① Find Cournot Equilibrium when there are three firms in the Market.

$P = a - bQ$ ; $Q = q_1 + q_2 + q_3$

$C_1 = C_2 = C_3 = C$

What is the equilibrium price? : $P^*$

What are firms' profit? $\pi_1 = \pi_2 = \pi_3 = ?$

$P = a - bq_1 - bq_2 - bq_3$

$C$ is constant ; $C_1 = C_2 = C_3 = C$

$\pi_1 = TR_1 - TC_1$

$= [a - bq_1 - bq_2 - bq_3]q_1 - C_1$

$\frac{\partial \pi_1}{\partial q_1} = a - 2bq_1 - bq_2 - bq_3 = 0$

$a - bq_2 - bq_3 = 2bq_1$

$q_1 = \frac{a}{2b} - 0.5q_2 - 0.5q_3$

$\pi_2 = TR_2 - TC_2$

$= [a - bq_1 - bq_2 - bq_3]q_2 - C_2$

$\frac{\partial \pi_2}{\partial q_2} = a - bq_1 - 2bq_2 - bq_3 = 0$

$a - bq_1 - bq_3 = 2bq_2$

$q_2 = \frac{a}{2b} - 0.5q_1 - 0.5q_3$

$\pi_3 = TR_3 - TC_3$

$= [a - bq_1 - bq_2 - bq_3]q_3 - C_3$

$\frac{\partial \pi_3}{\partial q_3} = a - bq_1 - bq_2 - 2bq_3 = 0$

$a - bq_1 - bq_2 = 2bq_3$

$q_3 = \frac{a}{2b} - 0.5q_1 - 0.5q_2$

Plug $q_3$ in $q_1$ ; $q_1 = \frac{a}{2b} - 0.5q_2 - 0.5[\frac{a}{2b} - 0.5q_1 - 0.5q_2]$

$q_1 = \frac{a}{4b} + 0.25q_1 - 0.5q_2$

$0.75q_1 = \frac{a}{4b} - 0.25q_2$

$= 0.25\frac{a}{b} - 0.5q_2$

$q_1 = \frac{1}{3}(\frac{a}{b} - q_2)$

Plug $q_3$ in $q_2$ ; $q_2 = \frac{a}{2b} - 0.5q_1 - 0.5[\frac{a}{2b} - 0.5q_1 - 0.5q_2]$

$q_2 = 0.25\frac{a}{b} - 0.25q_1 + 0.25q_2$

$0.75q_2 = 0.25(\frac{a}{b} - q_1)$

$q_2 = \frac{1}{3}(\frac{a}{b} - q_1)$

Plug $q_2$ in $q_1$ ; $q_1 = \frac{1}{3}[\frac{a}{b} - (\frac{1}{3}(\frac{a}{b} - q_1))]$

$q_1 = \frac{1}{3}(\frac{a}{b} - \frac{a}{3b} + \frac{q_1}{3})$

$9q_1 = \frac{3a}{b} - \frac{a}{b} + q_1$

$8q_1 = \frac{2a}{b}$

$q_1 = \frac{a}{4b}$ //

$q_2 = \frac{a}{3b} - \frac{a}{12b}$

$12q_2 = \frac{4a}{b} - \frac{a}{b}$

$q_2 = \frac{a}{4b}$ //

$q_3 = \frac{a}{2b} - 0.5\frac{a}{4b} - 0.5\frac{a}{4b}$

$q_3 = \frac{a}{4b}$ //

$\therefore$ $P = a - b[\frac{a}{4b} + \frac{a}{4b} + \frac{a}{4b}]$

$P = a - \frac{3}{4}a$

$P = \frac{a}{4}$ #

$\pi_1 = Pq_1 - C_1$

$= (\frac{a}{4})(\frac{a}{4b}) - C_1$

$= \frac{a^2}{16b} - C_1$ #

$\pi_2 = Pq_2 - C_2$

$= (\frac{a}{4})(\frac{a}{4b}) - C_2$

$= \frac{a^2}{16b} - C_2$ #

$\pi_3 = Pq_3 - C_3$

$= (\frac{a}{4})(\frac{a}{4b}) - C_3$

$= \frac{a^2}{16b} - C_3$ #

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② If there are N firm ...

$q_i^* = f(N)$ , $P = (N)$ , $\pi_i = f(N)$

$P = a - bQ$ ; $Q = q_N$

$C_N = C$

$\pi_i = P(Q)q_i - C_i q_i = [a - b(q_N)]q_i - C_i q_i$

Assume that $q_1 + q_2 + \ldots + q_n = A$

$P = a - b(q_1 + q_2 + \ldots + q_n)$

$P = a - bq_1 - bq_2 - \ldots - bq_n$

$\pi_1 = (a - bq_1 - bq_2 - \ldots - bq_n)q_1 - C_1$

$\vdots$

$\pi_n = (a - bq_1 - bq_2 - \ldots - bq_n)q_n - C_n$

$\frac{\partial \pi_1}{\partial q_1} = a - 2bq_1 - \ldots - bq_n = 0$

$\frac{a}{2b} - 0.5(q_2 + q_3 + \ldots + q_n) = q_1$

$\frac{a}{2b} - 0.5(q_1 + q_2 + \ldots q_{n-1}) = q_n$

$q_1 - 0.5q_1 = \frac{a}{2b} - 0.5(q_1 + q_2 + \ldots + q_n)$

$0.5q_1 = \frac{a}{2b} - 0.5A$

$q_1 = \frac{a}{b} - A$

$q_2 = \frac{a}{b} - A$

$\vdots$

$q_n = \frac{a}{b} - A$

According to $A = q_1 + q_2 + \ldots q_n$ ;

$A = n\left(\frac{a}{b} - A\right)$

$A = n\frac{a}{b} - nA$

$(n+1)A = n\frac{a}{b}$

$A = \frac{na}{(n+1)b}$

$q_i = \frac{a}{(n+1)b}$ #

$P = a - b(A)$

$= a - b\left[\frac{na}{(n+1)b}\right]$

$= a - \frac{n}{n+1}a$

$= \frac{na + a - na}{n+1}$

$P = \frac{a}{n+1}$ #

$\pi_i = Pq_1 - C_i$

$= \left(\frac{a}{n+1}\right)\left[\frac{a}{(n+1)b}\right] - C_i$

$\pi_i = \frac{a^2}{(n+1)^2 b} - C_i$ #

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## ③ From $Q_2$, What happen if $N \to \infty$, $N = 1$

if $N \to \infty$ ; $q_i = \frac{a}{(n+1)b} \to 0$

→ Each firm reach closer to zero unit

$A = nq_i \to \infty$

→ Every firm combined with Q together will be nearly $\infty$ unit

$P = \frac{a}{n+1} \to 0$

→ When supply increase, price will decrease until reach nearly zero

$\pi_i = \frac{a^2}{(n+1)^2 b} - C_i \to -C_i$

→ Each firm loses their profit and fixed cost is equal to C

if $N \to 1$ ; $q_i = \frac{a}{(n+1)b} = \frac{a}{2b}$ Since $Q = \frac{a}{2b} < Q = \frac{na}{(n-1)b}$

→ Monopoly can sell less quantity

$A = nq_i = Q$ Since $n = 1$

→ Firm will become a monopoly

$P = \frac{a}{n+1} = \frac{a}{2}$ Since $P_m = \frac{a}{2} > P = \frac{a}{n+1}$

→ Monopoly sets a higher price

$\pi_i = \frac{a^2}{(n+1)^2 b} - C_i = \frac{a^2}{4b} - C_i$ But $\pi_m > \pi_i = \frac{a^2}{(n+1)^2 b} - C_i$

→ Monopoly can get higher profits

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