14.01 Fall 2010: Midterm 2 Solution Set

1. True/False/Uncertain Questions (16 points)

In this section, write whether each statement is True, False or Uncertain. You should fully explain your answer, including diagrams where appropriate. Points will be given based on your explanation.

(a) (4 points) Two firms are producing similar goods, but one enjoys economies of scale and one has diseconomies of scale. Claim: both firms can have an identical long-run linear expansion path.

True. A linear expansion path simply indicates that the optimal mix of labor and capital does not change, but there can be either economies or diseconomies of scale depending on the production function. These firms could have the same expansion path, but output using the same quantity of inputs will not be the same.

(b) (4 points) A firm is currently earning negative profit on each good it produces. Claim: it is always optimal for this firm to shut down in the short run.

False. A firm will not shut down in the short run as long as its revenue is greater than average variable cost. If revenue is less than average variable cost (i.e., the absolute value of negative profits is larger than the fixed costs), the firm will shut down. In the long run, of course, firm exit will occur and profits will go to zero.

(c) (4 points) The market for drug production is characterized by both lengthy periods of patent protection and the need for FDA permission to market products. Claim: this market will be characterized by production at the minimum level of average cost in the long run.

Uncertain. Both patent protection and government regulation constitute market barriers in this case. In a market with barriers to entry, the long-run supply curve will not necessarily be horizontal and average cost will not necessarily be minimized. To guarantee a horizontal supply curve, there must be be no barriers to entry, all firms must be identical, and there can be no variation in input costs.

(d) (4 points) Cooperative behavior between two oligopolists is impossible if they know that they will be competing for a limited number of years.

True. A cooperative equilibrium can be sustained only if the competition game will continue forever. If they know the period of competition is finite, both will cheat.

2. Costs and profit maximization (22 points)

A profit-maximizing, price-taking firm produces output Y using a single input X. The firm can produce 0, 8, 9, or 15 units of Y by using 0, 4, 7, or 9 units of X, respectively.

There are no other possible input-output combinations. The firm's production function is therefore given by:

$$Y = f(X) = \begin{cases} 0 & \text{if } X = 0 \\ 8 & \text{if } X = 4 \\ 9 & \text{if } X = 7 \\ 16 & \text{if } X = 12 \end{cases}$$

The price of input X is 1 dollar per unit.

(a) (4 points) Write the firm's total cost as a function of output.

$$C(Y) = \begin{cases} 0 & \text{if } Y = 0 \\ 4 & \text{if } Y = 8 \\ 7 & \text{if } Y = 9 \\ 12 & \text{if } Y = 16 \end{cases}$$

(b) (6 points) Find the firm's supply function $y(p)$. Explain your answer.

$$y(p) = \begin{cases} 0 & \text{if } p < 1/2 \\ 8 & \text{if } 1/2 \leq p < 1 \\ 16 & \text{if } p \geq 1 \end{cases}$$

If output increases from 0 to 8, costs per unit increase by \$0.50/unit. Therefore the firm will supply 0 units if $p < \frac{1}{2}$.
If the firm increases output from 8 to 9, the cost to produce the additional unit is \$3. However, if the firm increases output from 8 to 16, the additional cost per unit of the additional units 8 is \$1/unit. Therefore the firm will produce 8 units when the price is above \$0.50 and below \$1, and 16 units if the price is above \$1.

(c) (5 points) Suppose that there are 5 such price-taking firms in the market, and that there is no entry. Market demand is given by $Q_D = 100 - 10p$. What is the equilibrium price and quantity in this market?
Total market supply with 5 firms is:

$$5 \cdot y(p) = \begin{cases} 0 & \textit{if } p < 1/2 \\ 40 & \textit{if } 1/2 \leq p < 1 \\ 80 & \textit{if } p \geq 1 \end{cases}$$

With this level of demand, the market clears at $p_M = 2$ and $Q_M = 80$.

(d) (7 points) Suppose now that instead of the 5 firms in part (c) there is actually a single monopolist that is five times as large as one of these individual firms. The monopolist's production function is therefore:

$$Y_M = 5 \cdot f(X_M) = \begin{cases} 0 & \text{if } X_M = 0 \\ 40 & \text{if } X_M = 20 \\ 45 & \text{if } X_M = 35 \\ 80 & \text{if } X_M = 60 \end{cases}$$

Demand is given by $Q_D = 100 - 10p$ as before. Assume now that entry is once again impossible. What is the equilibrium price and quantity in this market? Compare this outcome with the equilibrium in (c) and explain why they are the same / differ.

The monopolist compares marginal revenue to marginal cost when deciding whether or not to increase production:

Q	$P = 10 - Q/10$	TR	TC	MR	MC	$Profit$
0	*10*	*0*	*0*			*0*
40	*6*	*240*	*20*	*240*	*20*	*220*
45	*5.5*	*247.5*	*35*	*7.5*	*15*	*212.5*
80	*2*	*160*	*60*	*-87.5*	*25*	*100*

The monopolist will not increase production beyond 40 because MR<MC for all quantities greater than 40. As a result, profits are maximized at $Q = 40$. The equilibrium price at this quantity is \$6.
This is a lower quantity and higher price than in (d) because the large monopoly firm has market power and the five smaller firms are assumed to be price takers.

3. Monopoly and oligopoly (27 points)

A uniform pricing monopolist has the following cost function and faces the following demand curve for its product

$$\begin{aligned} C(Q) &= 20Q \\ P &= 100 - Q \end{aligned}$$

(a) (3 points) Find the monopolist quantity (Q_m), price (P_m), and deadweight loss relative to the perfectly competitive outcome. Draw a diagram labeling the perfectly competitive outcome as A, and the monopolist outcome as B. Be sure to include the marginal cost and marginal revenue curves in your diagram.
The monopolist sets $MR = MC \implies 100 - 2Q = 20 \implies Q_m = 40, P_m = 60$.
$DWL = \frac{1}{2}40 * 40 = 800$.

(b) (6 points) There are two possible scenarios for the monopolist:

i. The government set a price ceiling of \$ 40/unit in which case the monopolist does not invest in any R & D because it is wary of future government regulation.

ii. There is no government regulation, so then the monopolist invests in R & D which then changes the cost function so that $MC = 0$.

Which scenario has higher welfare (ignore the cost of R & D for producer surplus)? Which scenario do the consumers prefer? Explain.

i. *At* $P = 40, Q = 60$, *we have* $CS = \frac{1}{2}BH = \frac{1}{2} * 60 * 60 = 1800$.

$$PS = BH = 60 * (40 - 20) = 1200$$
$$W = CS + PS = 3000$$

ii. $MC = 0, MR = MC \implies 100 - 2Q = 0 \implies Q_m = 50, P_m = 50$
At $P_m = 50$, $Q_m = 50$, *we have:*

$$CS = \frac{1}{2}BH = \frac{1}{2} * 50 * 50 = 1250$$
$$PS = BH = 50 * 50 = 2500$$
$$W = CS + PS = 3750$$

Consumers would prefer scenario (i) since consumer surplus is higher because they pay a lower price. Welfare is higher under scenario (ii) because the cost saving R & D generates large producer surplus and also limits the loss to consumer surplus because output expands.

(c) (6 points) For plan (i), the MR curve features a discontinuity at some Q'. Explain intuitively why the MR curve has this discontinuity.

Generally there are two effects for a monopolist when you increase Q by one unit: the "output effect" when you get to sell the additional unit you produce, and the "poisoning the well" effect when you receive a lower price on the inframarginal units (units you continue to sell). When $Q < Q'$, the MR is constant at the price ceiling of 40 because the monopolist is a price taker. While the monopolist would like to charge more, it is constrained by the government regulation and only has the "output effect". When $Q > Q'$, the MR suddenly drops because you are already selling a lot of inframarginal units, and now the government price ceiling no longer binds, which implies that the "poisoning the well" effect is very large , leading to this discontinuity.

(d) (6 points) In scenario (ii), when $MC = 0$, the monopolist chooses (Q_m, P_m) such that $|\epsilon^D| = 1$. Will an unregulated uniform pricing monopolist ever choose (Q_m, P_m) such that $|\epsilon^D| < 1$? Explain intuitively.

On the inelastic portion of the demand curve, the marginal revenue is negative. If the monopolist is ever on this portion of the demand curve, you can increase profits unambiguously by decreasing quantity by one unit. It is able to save the marginal cost, and its revenues also increase since $MR < 0$.

(e) (6 points) Go back to your solution in (a). Suppose now the government allows one other identical firm to enter this market and firms compete on quantity. Let $x =$ the value of the MR at the monopolist output when there's only one firm. Claim: If the two firms each produce half the Monopoly quantity, then $MR = x$ for both firms at current levels of output. Is this claim true, false, or uncertain? Please explain your reasoning.

False. $MR > x$ for each of the firms, because when the quantity is split between two firms, there are fewer inframarginal units so that the "poisoning the well" effect is smaller from the perspective of one firm. The "output effect" is the same for either the duopoly case or monopoly case.

4. Trade in sweat-trapping headbands (35 points)

The U.S. demand for sweat-trapping headbands is summarized by the function $q_d = 1200 - p$, where p is the market price of a headband. There are currently 49 identical, profit-maximizing domestic headband producers in the U.S., each with the cost function $TC(q) = 72 + 0.5q^2$. U.S. consumers consider domestically produced headbands to be identical to foreign-produced headbands, and currently have access to a huge supply of foreign-made handbands at a constant price of \$10 per band (that is, we can think of the worldwide supply of sweat-trapping headbands as a horizontal curve at $p = 10$).

(a) (5 points) Write down an expression for the supply curve for an individual domestic headband producer. If there is perfectly free international trade in sweat-trapping headbands, what will be the market price of a headband in the U.S.? How many headbands will be purchased in the U.S.? How many of those will be imported from abroad?

Individual domestic producers' supply function can be found by setting $P = MC = Q^{i,dom}$. *Since there are 49 domestic producers, the total domestic supply will be* $Q^{dom} = 49P$ *or* $Q^{dom}/49 = P$. *The market price will be equal to the world price of 10. Since the market demand is* $P = 1200 - Q$, *this implies* $Q^{total} = 1200 - 10 = 1190$. *Domestic producers supply* $Q^{dom} = 49 \cdot 10 = 490$ *units and foreign producers supply the remainder,* $Q^{foreign} = 1190 - 490 = 700$.

(b) (5 points) What will be the profits of each domestic headband producer? What will be the total profits earned by firms in the U.S. domestic headband industry? Assume, for now, that the number of domestic producers remains fixed at 49. Illustrate your answer with two diagrams: one showing the profit-maximization decision of an individual domestic firm, the other showing the entire U.S. headband industry.

Since $P = 10$ *and each domestic firm produces 10 units, individual profits are:*

$$\pi = P \cdot Q - TC(Q) = 10 \cdot 10 - 0.5 \cdot (10)^2 - 72 = -22$$

Industry profits are $49 \cdot (-22) = -1078$.

(c) (2 points) What do you predict would happen to the U.S. domestic headband industry in the long run?

As short run profits are negative, we expect firms to exit this market in the long run.

(d) (3 points) Suppose the U.S. government passes a dramatic new trade bill, the Sweat-Trapping Headbands Industry Protection Act of 2009, outlawing all imports of foreign-made head-bands. If the number of domestic headband producers remains fixed at 49, what will be the new market price of a headband? How many headbands will be purchased in the U.S.?

When imports are banned, the new market equilibrium is the intersection of demand and domestic supply: $1200 - Q = Q/49 \Longrightarrow Q = 1200 \cdot 49/50 = 1176$, *so* $P = 24$.

(e) (6 points) What will be the profits of each domestic producer after the new law is passed? What is the total increase in profits in the domestic headband industry as a result of this new trade law? Depict graphically the change in consumer surplus for headband buyers in the United States as a result of this policy as compared to your answers in (a). Under which scenario will consumer surplus be larger?

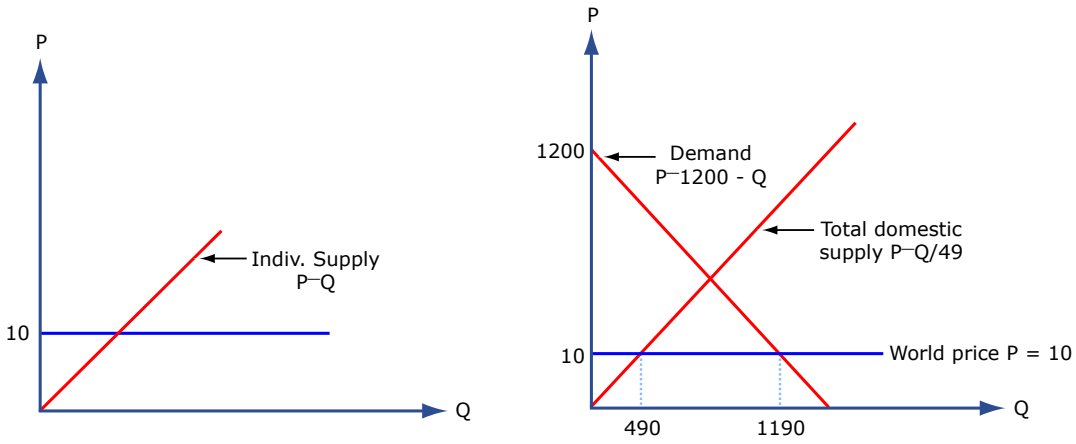
Individual profits are: $\pi = 24 \cdot 24 - 0.5 \cdot (24)^2 - 72 = 216$, *and industry profits are* $49 \cdot 216 = 10584$. *The total change in the industry profits is thus* $10584 - (-1078) = 11662$. *Consumer surplus is larger in the free trade case by the triangle indicated on the graph below.*

(f) (6 points) Assuming that the law described in (d) remains in force, but that there is free entry and exit in the domestic headband industry over time, what do you predict will be the long-run market equilibrium price? How many sweat-trapping headbands will be sold in the U.S.? How many headband-producing firms will there be in the U.S. in the long run?

Since profits are positive in the short run equilibrium without imports, firms will enter until $MC = ATC$, *such that individual profits are zero. Solving for the individual quantities:*

$$Q = 72/Q + 0.5 \cdot Q \Longrightarrow Q^2 = 72 \cdot 2 = 144 \Longrightarrow Q = 12$$

With $P = MC$ *this implies* $P = 12$. *The total quantity in the market is thus* $Q^{total} = 1200 - 12 = 1188$. *And since each firm produces 12 units, we have* $99 = 1188/12$ *firms in the long run market equilibrium (or* 50 *new firms entering).*



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(g) (8 points) Suppose that instead of the bill described in (d), the U.S. government decides to pass a less extreme law, assessing a $t\%$ tax on all imports of foreign headbands. How large must t be (5%? 10%? etc.) in order to ensure that the 49 existing domestic producers can remain in business in the long run?

If the government sets a tax t, then the market price will be $P^{tax} = P \cdot (1+t) = 10 \cdot (1+t)$. From the individual supply functions $Q = P$, this implies that producers are each selling $10 \cdot (1+t)$ units. Their profits are thus:

$$\pi = P \cdot Q - TC(Q) = (10 \cdot (1+t))(10 \cdot (1+t)) - 0.5 \cdot (10 \cdot (1+t)))^2 - 72 = 50 \cdot (1+t)^2 - 72$$

For individual profits to be zero, we need

$$72/50 = (1+t)^2 \Longrightarrow 1.44 = (1+t)^2 \Longrightarrow t = 0.2 = 20\%$$

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