost. One new firm will enter the market to take its place, assuming the new firm is not taxed like the original one.

15. A sales tax of 10% is placed on half the firms (the polluters) in a competitive industry. The revenue is paid to the remaining firms (the nonpolluters) as a 10% subsidy on the value of output sold.

a. Assuming that all firms have identical constant long-run average costs before the sales tax-subsidy policy, what do you expect to happen (in both the short run and the long run) to the price of the product, the output of firms, and industry output? (*Hint*: How does price relate to industry input?)

In long-run equilibrium, the price of the product equals each firm's minimum average cost. So, if a long-run competitive equilibrium existed before the sales tax-subsidy policy, price would have been equal to marginal cost and long-run minimum average cost. After the sales tax-subsidy policy is implemented, the net price received by polluters (after deducting the sales tax) falls below their minimum average cost. They will reduce output to the point where price minus the tax equals short-run marginal cost. The non-polluters will increase output because the net price they receive increases by 10%, and they will produce where net price equals short-run marginal cost. Total industry output may increase, decrease or stay the same in the short run. A likely scenario would be for the reduction in output from the polluters to be roughly equal to the increase in production from the non-polluters, keeping industry output and price about the same as they were before the sales tax-subsidy policy was implemented.

In the long run, all the polluters will exit the industry because their net price would be below the minimum average cost. Non-polluters, on the other hand, receive a price above minimum average cost because of the subsidy. They earn economic profits that will encourage the entry of other non-polluters. If this is a constant-cost industry, minimum average cost will remain unchanged as entry occurs. As more and more non-polluters enter the market, they will push the market price below the original equilibrium price because of the 10% subsidy. In fact, price should fall by about 10%. Total industry output will increase, although each individual firm will produce the same amount of output it did before the tax-subsidy policy.

b. Can such a policy *always* be achieved with a balanced budget in which tax revenues are equal to subsidy payments? Why or why not? Explain.

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No. As the polluters exit and non-polluters enter the industry, revenues from the sales tax imposed on polluters decrease and subsidies paid to the non-polluters increase. This imbalance occurs when the first polluter leaves the industry and becomes larger and larger as more polluters exit and non-polluters enter the industry. If the taxes and subsidies are readjusted with every exiting and entering firm, then tax revenues from polluting firms will shrink and the non-polluters will get smaller and smaller subsidies. Taken to the extreme, both the sales tax and the subsidy will disappear.

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