Final Examination

ECON 4114 Industrial Organization and Competitive Strategies 2020

Part 1

Time allowed: 50 minutes **Total points: 50 points**

1. Firm A and Firm B supply differentiated final goods, with the following system of demand.

$$\begin{aligned} q_A(p_A, p_B) &= 120 - 3p_A + p_B; \\ q_B(p_A, p_B) &= 120 - 3p_B + p_A. \end{aligned}$$

The production of each unit of final good requires processing an intermediate good. **The marginal cost of producing the intermediate goods is** 10**, and the processing cost is** 0**.**

Firm B has the capability of producing intermediate goods by itself (at the marginal cost of 10). In contrast, Firm A cannot make them itself and must procure from an upstream manufacturer Firm U.

Events unfold in the following order. First, Firm U sets the price p_m of its intermediate goods. After observing the choice of p_m, Firm A and Firm B compete by simultaneously choosing their respective retail prices p_A and p_B.

(a) (12 points) Find the subgame-perfect Nash equilibrium of the game.

Solution: Given p_m*, Firm A's profit is* $(p_A - p_m)(120 - 3p_A + p_B)$*. The FOC is*

$$\frac{\partial}{\partial p_A}\left((p_A - p_m)(120 - 3p_A + p_B)\right) = p_B - 6p_A + 3p_m + 120 = 0 \Leftrightarrow p_A = \frac{p_B + 3p_m + 120}{6}.$$

Firm B's profit is $(p_B - 10)(120 - 3p_B + p_A)$*. The FOC is*

$$\frac{\partial}{\partial p_B}\left((p_B - 10)(120 - 3p_B + p_A)\right) = p_A - 6p_B + 150 = 0 \Leftrightarrow p_B = \frac{p_A + 150}{6}.$$

The intersection of the best responses give

$$p_A = \frac{18}{35}p_m + \frac{174}{7} \text{ and } p_B = \frac{3}{35}p_m + \frac{204}{7}.$$

Given this Nash equilibrium of the second-stage subgame, Firm U's demand is

$$120 - 3p_A + p_B = 120 - 3\left(\frac{18}{35}p_m + \frac{174}{7}\right) + \left(\frac{3}{35}p_m + \frac{204}{7}\right) = \frac{3}{35}(870 - 17p_m).$$

Firm U's optimal price is thus given by FOC:

$$\frac{\partial}{\partial p_m}\left(\frac{3}{35}(870 - 17p_m)(p_m - 10)\right) = \frac{624}{7} - \frac{102}{35}p_m = 0 \Leftrightarrow p_m = \frac{520}{17} \approx 30.588.$$

SPNE: $p_m = \frac{520}{17} \approx 30.588$*. Firm A's strategy:* $\frac{18}{35}p_m + \frac{174}{7}$*, Firm B's strategy:* $\frac{3}{35}p_m + \frac{204}{7}$*.*

(b) (8 points) Firm U proposes to adopt a franchise fee contract in selling intermediate goods to Firm A: after receiving a lump-sum franchise fee, Firm U supplies intermediate goods to Firm A at its marginal cost of 10. If the franchise fee contract is signed, it becomes public knowledge before Firm A and B set their retail prices.

Without using any calculation, discuss the impact of the franchise fee contract on **the joint profit of Firm A and Firm U**.

Solution: On the one hand, the franchise fee contract eliminates the double-marginalization problem, bringing a positive impact to the joint profit. On the other hand, Firm B would respond by more aggressive pricing, thus hurting their joint profit. The overall effect depends on whether the magnitude of the benefit or cost is stronger.

(Total: 20 points)

2. Consider a monopoly supplier of an experience goods, of which the quality cannot be ascertained by consumers at the time of purchase. The quality of the goods supplied is denoted by q, which can take any value in the interval $[0, 10]$. Each unit of good with quality q requires a production cost of $c(q) = 1 + q^2$. Consumption of the goods with quality q brings a utility of $v(q) = 2 + 4q$. For simplicity, suppose there is one unit of consumers, and each consumer demands at most one unit of the experience goods in each period. In each period, events unfold in the following order.

- The firm chooses the quality q of its goods, as well as its price.
- Consumers learn the price, but not the quality chosen, and decide whether to purchase the goods or not.
- If they purchase the goods, then they consume it, learn the quality q, and derive the corresponding utility.

The game above is infinitely repeated, with all previous qualities become public record. All players share a common discount factor $\delta \in (0, 1)$.

(a) (1 mark) What is the level of quality that maximizes the total surplus, i.e., $v(q) - c(q)$? Denote this level of quality by q^*.

Solution: As $v(q) - c(q) = 2 + 4q - (1 + q^2) = 1 + 4q - q^2$, *the optimal value of* q *is given by* $4 - 2q = 0 \Leftrightarrow q^* = 2$.

(b) (8 marks) Suppose $\delta = 0.9$. Consider the following trigger strategies for the firm and consumers which give the outcome that quality $\hat{q}$ is produced in every period.

- We say the firm has
  - a **good reputation** if there is no previous period in which the revealed quality is different from $\hat{q}$; and
  - a **bad reputation** if in some previous period, the revealed quality is different from $\hat{q}$.
- The firm produces quality $\hat{q}$ and charges price $v(\hat{q})$, if it has a good reputation. It produces quality 0 and charges price $v(0)$, if it has a bad reputation.

- Consumers only buy the goods at prices no higher than $v(\hat{q})$, if the firm has a good reputation They only buy at prices no higher than $v(0)$, if the firm has a bad reputation.

Can the trigger strategies support a subgame-perfect Nash equilibrium (SPNE) with the outcome that the firm produces quality q^* every period? Explain.

Solution: If the firm has a good reputation and follows the trigger strategy, its profit is $\frac{1}{1-\delta}(v(2)-c(2)) = \frac{1}{1-0.9}(2+4(2)-(1+2^2)) = 50$. *If it deviates for one period, the maximum profit is* $v(2)-c(0)+\frac{\delta}{1-\delta}(v(0)-c(0)) = 2+4(2)-1+\frac{0.9}{1-0.9}(2-1) = 18$. *The one-shot deviation is unprofitable.*

If the firm has a bad reputation and follows the trigger strategy, its profit is $\frac{1}{1-0.9}(2-1) = 10$. *Any deviation will either lead to a higher cost or lower price and thus unprofitable.*

Consumers do not have a profitable deviation because their willingness to pay coincides with their utility of consumption following all histories.

(c) (7 marks) Suppose $\delta = 0.3$. What is the highest level of quality that can be supported as a SPNE outcome by the trigger strategies? What is the firm's per-period profit?

Solution: The firm has no profitable one-shot deviation if and only if

$$2+4q-\left(1+q^2\right) \geq (1-0.3)(2+4q-1)+\delta(2-1) \Leftrightarrow q \leq 4(0.3) = 1.2.$$

The firm's per-period profit is

$$2+4(1.2)-\left(1+(1.2)^2\right) = 4.36.$$

(d) (7 marks) Suppose the experience-goods firm develops a new technology of production. The new technology gives rise to the following new cost function $c_{new}(q) = q+0.75q^2$. It can be checked (and you do not need to) that

- the value of q^* computed in part (a) would still maximize the total surplus with this new cost function; and
- for any quality level, the new cost function is never higher than the initial cost function, i.e., $c_{new}(q) \leq c(q)$.

Redo part (c) assuming the firm has this new cost function.

Solution: The firm has no profitable one-shot deviation if and only if

$$\begin{aligned} & 2+4q-\left(q+0.75q^2\right) \geq (1-\delta)(2+4q-0)+\delta(2-0) \\ \Leftrightarrow\ & q \leq \frac{16\delta-4}{3} = \frac{16(0.3)-4}{3} = \frac{4}{15} \approx 0.266\,67. \end{aligned}$$

The firm's per-period profit is

$$2+4\left(\frac{4}{15}\right)-\left(\frac{4}{15}+0.75\left(\frac{4}{15}\right)^2\right) = 2.746\,7.$$

(e) (7 marks) Does the firm enjoy a higher or lower profit by adopting the less-costly production technology mentioned in part (d)? Explain in terms of the firm's incentives in maintaining a good reputation for producing high quality.

Solution: The firm's profit goes down with the adoption of the less-costly technology. This is because the less-costly technology increases the profit of deviation and weakens the punishment for deviation, making it more difficult to sustain a good firm reputation.

(Total: 30 points)

End of Part 1