Chapter 9
Monopoly

SOLUTIONS TO END-OF-CHAPTER QUESTIONS

MONOPOLY PROFIT MAXIMIZATION

1.1 When the inverse demand curve is linear, marginal revenue has the same intercept and twice the slope. Thus, if inverse demand is $P = 300 - 3Q$, then marginal revenue is $MR = 300 - 6Q$. The demand curve intersects the horizontal, quantity axis when price equals zero:

$$p = 300 - 3Q$$

$$0 = 300 - 3Q$$

$$300 = 3Q$$

$$Q = 100 \text{ units.}$$

The marginal revenue curve intersects the horizontal, quantity axis when marginal revenue equals zero:

$$MR = 300 - 6Q$$

$$0 = 300 - 6Q$$

$$Q = 50 \text{ units.}$$

1.2   Marginal revenue (*MR*) is the change in revenue (*R*) with respect to quantity:

$$MR = \frac{\partial R}{\partial Q}.$$

Revenue is price multiplied by quantity:

$$R = p*Q.$$

Substituting the demand equation for *p*,

$$R = 10Q^{-0.5}(Q)$$

$$R = 10Q^{0.5}.$$

Taking the derivative of *R* with respect to *Q*, marginal revenue is

$$MR = 5Q^{-0.5}.$$

1.3   The elasticity of demand is the percentage change in quantity divided by the percentage change in price:

$$\varepsilon = \frac{\Delta Q}{Q} \div \frac{\Delta p}{p}$$

$$\varepsilon = \frac{\Delta Q}{\Delta p}\left(\frac{p}{Q}\right).$$

When *Q* = 10, *p* = 500 − 10(10) = $400. The demand function is *Q* = 50 − 0.10*p*. The slope of the demand function is

$$\frac{\Delta Q}{\Delta p} = -0.10.$$

Therefore, the elasticity of demand is
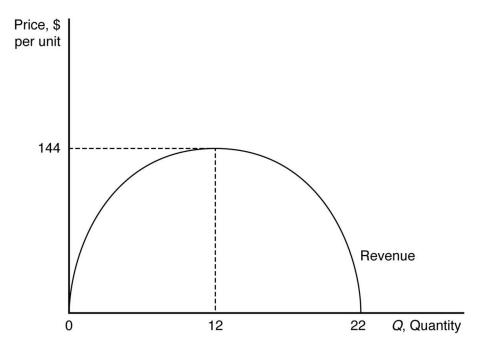
$$\varepsilon = -0.1\left(\frac{400}{10}\right) = -4.$$

Revenue is price multiplied by quantity, which is $400 × 10 = $4,000.

1.4   Price and quantity are related through the demand function. Therefore, when one is determined, the other one is simultaneously fixed. Therefore, the monopoly cannot determine both. As long as the monopoly chooses the level that maximizes its profit, it does not matter whether it chooses the price level or the quantity.

1.5   Revenue is maximized when the change in revenue is zero. This occurs at the quantity
        where marginal revenue is zero, which is at *Q* = 12 units.
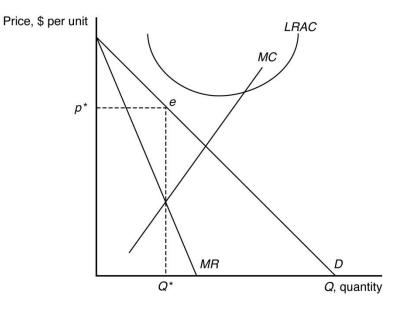
        A monopoly maximizes profit by producing the quantity where marginal revenue equals
        marginal cost. Revenue is maximized at the quantity where marginal revenue equals zero.
        Because marginal revenue is decreasing with output and marginal costs are positive,
        marginal revenue equals marginal cost at a smaller quantity than when marginal revenue
        equals zero.

        Revenue equals price multiplied by quantity. Revenue is zero when price is zero and when
        the quantity demanded is zero and is maximized when quantity equals 12 units.
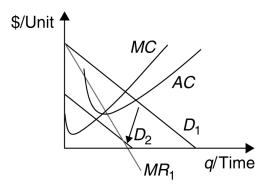

1.6   This test is relevant because if the club were maximizing revenue, it would be operating at
        the level *MR* = 0, where the elasticity is −1.

1.7   A monopoly maximizes profit by producing the quantity where marginal cost (*MC*) equals
        marginal revenue (*MR*). Price is then set according to the demand curve (*D*). The profit-
        maximizing price and quantity for a monopoly are indicated by point "e" in the figure on
        the next page. The long-run average cost of production at that quantity is indicated by the
        long-run average cost curve.

        A monopoly will shut down in the long run if it would incur losses when producing
        optimally. A firm will incur losses if its price is less than the long-run average cost of
        production. Because a monopoly maximizes profit by charging the price indicated by its
        demand curve at the quantity where marginal revenue equals marginal cost, a monopoly
        would incur losses when producing optimally if the long-run average cost curve is above
        (greater than) the demand curve at the profit-maximizing quantity.

For example, at the long-run average cost indicated by *LRAC* in the graph below, the monopoly breaks even in the long run when producing optimally (at *Q**). If long-run average costs were higher, then the monopoly would shut down; if lower, it would earn profit.

1.8 A competitive firm operates at the lowest point of its long-run average cost curve due to competition: if it raises its price above the lowest possible long-run average cost, then it will sell no output (because other firms would be able to sell output for less). The firm would not lower its price less than the lowest possible long-run average cost because it would incur losses. A monopoly faces no competition, so it is able to maximize profit by producing where marginal revenue equals marginal cost without other firms charging lower prices until price equals the lowest possible long-run average cost. That is, even if a monopoly is not operating where long-run average costs are minimized, no other firms are present in the market to profitably charge lower prices.

1.9 When demand is D_1, the price the monopoly sets (vertically above the point of intersection of MR_1 and *MC* on D_1) is above the *AC*, and thus the monopoly makes a positive profit. However, when the demand curve shifts to the left, to D_2, the demand is below the *AC* curve, and there is no price where the monopoly can make a positive profit.

1.10 Set *MC* = *MR* and solve:

$$MR = 100 - 2Q$$
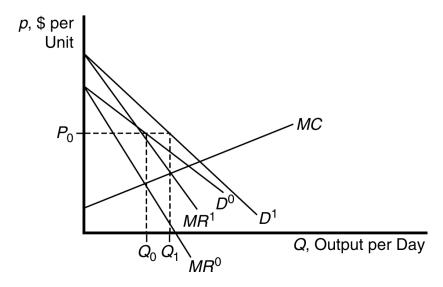$$MC = 5$$
$$5 = 100 - 2Q$$
$$Q^* = 47.5$$
$$p^* = 52.5$$

If $C(Q) = 100 + 5Q,$ the answer does not change because marginal cost is still $MC = 5,$ and therefore the profit-maximizing condition is still the same.

1.11 Set *MC* = *MR* and solve:

$$MR = \frac{dR}{dQ} = \frac{d}{dQ}(10Q^{-1/2} \cdot Q) = \frac{d}{dQ}(10Q^{1/2}) = 5Q^{-1/2}$$
$$MC = 5$$
$$Q^* = 1$$
$$p^* = 10$$

1.12 See the figure below. If the demand curve shifts from D^0 to D^1, output increases from Q_0 to Q_1, but price remains unchanged. The monopoly does not have a supply curve because there is not a unique correspondence between price and quantity supplied.

MARKET POWER

2.1   The Lerner Index or price markup is the ratio of the difference between price and marginal cost to the price:

$$L = \frac{p - MC}{p},$$

which is equal the negative of the reciprocal of the elasticity of demand:

$$L = -\frac{1}{\varepsilon}.$$

Thus,

$$\frac{p}{MC} = \frac{\varepsilon}{1+\varepsilon}.$$

That is, as the elasticity of demand, which is negative and greater than 1 in absolute value when the monopoly produces optimally, gets smaller in absolute value, the ratio $\dfrac{p}{MC}$ gets larger. Monopolies that face demand curves that are only slightly elastic set prices that are multiples of their marginal cost and have Lerner Indexes close to 1.

A monopoly maximizes profit by producing the quantity where marginal cost equals marginal revenue. Because marginal costs are assumed to be positive, this occurs where marginal revenue is positive. Marginal revenue equals the change in revenue with respect to output, which is only positive when the elasticity of demand is elastic. If demand were inelastic, then marginal revenue would be negative.

2.2 A monopolist may set price equal to marginal cost if other firms can enter costlessly. If there is free entry, any price above marginal cost will attract other firms. Thus even though the firm has no current competitors, it sets price equal to marginal cost to deter entry of potential competitors. Also, if not all customers are charged the same price (price discrimination), the firm may want to sell the last unit where price equals marginal cost.

2.3 The Lerner Index is (84.95 – 37)/84.95 = 0.56. Hence, Stamps.com believes that it faces a demand elasticity of –1.79.

2.4 The Lerner index is (1,840.8 – 100)/1,840.8 = 0.95. Hence, Tenet believes that the elasticity it faces is –1.06.

2.5 Apple's price/marginal cost ratio was $349/84 = 4.155.

The Lerner Index or price markup is the ratio of the difference between price and marginal cost to the price:

$$L = \frac{p - MC}{p}.$$

Therefore,

$$L = \frac{349 - 84}{349} = 0.76.$$

Finally, a monopoly operates optimally where

$$MR = MC$$

$$p\left(1 + \frac{1}{\varepsilon}\right) = MC.$$

With a marginal cost of $84 and a profit-maximizing price of $349, the elasticity of demand is

$$\varepsilon = -1.317.$$

2.6 Amazon's Lerner Index was $(p - MC)/p = (359 - 159)/359 \approx 0.557$. Using Equation 11.11, we know that $(p - MC)/p \approx 0.557 = -1/\varepsilon$, so $\varepsilon \approx -1.795$.

2.7 Given that Apple's marginal cost was constant, its average variable cost equaled its marginal cost, $200. Its average fixed cost was its fixed cost divided by the quantity produced, $736/Q$. Thus, its average cost was $AC = 200 + 736/Q$. Because the inverse demand function was $p = 600 - 25Q$, Apple's revenue function was $R = 600Q - 25Q^2$, so $MR = dR/dQ = 600 - 50Q$. Apple maximized its profit where $MR = 600$
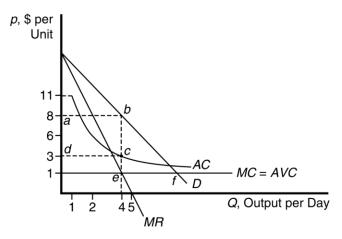
− 50Q = 200 = *MC*. Solving this equation for the profit-maximizing output, we find that *Q* = 8 million units. By substituting this quantity into the inverse demand equation, we determine that the profit-maximizing price was

p = $400 per unit, as the figure shows. The firm's profit was π = (*p* − *AC*)*Q* = [400 − (200 + 736/8)]8 = $864 million. Apple's Lerner Index was (*p* − *MC*)/*p* = *[400 −* 200*]*/400 = ½. According to Equation 9.10, a profit-maximizing monopoly operates where (*p* − *MC*)/*p* = −1/ε. Combining that equation with the Lerner Index from the previous step, we learn that ½ = −1/ε, or ε = −2.

2.8   The market power of these firms (and many others) has been eroded by changes in consumer tastes and preferences, changes in technology, and increased competition from competitors.

MARKET FAILURE DUE TO MONOPOLY PRICING

3.1   See the figure below. The values of price and quantity depend on the demand curve drawn by the student. Profits are area *abcd,* and the deadweight loss is area *bef*.

3.2   The monopoly's profit-maximizing price is $65, and quantity is 55. The competitive market price is $10, and quantity is 110. Deadweight loss is equal to a triangle with a base equal to the difference in the monopoly quantity and the competitive quantity (110 − 55 = 55) and a height equal to the difference in them monopoly price and the competitive price (65 − 10 = 55): *DWL* = 0.5 × 55 × 55 = $1,512.50.

3.3   The effect of a franchise tax or lump-sum tax on a monopoly is to reduce profits by the amount of the tax. Because marginal cost is unchanged, the profit-maximizing/loss-minimizing output and price remain unchanged, with one exception. If the tax is large enough, losses may exceed fixed costs. If that is the case, the firm will shut down (produce no output) in order to minimize losses.

3.4   Before the tax, the monopolist will produce where *MC* = *MR*, or where 120 − 2*Q* = 10. *Q** = 55, *p** = 65, consumer surplus is $1,512.50, (120 − 65)*55/2, and producer surplus is (65

– 10)*55 = $3,025 for total welfare of $4,537.50. After the tax, the producer's new *MC* is 20. *Q** = 50, *p** = 60 for producers and 70 for consumers. Thus, the incidence of the tax falls equally on consumers and producers (that is, it is 0.5 to consumers). The new consumer surplus is $1,250, producer surplus is $2,500, and tax revenue is $500, for a total welfare of $4,250. Thus, both consumers and producers are worse off with the tax, and total welfare is lower.

3.5   Suppose that the monopoly faces a constant-elasticity demand curve, with elasticity ε, and has a constant marginal cost, *m*, and that the government imposes a specific tax of τ. The monopoly sets its price such that $p = (m + \tau)/(1 + 1/\varepsilon)$. Thus, $dp/d\tau = 1/(1 + 1/\varepsilon) > 1$.

3.6   A tax on profit will not change firm behavior unless it causes profit to fall below zero (in which case the firm / market may cease to exist). Equilibrium price and quantity remain the same as does consumer surplus. Producer surplus is reduced by the amount of the tax, but as that tax revenue remains part of the broader market outcome, overall surplus remains unchanged as well.

CAUSES OF MONOPOLY

4.1   Yes. The demand curve could cut the average cost curve only in its downward-sloping section. Consequently, the average cost is strictly downward sloping in the relevant region.

4.2   No. In order for a firm to be a natural monopoly, its production must exhibit economies of scale; that is, firm's average cost curve must be downward sloping. If the firm operates in the upward-sloping region of its average cost curve, it is possible that two or more firms could produce in the same industry more efficiently than one firm.

4.3   Yes. Because the AC curve is always downward sloping, it will always be less expensive for a single firm to produce 2*x* than for two different firms to each produce *x* units.

4.4   Once a book is online, it is available to consumers for free. As a result, the publisher may lose some consumers after the copyright expires. Limiting the length of a copyright (in the United States or elsewhere) would encourage the publisher to charge a higher price for the novel, as the publisher attempts to recoup the cost of publishing the novel and earn profit in a shorter period before the copyright expires. After the copyright runs out, the publisher may lower the price of the novel to stay competitive with the online version.

4.5   When the demand curve is linear, the marginal revenue curve will always be linear with twice the slope of the demand curve. This is true because when multiplying the demand curve by *Q* to obtain total revenue, we always obtain a squared term in the revenue

function, which then doubles the slope when we take the derivative to obtain marginal revenue. For example, if the demand curve is

$$P = a - bQ$$

$$TR = aQ - bQ^2$$

$$MR = \frac{dTR}{dQ} = a - 2bQ.$$

Because the slope of *MR* is double of the slope of the linear demand curve, the *MR* curve always crosses the *MC* segment in the middle between the *y*-axis and point e_c. Hence, triangles *A* and *C* have one equal side and three equal angles, which implies that these triangles are equal.
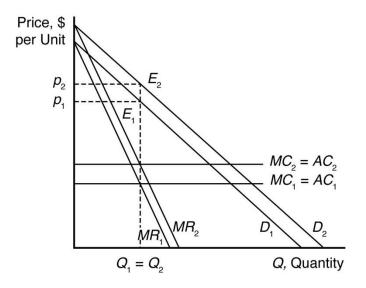
ADVERTISING

5.1   In the figure, let D_1 and MR_1 be demand and marginal revenue before advertising. Assume the monopoly has a constant marginal cost with no fixed cost such that $MC_1 = AC_1$. Then, suppose the monopoly advertises and that the advertising shifts demand and marginal revenue to D_2 and MR_2.

Assume advertising is a marginal cost, such that marginal cost continues to equal average cost after advertising, and that marginal costs remain constant.

A monopoly maximizes profit by producing the quantity where marginal revenue equals marginal cost. For the monopoly to break even from advertising, the marginal cost curve with advertising must shift up by enough that the increase in cost cancels the increase in revenue.

A marginal cost curve ($MC_2 = AC_2$), reflecting the cost of the advertising, is illustrated such that the monopoly breaks even from advertising.

5.2 To maximize profit, the monopoly must set marginal revenue MR ($= \partial R/\partial Q$) equal to marginal cost, MC and must set the marginal revenue of advertising, MR_A ($= \partial Q/\partial A$) equal to the marginal cost of advertising, which is 1. $R = pQ = 100Q - Q^2 + 5A - A^2$. Setting $MR = MC$ yields $100 - 2Q = 10$ or $Q = 45$. Setting $MR_A = 1$ yields $5 - 2A = 1$ or $A = 2$.

5.3 The marginal revenue function (MR) is

$$MR = 0.75Q^{-0.25}A^{0.5}.$$

Set marginal revenue from output equal to its marginal cost and solve for Q to find the profit-maximizing output level:

$$Q = A^2/4096. \tag{1}$$

The change in profit given a small change in advertising is

$$0.5Q^{0.75}A^{-0.5} - 0.25.$$

Set marginal revenue from advertising equal to its marginal cost and solve for A to find the profit-maximizing level of advertising:
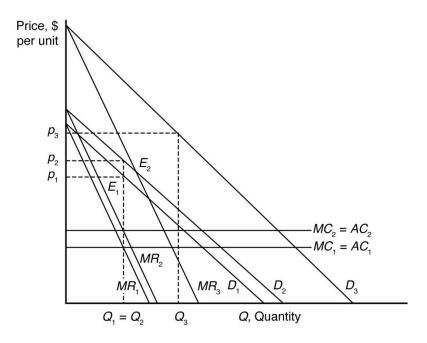
$$A = Q^{1.5}/0.25. \tag{2}$$

Substituting this expression for A into equation (1) above and solving for Q,

$$Q = 16 \text{ units.}$$

Substituting this value for Q into equation (2) above and solving for A,

$$A = 256.$$

Substitute the profit-maximizing values for Q and A into the demand equation and solve for p to find the profit-maximizing price ($p = \$8.00$).

5.4   People who buy a single copy often have a relatively less elastic demand than those who subscribe. If you are about to board a plane and have nothing to read, you are willing to pay a relatively high price for your favorite magazine. The magazine's cost of providing a newsstand copy and a subscription differ. The cost of providing newsstand copies is higher than the subscription cost if the magazine must accept returns of unsold copies. Thus, both the relatively less elastic demand and higher costs would cause the newsstand price to exceed the subscription price.

5.5   A fixed subsidy has no effect on the price or number of subscriptions sold. However, it might keep a magazine from shutting down.

5.6   Assume the following figure illustrates the effect of Super Bowl advertising but not the effect of social media for a monopoly. Before the advertising, demand is D_1, marginal revenue is MR_1, and marginal cost is MC_1. The monopoly initially maximizes profit at a price of p_1 and a quantity of q_1 at point e_1. Then, the monopoly advertises with a commercial during the Super Bowl. Assume the advertising increases the marginal cost of production to MC_2 and increases demand and marginal revenue to D_2 and MR_2. The new profit-maximizing price and quantity are p_2 and q_2 at e_2.

Super Bowl commercials receive extra exposure because these ads often go viral on the Internet. Consequently, once the effects of social media are added, the demand curve (and, correspondingly, the marginal revenue curve) shifts farther to the right at no additional advertising cost. This increases the demand for Super Bowl commercials (to D_3), increasing the price and quantity that maximizes profits.

NETWORKS, DYNAMICS, AND BEHAVIORAL ECONOMICS

6.1 When the hoi polloi buy the chocolate, the snobs won't buy. So the monopoly is facing a relatively flat demand curve, which suggests a low-price, high-quantity outcome. On the contrary, if the hoi polloi do not buy the chocolate, the snobs will buy. In this situation, the monopoly will face a steep demand curve, resulting in a high-price, low-quantity outcome. If the demand curve for the snobs is substantially steeper than that for the hoi polloi such that the profit from the former is larger than that from the latter, the monopoly will choose to cater to the snobs.

6.2 Given that the demand curve is $p = 10 - Q,$ its marginal revenue curve is $MR = 10 - 2Q.$ Thus the output that maximizes the monopoly's profit is determined by $MR = 10 - 2Q = 2 = MC,$ or $Q^* = 4.$ At that output level, its price is $p^* = 6,$ and its profit is $\pi^* = 16.$ If the monopoly chooses to sell 8 units in the first period (it has no incentive to sell more), its price is 2, and it makes no profit. Given that the firm sells 8 units in the first period, its demand curve in the second period is $p = 10 - Q/\beta,$ so its marginal revenue function is $MR = 10 - 2Q/\beta.$ The output that leads to its maximum profit is determined by $MR = 10 - 2Q/\beta = 2 = MC,$ or its output is $4\beta.$ Thus, its price is 6, and its profit is $16\beta.$ It pays for the firm to set a low price in the first period if the lost profit, 16, is less than the extra profit in the second period, which is $16(\beta - 1).$ Thus, it pays to set a low price in the first period if $16 < 16(\beta - 1),$ or $2 < \beta.$

6.3 The main factor is the large base of buyers and sellers, that is the network that eBay created by reaching a critical mass of users. By providing a single online location where

buyers and sellers can meet, eBay is able to create these positive externalities in the form of lower search costs and easier and safer transactions using their feedback rating system.

MANAGERIAL PROBLEM

7.1   A monopoly maximizes profit by producing the quantity where marginal revenue equals marginal cost. It then charges the price indicated by the demand curve. When generic drugs enter the market after the patent on a brand-name drug expires, the demand curve facing the brand-name firm shifts toward the origin (to the left). It also becomes less elastic at the original price (and becomes steeper). The firm now maximizes its profit at a point where the quantity is smaller. However, the new profit-maximizing price may be higher than the initial price because the demand curve is less elastic at the new optimum. This is possible if the brand-name firm has two types of consumers with different elasticities of demand who differ in their willingness to switch to a generic. Loyal consumers may prefer the brand-name drug because they are more comfortable with a familiar product, worry that new products may be substandard, or fear that differences in the ingredients might affect them.

7.2   A monopoly maximizes profit by producing the quantity where marginal revenue equals marginal cost. It then charges the price indicated by the demand curve. When generic drugs enter the market after the patent on a brand-name drug expires, the demand curve facing the brand-name firm shifts toward the origin (to the left). The firm now maximizes its profit at a point where the quantity is smaller. The new profit-maximizing price may be higher than the initial price if the demand curve is less elastic (steeper) at the new optimum. However, if the leftward shift is parallel, then the new demand curve's slope does not change. That is, the demand curve becomes no steeper. At the smaller quantity, the elasticity of demand becomes more elastic. Therefore, the brand-name firm will not charge a higher price.

7.3   A patent is an exclusive right granted to the inventor of a new and useful product, process, substance, or design for a specified length of time. The length of a patent varies across countries, although it is now 20 years in the United States and in most other countries. This right allows the patent holder to be the exclusive seller or user of the new invention.

A monopoly maximizes profit by producing the quantity where marginal revenue equals marginal cost. It then charges the price indicated by the demand curve. When generic drugs enter the market after the patent on a brand-name drug expires, the demand curve facing the brand-name firm shifts toward the origin (to the left).

If patent lengths were reduced, then a monopoly drug manufacturer while under the patent would not charge higher prices because demand would be unchanged. Furthermore, reducing patent lengths would not change the marginal cost of production,

although the monopoly would have fewer periods with the patent to recoup the fixed cost of developing the drug.

SPREADSHEET EXERCISES

See the associated Excel files.