5 Oligopolistic Competition

Practice Question 12 (Stackelberg Equilibrium)**.** Duopoly quantity-setting firms face inverse market demand of

$$p = 175 - q_1 - q_2$$

Each firm has a marginal cost of \$70 per unit. Firm 2 has a fixed cost of entry of \$100. Suppose firm 1 moves first.

(a) What is the Stackelberg equilibrium output for each firm and what is the equilibrium price?

(b) What is the minimum quantity that firm 1 would have to produce to deter firm 2 from entering the market?

(c) What is the optimal strategy for firm 1 ? That is, should firm 1 produce the amount that deters entry, or Stackelberg leader output?

Solutions:

(a) Step 1: Given the output firm 1 chooses, what is firm 2's best response?

$$MR_2 = 175 - q_1 - 2q_2 = MC = 70$$

$$\Rightarrow q_2 = 52.5 - 0.5q_1$$

Step 2: The leader, firm 1, knowing that firm 2 will use its Cournot best-response curve, can use this knowledge to manipulate the follower. It does this by substituting firm 2's best-response curve into the inverse market demand curve.

$$p = 175 - q_1 - (52.5 - 0.5q_1) = 122.5 - 0.5q_1$$

Step 3: Firm 1 maximizes its profit as if it were a monopoly facing a residual demand function.

$$MR_1 = 122.5 - q_1 = MC = 70$$

$$\Rightarrow q_1^* = 52.5$$

$$\Rightarrow q_2^* = 52.5 - 0.5q_1^* = 26.25$$

$$\Rightarrow p^* = 175 - q_1^* - q_2^* = 96.25$$

(b) For firm 2 not entering the market, it must be that $\pi_2 = 0$.

$$\begin{aligned}
\pi_2 &= (p - 70)q_2 - 100 \\
&= (175 - q_1 - q_2 - 70)q_2 - 100 \\
&= [105 - q_1 - (52.5 - 0.5q_1)](52.5 - 0.5q_1) - 100 \\
&= (52.5 - 0.5q_1)^2 - 100 = 0 \\
\Rightarrow 52.5 - 0.5q_1 &= 10 \\
0.5q_1 &= 42.5 \\
q_1 &= 85
\end{aligned}$$

(c) For firm 1, profit of producing Stackelberg leader output is

$$\pi_1^S = (96.25 - 70) \cdot 52.5 = 1378.125$$

If Firm 1 produces the amount at $q_1 = 85$ that deters entry of firm 2, firm 2 would not enter the market($q_2 = 0$). Then $p = 175 - 85 - 0 = 90$. Profit of firm 1 is:

$$\pi_1^D = (90 - 70) \cdot 85 = 1700 > \pi_1^S$$

So the optimal strategy for firm 1 should be producing the amount that deters entry.

Practice Question 13 (Bertrand Equilibrium)**.** Consider the following Bertrand game where firms 1 and 2 have the following demands:

$$q_1 = 14 - p_1 + \frac{1}{4}p_2$$

$$q_2 = 14 - p_2 + \frac{1}{4}p_1$$

where q_1 and q_2 represents pizzas sold per hour at each firm. For simplicity, suppose that all costs are fixed at $F_1 = F_2 = 20$ per hour.

(a) Briefly explain why the two firms' pizzas are substitutes for each other.

(b) What are the Nash equilibrium prices of pizzas? How much profit does each firm make per hour? Show your work.

(c) Draw a diagram of the two firms' best-response functions. Using the best response functions, explain why firm 1 would NOT set a price of $6 per pizza in equilibrium.

Solutions:

(a) If $p_2 \uparrow$, then $q_1 \uparrow$; if $p_1 \uparrow$, then $q_2 \uparrow$. This is exactly the definition of substitutes.

(b) Notice that $MC_1 = MC_2 = 0$. We need to find TR and MR in terms of prices for each firm and set $MR = 0$ for each firm. The market is symmetric, so can look at firm 1 only.

$$TR_1 = q_1 p_1 = (14 - p_1 + \frac{1}{4}p_2)p_1$$

$$\Rightarrow MR_1 = \frac{dTR_1}{dp_1} = (14 - p_1 + \frac{1}{4}p_2) - p_1 = 14 - 2p_1 + \frac{1}{4}p_2 = 0$$

So the best response function for firm 1 is

$$p_1 = p_1(p_2) = 7 + \frac{1}{8}p_2$$

By symmetry, the best response function for firm 2 is

$$p_2 = p_2(p_1) = 7 + \frac{1}{8}p_1$$

Solve for the Bertrand equilibrium,

$$p = 7 + \frac{1}{8}p$$

$$\Rightarrow p_1^* = p_2^* = p = 8$$

The profit each firm is making per hour is

$$\pi_1 = \pi_2 = (14 - \frac{3}{4}p)p - 20 = (14 - 6) \times 8 - 20 = 44$$

(c) Suppose firm 1 did set $p_1 = 6$, then 2's BR would be to set

$$p_2 = 7 + \frac{1}{8} \times 6 = 7.75$$

But then

$$p_1 = 7 + \frac{1}{8} \times 7.75 = 7.97$$

Thus $p_1 = 6$ cannot be a Nash equilibrium - 1 would want to raise its price. If you continue this way, $p_2(7.97) = 7.996$ and $p_1(7.996) = 7.9995$, we get closer and closer to the equilibrium.

Practice Question 14 (Monopolistic Competition)**.** An incumbent firm, Firm 1, faces a potential entrant, Firm 2, with a lower marginal cost. The market demand curve is

$$p = 120 - q_1 - q_2$$

Firm 1 has a constant marginal cost of \$20, while Firm 2's is \$10.

(a) What are the Nash-Cournot equilibrium price, quantities, and profits if the government does not intervene?

(b) To block entry, the incumbent appeals to the government to require that the entrant incur extra costs. What happens to the Nash-Cournot equilibrium if the legal requirement causes the marginal cost of the second firm to rise to that of the first firm, \$20?

(c) Now suppose that the barrier leaves the marginal cost alone but imposes a fixed cost. What is the minimal fixed cost that will prevent entry?

Solutions:

(a) For firm 1,

$$MR_1 = 120 - q_2 - 2q_1 = MC_1 = 20$$
$$\Rightarrow q_1 = 50 - \frac{1}{2}q_2$$

For firm 2,

$$MR_2 = 120 - q_1 - 2q_2 = MC_2 = 10$$
$$\Rightarrow q_2 = 55 - \frac{1}{2}q_1$$

Solving these two BRs yield

$$q_1^* = 30, \quad q_2^* = 40, \quad p^* = 120 - 30 - 40 = 50$$

Then the profits are

$$\Rightarrow \pi_1 = (50 - 20) \times 30 = 900, \quad \pi_2 = (50 - 10) \times 40 = 1600$$

(b) Now $MC_2 = 20$, then firm 2's BR becomes

$$q_2 = 50 - \frac{1}{2}q_1$$

Symmetry between firm 1 and firm 2 yields

$$q_1^* = q_2^* = \frac{100}{3}, \quad p^* = 120 - 2 \times \frac{100}{3} = \frac{160}{3}$$
$$\pi_1 = \pi_2 = (\frac{160}{3} - 20) \times \frac{100}{3} = \frac{10000}{9}$$

(c) As Firm 2's profit was 1,600 in part (a), a fixed cost slightly greater than 1,600 will prevent entry.