b. WI is already earning the maximum profit possible in this industry (absent price discrimination). Therefore, integration with one or even many downstream retailers cannot raise WI's profits or price P to consumers. Even if WI bought all downstream retailers, it would still maximize profits by setting P = \$55, selling 45 units, and earning \$2,025 in profit.

c. Competitive manufacturing price = marginal cost = \$10. Competitive retail price = manufacturing price = \$10.

Chapter 17

17.1 a. The Great Toy Store's marginal revenue curve is $MR^R = 1{,}000 - 4Q$ and the Toy Store maximizes profit by equating MR and MC, giving $r = 1{,}000 - 4Q$, which is also Tiger-el's demand curve. Tiger-el therefore has a marginal revenue curve of $MR^M = 1{,}000 - 8Q$. Equating this with the Tiger-el's marginal cost $c = \$40$ yields $Q = 120$. From the Tiger-el demand curve, $r = 1000 - 4Q$, this implies a wholesale price of $r = \$520$. From the retail demand curve facing the Great Toy Store, $P = 1{,}000 - 2Q$, the retail price will be \$760.

b. The Great Toy Store will earn profit of (\$760 − \$520) × 120 = \$28,800. Tiger-el will earn profit of (\$520 − \$40) × 120 = \$57,600.

c. Tiger-el receives $c = \$40$ for each unit plus a sales royalty of 2/3 of all sales. Hence, Tiger-el's total revenue is $(c + 0.667P)Q = \$40Q + 0.6667 \times \text{PQ} = (\$40 + 666.67 - 1.333Q)Q$. Its marginal revenue is therefore $706.67 - 2.667Q$. Equating this with its marginal cost $c = \$40$ yields an optimal output of: $Q = 250$. The retail price will therefore be $P = 1{,}000 - 500 = \$500$. Total Toy Store revenue will be \$125,000. The Toy Store keeps one-third of this less wholesale costs = 0.3333 × \$125,000 − \$40 × 250 = \$41,666.67 − \$10,000 = \$31,666.67 as retail profit. Tiger-el keeps the remainder = \$93,333.33 as its revenue leaving it \$83,333.333 as profit after production costs.

17.2 a. From equation (17.6) we have $(10 - 6)/2 = s^2/2 + 2s^2 + (17.7)$. Hence, $s = \sqrt{(2/2.5)} = 0.894$. From equation (17.7), $P = (10 + 6 + s^2)/2 = \$8.4$. From the demand curve, $Q = 0.894(10 - 8.4)100 = 143.4$. Hence, the manufacturer's profit is: (\$6 − \$5) × 143.4 = \$143.4.

b. If the wholesale price $r = \$7$, then the service level s falls to $s = \sqrt{(1.5/2.5)} = 0.775$. In turn, this implies a retail price of $P = (10 + 7 + 0.775^2)/2 = \$8.80$. The total amount sold falls to $0.775(\$10 - \$8.80)100 = 93$.

17.3 a. Because marginal cost $c = 0$, profit maximization is the same as revenue maximization, i.e., the firm will wish to produce where marginal revenue $MR = 0$. When demand is strong, the inverse demand is: $p = 10 - Q/100$. Hence $MR^S = 10 - Q/50$. The revenue-maximizing choice of Q is therefore $Q = \$500$ implying a retail price of \$5. When demand is weak, the inversed demand is: $p = 10 - Q/30$, so that marginal revenue in this case of $M^W = 10 - Q/15$ which, in turn, implies an optimal output of $Q = 150$. Substitution of this into the weak case inverse demand curve then implies a price of \$5 again.

b. If the 500 units have already been produced then their production cost is sunk. As a result, the firm's marginal cost is zero and it will wish to sell either the full capacity of 500 units or to the point where $MR = 0$, depending on which constraint binds first. When demand is strong and $MR^S = 10 - Q/50$, the firm will wish to sell all 500 units. When demand is weak and $MR^W = 10 - Q/15$, the firm will wish to sell only 150 units. In the first case, the retail price is \$5 and the firm earns a profit of \$2,500. In the second case, the retail price is again \$5, but the firm earns a profit of only \$750. Because these cases occur with equal probability, the expected profit conditional on having produced 500 units is $(\$2500 + \$750)/2 = \$1{,}625$.

c. Once bought as a block of 500 units, competitive retailers treat the wholesale cost as sunk. Therefore, their marginal cost is 0. Because they will sell so long as price exceeds marginal cost, competitive retailers will sell all 500 units at the market-clearing price of \$5 if demand is strong. When demand is weak, they will continue selling until the number of units sold is 300 and the retail price as fallen to 0.

d. Let w be the implicit wholesale price per unit when a block of 500 units is initially sold. In the competitive retail sector case, retail profits net of initial wholesale costs are \$2,500 less $w500$ when demand is strong and 0 less $w500$ when demand is weak. Hence, expected retail profits are $0.5 \times \$2500 + 0.5 \times 0 - w500$. Because competitive retailers need to expect to break even, the wholesale price necessary to induce competitive retailers to stock 500 units is $w = \$2.50$. If the manufacturer sets this price, competitive retailers as a group can be persuaded to stock 500 units. Accordingly, the manufacturer will earn a profit of $\$2.50 \times 500 = \$1{,}250$.

Chapter 18

18.1 a. $n^* = 2$.

b. q per division = 15. Profit per division = \$225. Profit per firm = \$450 less (\$90 in sunk division costs) \$360.

c. $Q = 60$; $P = \$40$.

d. Pure monopoly: $P^M = \$62.50$; $Q^M = \$37.50$; $\Pi^M = \$1406.25$ less \$45 (sunk cost for $n = 1$ division) = \$1361.25

Chapter 19

19.1 a. $a = 100$ implies $dP/dQ = -0.1$; $a = 1{,}000$ implies $dP/dQ = -0.0316$.

b. i. $MR = 100 - 0.04Q$.

ii. $P = \$80$; $Q = 1{,}000$.

iii. Price elasticity (absolute value) = 4. Elasticity of sales with respect to advertising = 1/2.

c. At $a = 2{,}500$, $P = \$80$; $Q = 1{,}000 \Rightarrow$ Advertising/Sales Ratio $= a/PQ = 0.03125$. Dorfman-Steiner condition requires Advertising/SalesRatio $= (1/2)/4 = 1/8$, is not satisfied here. Optimal advertising rate that does satisfy Dorfman-Steiner condition yields: $a = 40{,}000$; $P = \$80$; $Q = 4{,}000$.

Chapter 20

20.1 With a marginal cost of \$28, the monopolist would like to price such that MR = MC. This implies $100 - 4Q = 28$, or $Q = 18$. At this quantity, price would be $P = 100 - 2(18) = \$64$. However, the current market price with Bertrand competition is \$60. Because the innovator's ideal monopoly price is greater than the current market price, this is a non-drastic innovation. The innovator has to reduce the price to \$59.99 in order to capture the market.

Say the innovator's new marginal cost of production is c_M. Then we want to choose a c_M such that $P_M < 60$. We know MR = MC and $100 - 4Q_M = c_M$, so $Q_M = 25 - c_M/4$, and $P_M = 100 - 2(25 - c_M/4) = 50 + c_M/2$.. Monopoly price $P_M < 60$ implies $50 + c_M/2 < 60$, which in turn implies $c_M < 20$. In order for the innovation to be drastic, c_M must be less than \$20.

20.2 a. The innovation is non-drastic if the monopolist's ideal price is greater than the competitive price, $P_M > P_C$. Because the firms compete in price, $P_C = c_C = 75$. The monopolist would profit-maximize by setting MR = MC, or $100 - 2Q_M = 60$, so $Q_M = 20$ and $P_M = 80$. Because $80 > 75$, this is a non-drastic innovation. If the innovation reduces cost to c_M, equating MR with MC gives $100 - 2Q = c_M$ which gives $Q = 50 - c_M/2$ and $P = 50 + c_M/2$. For this to be a drastic innovation requires that $50 + c_M/2 \leq 75$ or $c_M \leq \$50$.

b. If the market is a monopoly the monopolist sets MR = MC, or $100 - 2Q = 75$, or $Q = 12.5$ and $P = \$87.5$ prior to the innovation, earning profit of \$156.25 per period prior to the innovation. With the innovation MC = 60 and so the monopolist sets $100 - 2Q = 60$ or $Q = 20$ and price $P = 80$. Profit after the innovation is therefore $\$(80 - 60) \times 20 = \$400$ per period. The monopolist values the innovation at $V_M = \$(400 - 156.25)/0.1 = \$2{,}437.50$.

c. Cournot duopolists facing the same marginal cost each produce output $Q_D = (A - c)/3B = 25/3 = 8.33$. Aggregate output is 16.67 and so price is \$83.33. Profit to each duopolist is $\$(83.33 - 75) \times 8.33 = \$69.44$.

d. Now we suppose firm 1 has innovated, so its marginal cost is $c_1 = 60$, but firm 2 has not innovated and still has marginal cost $c_2 = 75$. Output of firm 1 is the duopoly output $Q_1 = (A - 2c_1 + c_2)/3B = 18.33$ and of firm 2 is $Q_2 = (A - 2c_2 + c_1)/3 = 3.33$. Aggregate output is 21.67 so price is \$78.33.

e. Profit to innovation, the innovating firm is $\$(78.33 - 60) \times 18.33 = \$336.11$. The innovating Cournot duopolist values the innovation at $V_D = \$(336.11 - 69.44)/0.1 = \$2{,}666.67$. Because $V_D > V_M$ this confirms that the duopolist values the innovation more than the monopolist.

Chapter 21

21.1 a. If the firms compete in price, then price is driven to marginal cost, so $P = \$70$ and $Q = 30$.

b. If the firm chooses research activity x its marginal cost becomes $70 - x$. Assuming that the innovation is non-drastic, the innovating firm will set price \$70 and sell 30 units. The resulting profit per period while the patent is in force is then $\$(70 - 70 + x)30 = 30x$. Aggregate profit over the life of the patent is then $V(x; 25) = \dfrac{1 - 0.9091^{25}}{1 - 0.9091} 30x - 15x^2 = 299.57x - 15x^2$. This equation is maximized when $dV/dx = 299.57 - 30x = 0$, or when $x \approx 10$.

c. If the patent duration is reduced to twenty years, then $V(x; 20) = \dfrac{1 - 0.9091^{20}}{1 - 0.9091} 30x - 15x^2 = 280.97x - 30x_2$ so $dV/dx = 280.97 - 30x = 0$, and. $x \approx 9.4$ Because of the decrease in the patent duration, the firm's R&D effort is decreased.

d. The total net surplus $TS(x; T) = V(x, T) + CS(x; T) - r(x)$. Consumer surplus is $CS(x; T) = \dfrac{1 - R^T}{1 - R} CS_P + \dfrac{R^T}{1 - R} CS_{NP}$ where $CS_P = (100 - 70)^2/2 = \$450$ is the consumer surplus per period while the innovation is on patent and $CS_{NP} = (100 - (70 - x))^2/2 = (30 + x)^2/2$ is the consumer surplus when the innovation goes off patent. Note: Consumer surplus is the triangle with height $100 - P$ and base $Q = 100 - P$. When the innovation comes off patent $P = c - x$. While on patent, $P = 70$. For $T = 25$, we know from part (c) that $x \approx 10$ and $TS(10; 25) = 2995.7 + (1 - 0.9091^{25})/(1 - 0.9091)^* 30^2/2 + 0.9091^{25}/(1 - 0.9091)^* 40^2/2 - 15^* 102 = \$6{,}801.61$. If we have $T = 20$, then $x \approx 9.4$, so $TS(9.4; 20) = 2809.7 + (1 - 0.9091^{20})/(1 - 0.9091)\, {}^1\!/_2{}^* 30^2 + 0.9091^{20}/(1 - 0.9091)^*\, {}^1\!/_2{}^* (30 + 9.4)^2 - 15^* 9.4^2 = \$6799.66$. Thus, total welfare decreases approximately \$2 if the patent life is decreases from 25 to 20 years.

21.2 a. If only BMI innovates, then ECN is shut out of the market and BMI monopolizes. Facing a demand curve of $P = 100 - 2Q$, a marginal cost of $c = 50$, and a fixed cost for setting up a lab of K, BMI maximizes the profit function $\Pi = Q(P - c) - K = Q(100 - 50 - 2Q) - K$. This function is maximized when $\partial\Pi/\partial Q = 50 - 4Q = 0$, which is when $Q = 12.5$ and $P = 100 - 2^*12.5 = 75$. Monopoly profits are $\Pi = 12.5(75 - 50) - K = \$312.5 - K$. Consumer surplus is the area of the triangle with height $100 - P$ and base Q, so $CS = 1/2\,{}^*25^*12.5 = \$156.25$.

b. If both BMI and ECN successfully innovate, then the two firms will compete, Cournot-style. Output of each firm is $Q_i = (A - c)/3B = 8.33$. Price is \$66.67 and profit of each firm including the cost of setting up a lab, $\Pi_1 = \Pi_2 = 8.33(66.67 - 50) - K = \$138.89 - K$. Consumer surplus is once again the area of the triangle with height $100 - P$ and base Q, so $CS = 1/2^*(100 - 66.67)^*16.67 = \$277.78$.

c. If only one firm sets up a lab, then likelihood that the lab is successful and the firm innovates is $\rho = 0.8$, and the likelihood that the lab is unsuccessful is $(1 - \rho) = 0.2$. Expected profit is $0.8(\$312.50) - K = \$250 - K$. If both firms set up a lab, then there are four possible outcomes for each firm. These are

i. BMI successfully innovates and ECN does not, with probability 0.8×0.2;
ii. both successfully innovate with probability 0.8×0.8;
iii. ECN successfully innovates while BMI does not, with probability 0.2×0.8;
iv. neither successfully innovate with probability 0.2×0.2.

In each of the last two cases, BMI makes no profit. So, its expected profit is: $0.8 \times 0.2 \times \$312.50 + 0.8^2 \times \$138.89 - K = \$138.89 - K$. The payoff matrix is:

		BMI	
		No R&D Division	R&D Division
ECN	No R&D Division	0, 0	0, \$250 – K
	R&D Division	\$250 – *K*, 0	\$138.89 – *K*, \$138.89 – *K*

d. For (No R&D, No R\$D) to be a Nash equilibrium $\$250 - K < 0$ or $K > \$250$. For (R&D, R&D) to be a Nash equilibrium $\$138.89 - K > 0$ or $K < \$138.89$. For $\$138.89 < K < \$250$ only one firm will do R&D.

e. The expected social surplus with only one lab is $0.8(\$312.50 + \$156.25) - K = \$375 - K$. With two labs it is $2 \times 0.8 \times 0.2 \times (\$312.50 + 156.25) + 0.8 \times 0.8 \times (138.89 + 277.78) - 2K = \$416.67 - 2K$. Two labs are optimal if $\$416.67 - 2K > \$375 - K$ or $K < \$41.67$.

21.3 a. With Cournot competition, firms choose quantity as the strategic variable. Each firm wants to maximize the profit function $\Pi_i = q_i(100 - 2(q_i + q_{-i}) - c) = q_i(40 - 2q_i - 2q_{-i})$. This function is maximized when $\partial\Pi_i/\partial q_i = 40 - 4q_i - 2q_{-i} = 0$, which is when $q_i = 10 - q_{-i}/2$. Because costs are symmetrical, $q_i = q_{-i}$, so both firms are on their best response functions when $q_i = q_{-i} = 6.67$ and $Q = 13.33$, so price is $P = 73.33$.

b. i. The two firms will still engage in Cournot competition, except that now the innovator's marginal cost is 50 and the non-innovator's is still 60. Say firm 1 is the innovator and firm 2 is the non-innovator, then $\Pi_1 = q_1(100 - 2q_1 - 2q_2 - 50)$ and $\Pi_2 = q_2(100 - 2q_2 - 2q_1 - 60)$. This leads to best response functions Firm 1: $q_1 = 12.5 - q_2/2$ and Firm 2: $q_2 = 10 - q_1/2$. Both firms are on their best response functions when $q_1 = 10$ and $q_2 = 5$, so $Q = 15$ and $P = 70$. Firm 1's profit is $\Pi_1 = 10(70 - 50) = \$200$ and firm 2's profit is $\Pi_2 = 5(70 - 60) = \$50$.

ii. If firm 1 licenses the invention to firm 2 at \$10 per unit, then firm 2's marginal production cost will be \$50 because of the innovation, but there is a \$10 royalty fee on each unit, so the overall marginal cost is still $c_2 = 50 + 10 = 60$. However, firm 1 also makes a profit of \$10 on every unit firm 2 sells, so the new profit functions are $\Pi_1 = q_1(50 - 2q_1 - 2q_2) + 10q_2$ and $\Pi_2 = q_2(40 - 2q_1 - 2q_2)$. This, however, leads to the same best response functions, because firm 1 does not have control over q_2, so the equilibrium quantities are still $q_1 = 10$, $q_2 = 5$, and $Q = 15$, and the equilibrium price is still $P = 70$. Firm 1's profit is $\Pi_1 = 10(70 - 50) + 5^*10 = 250$ and firm 2's profit is $\Pi_2 = 5(70 - 50) - 5^*10 = 50$.

iii. Say that firm 1 licenses the product to firm 2 for a fee K. Then both firms will take advantage of the innovation and have a marginal cost $c = 50$. Profits are $\Pi_1 = q_1(P - 50) + K$ and $\Pi_2 = q_2(P - 50) - K$. Best response functions are now Firm 1: $q_1 = 12.5 - q_2/2$ and Firm 2: $q_2 = 12.5 - q_1/2$. Both firms are on their best response functions when $q_1 = q_2 = 8.33$, $Q = 16.67$, and price is $P = 66.67$. Profits are $\Pi_1 = 8.33(66.67 - 50) + K = 138.89 + K$ and $\Pi_2 = 8.33(66.67 - 50) - K = 138.89 - K$.

Firm 2 will be willing to pay the licensing fee as long as the profit from buying the license and using the innovation is greater than the profit from part (i), where it didn't have the license. Thus, as long as $138.89 - K > 50$, firm 2 will buy the license. This requires $K < 88.89$.

Firm 1 should price the license so that it is just marginally better for firm 2 to buy the license, so the price should be $K = 88.88$. Firm 1's profits will be $\Pi_1 = 138.89 + 88.88 = \$227.77$. Firm 2's profits will be $\Pi_2 = 138.89 - 88.88 = \$50.01$. Note that in this example the innovator would prefer the royalty to the fixed fee.

Chapter 22

22.1 a. The consumer who is indifferent between buying the good and not buying is has basic valuation v_i satisfying the condition $(0.4 + 6f^2)v^M = p$. Hence, with $p = 50$, we have: $v^M = p/(0.4 + 6f^2) = 50/(0.4 + 6f^2)$.

b. The market fraction f that is served is given by $f = 1 - v^M/100$. Hence we have $f = 1 - 0.5/(0.4 + 6f^2)$. This equality holds when either $f = 0.1905$ or $f = 0.906$. The second solution is stable.

Chapter 23

23.1 A dominant strategy is one that gives you a payoff greater than any other strategy regardless of what is chosen by other players. Clearly it does not pay to bid more than your willingness to pay. You will lose anytime that you win. The other strategy you could choose is to stop bidding when the price is less than your true valuation. Suppose that the auction price is p and your true valuation is V. If $p < V$ and you stop bidding your payoff is 0, whereas if you bid $p + \varepsilon < V$ then your payoff is $V - (p + \varepsilon) > 0$. So, for any $p < V$, continuing to bid is a dominant strategy. Because you also cannot gain but may lose if you bid $V + \varepsilon$, bidding V is a dominant strategy.

23.2 Your best strategy here is to assume that you are the one with the highest valuation. In other words you assume that the other seven bidders have valuations drawn from a uniform distribution over the interval [0, 200]. If we assume that these bids are evenly spaced out over the interval then the lowest would be $25(=1/8^*200)$, the next $50(=2/8^*200)$, the next 75, the next 100, the next 125, the next 150, and finally the highest bid from the other bidders will be $175(=7/8^*200)$. You should submit a bid of \$175 to win the auction.

23.3 Your \$20,000 estimate is likely too high by the amount $\left(\frac{n-1}{n+1}\right)\$3000 = \left(\frac{8-1}{8+1}\right)\$3000 =$ \$2,333.33 If you bid \$20,000 that is the amount you are likely overbidding.

Chapter 24

24.1 a. The marginal revenue for firm A is: $MR_A = 1000 - q_B - 2q_A$. Setting this equal to marginal cost $MC_A = 400$ yields firm A's best response function: $q_A = 300 - q_B/2$. By symmetry, firm B's best response is: $q_B = 300 - q_A/2$. Hence, the Nash equilibrium is: $q_A = q_B = 200$, implying $Q = 400$; $P = \$600$; and profit to each firm $\pi_A = \pi_B =$ \$40,000.

b. From equation (24.8) or (24.9), the optimal subsidy $s^* = (A - c)/4$. Here we have $A = \$1000$ and $c =$ marginal cost $= \$400$. Hence the optimal subsidy is $s^* = \$150$. It follows from equation (24.3) that $q_A = (1000 - 400 + 2s^*)/3 = 300$. Firm B's best response function in turn implies that: $q_B = 300 - q_A/2 = 150$. Because total output is $Q = 450$, the market price is \$550.

i. Firm A's profit is: $(\$550 - c + s^*)q_A = \$300 \times 300 = \$90{,}000$.

ii. The cost of the subsidy is $s^*q_A = \$150 \times 300 = \$45{,}000$.

iii. The net gain from the subsidy is $\$90{,}000 - \$45{,}000 = \$45{,}000$

24.2 In general, we know from Chapter 9 that the Cournot model with cost differences implies the following output levels: $q_A = (A - 2c_A + c_B)/3$; and $q_B = (A + c_A - 2c_B)/3$. Before the tariff, the marginal cost for each firm is $c_A = c_B = 12$. Hence, prior to the tariff, each firm had output: $q_A = q_B = 88/3$. So, total output was $Q = 58.67$ implying a price $P = \$41.33$. Pre-tariff profit to firm A is: $29.33^2 = \$860.44$. Consumer surplus in Country A in the no-tariff case is: $0.5 \times (100 - 41.33) \times 58.67 = \$1720.89$. After the tariff, firm A still has a marginal cost of $c_A = 12$. However, firm B loses scale economies and so has an increase in the marginal cost of production to $s_B = 14$. To this higher marginal cost, we must add the additional 2-dollar tariff. Hence, within country A, firm faces an implicit marginal cost—production plus tariff—of $14 + 2 = 16$ for units sold in country A. It follows that after the tariff, each firm's output will be: $q_A = (100 - 24 + 16)/3 = 92/3$; and $q_B = (100 + 12 - 32)/3 = 80/3$. Hence, total output is $Q = 57.333$, implying a price of $P = \$42.67$. Firm A's profit is now: $(\$42.67 - \$12) \times 92/3 = \$940.455$. Consumer surplus in Country A is now: $0.5 \times (100 - 42.67) \times 57.33 = \$1643.46$. Producer surplus has increased by $\$940.44 - \$860.44 = \$80$. Consumer surplus has decreased by $\$1720.89 - \$1643.46 = \$77.33$.

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