

Economics 644 – Midterm Solutions

1. Cournot Game with n Firms

- See lecture notes. Defining the Nash Equilibrium solution concept in words or using mathematical notation are both acceptable.
- Each firm solves:

$$\text{Max}(q_i) \{ q_i(36 - q_i - Q_{-i} - 6) \} \quad \text{where } Q_{-i} = \sum_{j \neq i}^n q_j$$

$$\text{FOC}(q_i): 36 - 2q_i - Q_{-i} - 6 = 0$$

$$\text{Solve for } q_i: q_i = 15 - \frac{1}{2} Q_{-i}$$

Impose symmetry: $q_i = q_j = q$ for all i, j

$$q = 15 - \frac{1}{2} * (n-1) * q$$

$$q + \frac{1}{2} * nq - \frac{1}{2} * q = 15$$

$$\frac{1}{2}q(1+n) = 15$$

$$q = 30/(1+n)$$

So the NE is for all firms to set $q = 30/(1+n)$.

- Given q solved in (b), $Q = nq = 30n/(1+n)$, and :

$$P = 36 - Q$$

$$P = 36 - 30n/(1+n)$$

$$P = (36 + 36n - 30n) / (1+n)$$

$$P = (36 + 6n) / (1+n)$$

$$P = 36 / (1+n) + 6n/(1+n)$$

Firm profits:

$$\pi_i = 30/(1+n) * [36/(1+n) + 6n/(1+n) - 6]$$

$$\pi_i = 30/(1+n) * [(36 + 6n - 6 - 6n)/(1+n)]$$

$$\pi_i = 30/(1+n) * [30/(1+n)]$$

$$\pi_i = 900/(1+n)^2$$

Therefore, as $n \rightarrow \infty$,

$$Q \rightarrow 30$$

$$P \rightarrow 6$$

$$\pi_i \rightarrow 0$$

Note these are the values that would result if the firms were competing in a perfectly competitive market. The marginal cost of production is 6 so $P = MC = 6$. Plugging $P = 6$ into the demand curve means $Q = 36 - 6 = 30$. Individual firm profits are 0 with marginal cost pricing. The Cournot model has this nice property that the equilibrium values gradually converge to the competitive outcome as you increase the number of players. This is unlike Bertrand which obtains the perfectly competitive outcome as long as there are at least two firms.

2. Simultaneous Move Game

- L strictly dominates C for player 2 ($1 > 0$, $0 > -1$, $-1 > -2$). After eliminating C for player 2, M strictly dominates T for player 1.
- There is no equivalent iterated elimination technique for weakly dominated strategies since players do in fact sometimes play weakly dominated strategies. Strictly dominated strategies (on the first iteration) are also automatically weakly dominated. Thus, we consider the entire game for part (b). L weakly dominates both C and R for player 2 ($1 > 0$, $0 > -1$, $-1 > -2$) and ($1 > 0$, $0 > -1$, $-1 = -1$). M weakly dominates both T and B for player 1 ($5 > 0$, $0 = 0$, $5 > 0$) and ($5 > 4$, $0 > -1$, $5 = 5$).
- Consider the game below with strictly dominated strategies crossed out:

		Player 2		
		L	C	R
Player 1	T	(0, 1)	(0, 0)	(0, 0)
	M	(5, 0)	(0, -1)	(5, -1)
	B	(4, -1)	(-1, -2)	(5, -1)

Pure Strategy Nash Equilibria are (M,L) and (B,R). Since players never play strictly dominated strategies, these cannot involve T or C (and they don't). However, (B,R) is PSNE in which both players are playing weakly dominated strategies.

- (M,L) is a strict Nash Equilibrium ($0 > -1$ and $5 > 4$). However, (B,R) is not strict ($-1 = -1$ and $5 = 5$ though equality of either one of these would make (B,R) not strict).

3. Pay for Delay

- a. Yes, the **pay of delay strategy will be strictly preferred**. Note that if the innovator goes to court, his expected payoff is:

$$E[U_{\text{innovator}} | \text{Court}] = \frac{1}{2} * (\pi^m - F) + \frac{1}{2} * (\frac{1}{2}\pi^m - F)$$

$$E[U_{\text{innovator}} | \text{Court}] = \frac{3}{4} \pi^m - F$$

His pay for delay payoff is $\pi^m - R$. Therefore pay for delay is (strictly) optimal if:

$$\pi^m - R > \frac{3}{4} \pi^m - F$$

$$\frac{1}{4} \pi^m > R - F$$

This inequality holds because $\frac{1}{4} \pi^m > 0$ and $R - F < 0$.

- b. Since the innovator will pay-for-delay if the generic challenges the patent, the generic firm compares a payoff of $R > 0$ from challenging to 0 from waiting. So the generic will **Challenge**.
- c. Upon a challenge by the generic firm, the innovator will have no choice but to go to court since pay-for-delay is no longer available. The generic's expected payoff from challenging is therefore:

$$E[U_{\text{generic}} | \text{Challenge}] = \frac{1}{2} * (-F) + \frac{1}{2} * (\frac{1}{2}\pi^m - F)$$

$$E[U_{\text{generic}} | \text{Challenge}] = \frac{1}{4} \pi^m - F < 0$$

Hence the challenger will now choose to **Wait** and obtain a payoff of zero.

- d. No, the generic drugs will be available to consumers **at the same time** as when pay-for-delay practices were allowed. As an aside (unrelated to the question), pay-for-delay tactics usually involve generic firms delaying entry, but still entering the market prior to the expiration of the patent. So in this case, banning pay-for-delay could lead to the perverse outcome that cheaper alternative drugs are available to consumers later than if pay-for-delay was allowed.