Industrial Organization

Resit Exam Spring 2024 – Solution Topics

1. True.

Suppose that two symmetric firms, *A* and *B*, compete *à la* Cournot. In the Cournot-Nash equilibrium, both firms will produce the same quantity. Therefore, if firms do not collude, the Herfindahl-Hirshman Index will take a value of $HHI_{No\ Collusion} = s_A^2 + s_B^2 = 0.5^2 + 0.5^2 = 0.5$.

On the other hand, if firms were to collude around the optimal collusive quantity, each would produce half the monopoly quantity. Hence, we would still have equal market shares ($s_A = s_B = 50\%$), implying that $HHI_{Collusion} = 0.5$.

As this example shows, the HHI – the most widely-used concentration measure – may take the same value when firms compete or collude. Thus, concentration measures do not tell us whether firms are colluding or not.

2. True.

The equilibrium price resulting from the static Bertrand model with *N* symmetric firms will be equal to their (common) marginal and average cost, due to the incentive to undercut one's competitors for any $P > MC$ (Bertrand Paradox). If a new firm enters the market with a lower marginal cost, the equilibrium price will decrease by ε as this (most efficient) firm undercuts all others. Moreover, in the infinitely repeated Bertrand game, a previously sustainable collusive agreement could become impossible if the new firm is so efficient that the present value of its profits following deviation is higher than the present value of its collusion payoffs for any $\delta \in [0,1]$. Hence, the market price would indeed decrease in both cases as a result of the increase in the number of firms.

However, if the new firm were to have the same marginal cost as the incumbents, the equilibrium price in the static game would be unchanged; in the infinitely repeated game, if collusion were previously impossible, then it would remain so. Thus, in both cases, the market price could also remain constant.

3.

(i)

Monopolist's profit-maximization problem:

$$\max_{\{Q^M\}} \pi^M = (10 - Q)Q - 2Q$$

$$FOC: \frac{d\pi^M}{dQ} = 0 \Leftrightarrow 10 - 2Q - 2 = 0 \Leftrightarrow \boldsymbol{Q^M = 4} \rightarrow P^M = 6$$

$$\boldsymbol{\pi^M} = (6 - 2) * 4 = \mathbf{16}$$

Since its installed capacity – "in excess of 10 physical units" – far exceeds its optimal choice, the monopolist will produce 4 units and consequently earn a profit of 16 monetary units.

(ii)

In order to deter *E*'s entry, the Incumbent would have to make it unprofitable. In practice, this means that the market price should drop to a value (marginally) below *E*'s marginal cost of 4, thereby ensuring that firm *E* would earn a negative profit upon entry.

Therefore, firm *I* would have to **produce $\boldsymbol{6(+\varepsilon)}$ units**, implying a market price of

$$P = 10 - (6+\varepsilon) = 4 - \varepsilon$$

and a profit for the Incumbent equal to

$$\pi_I^{Deter} = (4 - \varepsilon - 2) * (6 + \varepsilon) \approx 12$$

(iii)

Accommodation → Stackelberg equilibrium.

First, we must calculate the Entrant/Follower's best response function:

$$\max_{\{q_E\}} \pi_E = (10 - q_I - q_E)q_E - 4q_E$$

$$FOC: \frac{\partial \pi_E}{\partial q_E} = 0 \Leftrightarrow 10 - q_I - 2q_E - 4 = 0 \Leftrightarrow q_E^* = 3 - \frac{q_I}{2}$$

Second, we solve the Incumbent/Leader's profit-maximization problem, considering BR_E:

$$\max_{\substack{\{q_I\} \\ s.t.\ q_E = 3 - \frac{q_I}{2}}} \pi_I = (10 - q_I - q_E)q_I - 2q_I \Leftrightarrow \max_{\{q_I\}} \left(10 - q_I - \left(3 - \frac{q_I}{2}\right)\right) q_I - 2q_I$$

$FOC: \frac{\partial \pi_I}{\partial q_I} = 0 \Leftrightarrow 10 - 2q_I - 3 + q_I - 2 = 0 \Leftrightarrow \boldsymbol{q_I = 5}$. Thus, $q_E = 3 - \frac{5}{2} = 0.5 \rightarrow P = 4.5$

$$\pi_I^{Accommodate} = (4.5 - 2) * 5 = 12.5$$

(iv)

$\pi_I^{Accommodate} > \pi_I^{Deter} \rightarrow$ The Incumbent prefers to accommodate *E*'s entry.

(v)

The Incumbent is now able to produce up to 4 units. Since they would need to produce at least $6(+\varepsilon)$ units to deter *E*'s entry, they are no longer able to do so.

(vi)

The Follower's best response function is unaffected by the new capacity constraint: $q_E^* = 3 - \frac{q_I}{2}$

Therefore, in the absence of the new restriction to its output, firm *I* would still choose to produce 5 units (recall part **(iii)**).

Now, since they can only produce up to 4 units, their optimal choice will be to pick the feasible quantity that is closer to 5 – i.e., they will **produce 4 units**. Hence, $q_E = 3 - \frac{4}{2} = 1 \rightarrow P = 5$

$$\pi_I^{q_I \leq 4} = (5-2) * 4 = 12$$

(vii)

Assuming that the cost of holding idle (or unused) capacity is lower than 0.5 monetary units (i.e., the difference between *I*'s profits in parts **(iii)** and **(vi)**), firm *I* is strictly better off when installing a capacity in excess of the monopoly quantity. It is an optimal strategy for that firm.

4.

(i)

Firms will collude as long as the present value of profits under collusion is higher than the present value of profits under deviation:

$$\frac{\pi^M}{2} + \delta\frac{\pi^M}{2} + \delta^2\frac{\pi^M}{2} + \cdots \geq \pi^M \Leftrightarrow \cdots \Leftrightarrow \delta \geq \frac{1}{2}$$

A discount factor greater than or equal to ½ is required to sustain collusion under this scenario.

(Note that showing at least some intermediate steps was required for full marks.)

(ii)

The optimal collusion price will be the price that maximizes total profits, in other words, the monopoly price:

$$\max_{\{p\}} \pi^M = p * q(p) - 6q(p)$$

$$FOC: \frac{d\pi^M}{dp} = 0 \Leftrightarrow 10 - 2p + 6 = 0 \Leftrightarrow p^M = 8 \rightarrow q^M = 2 \rightarrow q_i^{Collusion} = 1$$

$$\boldsymbol{\pi^{Collusion}} = (8-6) * 1 = \mathbf{2}$$

The optimal tacit collusion price is equal to 8; this is where the sum of their profits will be highest.

(iii)

[If $MC'_1 = 2$, firm 1's collusion profit would be $\pi_1^{Collusion} = (8-2) * 1 = 6$. However, if they decide to deviate from the collusive agreement by charging (slightly below) **6** monetary units – this is the monopoly price given firm 1's new marginal cost, and it is sufficiently low to keep firm 2 out of the market forever – then $\pi_1^{Deviation} = (6-2) * 4 = 16$. Therefore, if firm 1's marginal cost drops to 2 as a result of the R&D project, then collusion will be definitely impossible, since deviation payoffs are strictly higher than collusion profits in each and every period.]

However, **if $MC'_1 = 5.5$, collusion may still be possible**:

- $\pi_1^{Collusion} = (8 - 5.5) * 1 = 2.5$
- $\pi_1^{Deviation;t=0} = (7.75 - 5.5) * 2.25 = 5.0625$, where 7.75 (2.25) is the monopoly price (quantity) given the new marginal cost of 5.5 – notice that this yields a higher profit for firm 1 upon deviation than simply undercutting the collusive price of 8 (that would lead to a profit of $(8 - 5.5) * 2 = 5$)
- After firm 2 detects firm 1's deviation, firm 1 can undercut its opponent forever by charging $P = 6(-\varepsilon) \rightarrow \pi_1^{Deviation;t>0} = (6 - 5.5) * 4 = 2$
- $2.5 + 2.5\delta + 2.5\delta^2 + \cdots \geq 5.0625 + 2\delta + 2\delta^2 + \cdots \Leftrightarrow \cdots \Leftrightarrow \delta \geq 0.837$

Since the two firms were tacitly colluding, we know that $\delta_i \geq \frac{1}{2}, i = \{1, 2\}$. Hence:

- If $\delta_1 \in [0.5, 0.837[$ $\rightarrow$ collusion is no longer possible
- If $\delta_1 \in [0.837, 1]$ $\rightarrow$ collusion is still possible

Hence, the R&D project did <u>not</u> prevent firms from tacitly colluding under *all* circumstances.

(iv)

The project can be harmful to firm 2 when it makes collusion impossible, since that would end its ability to earn a positive profit. This would certainly happen if $MC'_1 = 2$.

If $MC'_1 = 5.5$ instead, the project will either be harmful or harmless depending on firm 1's discount factor: if $\delta_1 \in [0.5, 0.837[$, the project will be harmful to firm 2; if $\delta_1 \in [0.837, 1]$, the project will not affect firm 2's profits.

(v)

The project can be beneficial to consumers when it makes collusion impossible, since that would lead to a lower market price. This would certainly happen if $MC'_1 = 2$.

If $MC'_1 = 5.5$ instead, the project will be either beneficial or inconsequential depending on firm 1's discount factor: if $\delta_1 \in [0.5, 0.837[$, the project will be beneficial to consumers; if $\delta_1 \in [0.837, 1]$, the project will not affect the market price, with consumer welfare being unchanged.