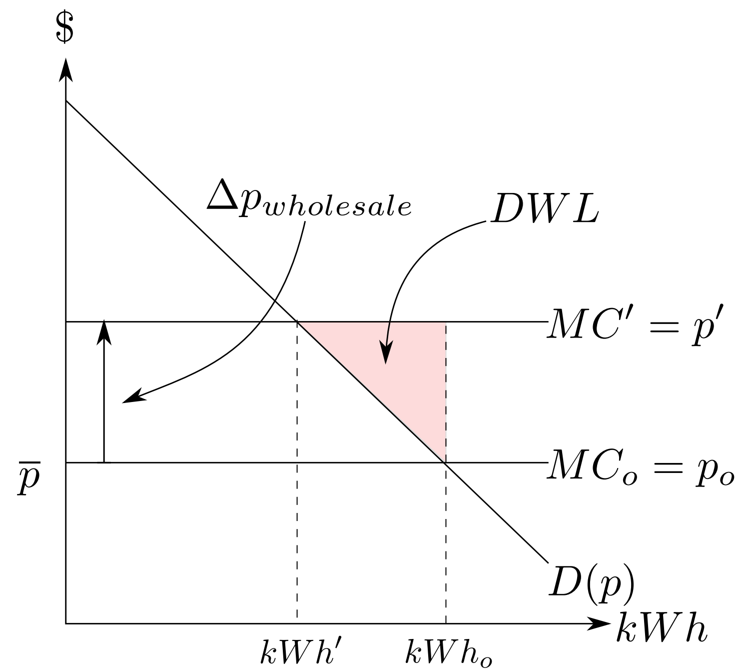
Econ 362 - Government Regulation of Business
College of William and Mary — March 22, 2012
John Parman

Midterm 2 - Solutions

You have until 1:50pm to complete the exam, be certain to use your time wisely. Answer all questions directly on the exam. You must show all of your work to receive full credit. Non-graphing calculators may be used (no graphing calculators or phones can be used). You may leave answers as fractions. Unless a problem says otherwise, you can assume that firms can produce fractions of units and charge non-integer prices (so a firm could produce 82.4 units and sell at a price of $5.325 per unit). Remember to put your name on the exam. Good luck!

Name: **ID Number:**

1. (10 points) Recall that two features that contributed to the California electricity crisis were the cap on the rates that utility companies could charge residential customers for electricity and restrictions on the ability of utility companies to produce their own electricity, making them more reliant on the wholesale electricity market. Use a graph with kWh of electricity on the horizontal axis and price of electricity on the vertical axis to show how these two features would lead to a deadweight loss to society when the wholesale price of electricity rises above the rate utility companies are allowed to charge customers. You can assume that residential customers have a linear, downward sloping demand curve and in the wholesale electicity market, price is equal to the marginal cost (so an increase in wholesale price implies an increase in marginal costs). Be certain to clearly label all of the relevant features of your graph.



On the graph above, the cap on residential electricity prices is represented by $\overline{p}$. Suppose that we start in a situation where the wholesale price, and therefore the marginal cost of electricity, is exactly equal to $\overline{p}$. This initial situation is given by marginal cost curve MC_o and would lead to a total amount of electricity consumed of kWh_o. Now consider higher marginal costs leading to a higher wholesale price of electricity, given by the marginal cost curve MC' on the graph. In this situation, the socially efficient level of electricity consumed would be kWh'. However, customers still see the price as $\overline{p}$ and will therefore still choose to consume kWh_o. On all of the units of electricity between kWh' and kWh_o, the true marginal costs of producing the electricity exceed the marginal benefits to consumers, leading to a deadweight loss equal to the shaded area on the graph.

2. (25 points) During off-peak hours, the inverse demand function for electricity in Williamsburg is given by

$$p(K_o) = 100 - K_o \tag{1}$$

where K_o is the amount of electricity demanded by the off-peak customers in kWh. During peak hours, the demand is given by

$$p(K_p) = 100 - \frac{1}{2}K_p \tag{2}$$

where K_p is the amount of electricity demanded by the peak customers in kWh. Currently, the city has one power plant that can produce up to 100 kWh of electricity. The marginal costs of producing a kWh of electricity at the plant are constant and equal to $25.

(a) Suppose that initially plant capacity cannot be changed and the city must charge a single price to customers of all types. What price would the city set in order to maximize total surplus? What is total surplus under this outcome?

Note that at a price of $50, peak demand is 100 kWh, the current plant capacity. So for any price above $50, peak demand would be less than current capacity and the marginal benefit of an additional kWh of electricity would exceed the marginal cost, meaning the electricity usage is inefficiently low. For any price below $50, lowering the price will lead to greater excess demand by peak customers but it will not change total surplus (the same 200 kWh of electricity are being consumed, lowering the price just transfers surplus from the electricity producer to peak consumers). Given that total surplus in the peak market is the same for any price below $50, we can focus on what price will maximize total surplus in the off-peak market. This will simply be the price where price is equal to marginal cost. Since marginal cost is constant and equal to $25, this price is $25. Off-peak demand at a price of $25 is:

$$p(K_o) = 100 - K_o$$

$$25 = 100 - K_o$$

$$K_o = 75$$

Total surplus will be the consumer surplus for each group of consumers plus the producer surplus in each market:

$$TS = CS_o + PS_o + CS_p + PS_p$$

$$TS = \frac{1}{2}(100-p)(K_o-0)+(p-25)(K_o-0)+\frac{1}{2}(100-50)(K_p-0)+(50-p)(K_p-0)+(p-25)(K_p-0)$$

$$TS = \frac{1}{2}(100-25)(75-0)+0+\frac{1}{2}(100-50)(100-0)+(50-25)(100-0)+0$$

$$TS = 7812.5$$

(b) Now assume that the city can set different prices for peak and off-peak customers. What prices will the city set? Assume the city wants to both maximize total surplus and avoid any excess demand.

The price for the off-peak consumers was already set to maximize total surplus in that market, so the off-peak price will remain \$25. Now for the peak customers, the regulator will want to raise the price to eliminate the excess demand. This means increasing the price to the point where peak demand is exactly 100 kWh:

$$p(K_p) = 100 - \frac{1}{2}K_p$$

$$p(100) = 100 - \frac{1}{2} \cdot 100$$
$$p = 50$$

So the peak price will be \$50.

(c) Now suppose that the capacity of the plant can be expanded at a cost of \$15 per kWh of additional capacity. So the marginal cost of a unit of electricity beyond the current capacity is equal to the \$15 to expand capacity by a unit in addition to the \$25 in marginal costs from operating the plant. What would the new optimal capacity be? How much will total surplus increase as a result of this change in plant capacity? Assume that the city continues to set prices such that total surplus is maximized and can still charge different prices to peak and off-peak customers.

To find the new optimal capacity, we can find where the peak demand curve intersects the marginal cost curve that incorporates the additional costs of expanding capacity:

$$p(K_p) = MC_{expand} + MC_{operate}$$
$$p(K_p) = 15 + 25$$
$$100 - \frac{1}{2}K_p = 40$$
$$K_p = 120$$

The total surplus will increase by the amount of consumer surplus added on those additional 20 units of capacity. This is simply the area under the peak demand curve, above the marginal cost curve (with the marginal costs of expanding capacity included) between 100 and 120 kWh:

$$\Delta TS = \frac{1}{2}(50 - 40)(120 - 100)$$

$$\Delta TS = 100$$

3. (10 points) Suppose that traditional rate of return regulation is being used to regulate a local telephone company. The local regulators are considering increasing the frequency of rate cases. Explain one reason why increasing the frequency of rate cases may increase consumer surplus in the short run. Also explain one reason why increasing the frequency of rate cases may decrease consumer surplus in the long run.

    Increasing the frequency of rate cases can help consumers in the short run by passing along cost savings more quickly. So if input prices fall or technology improves, the resulting lower costs for firms will translate into lower prices and greater consumer surplus for consumers after the next rate case in which prices are adjusted to reflect the lower costs. When there are longer stretches of time between rate cases, there is a longer delay before cost savings get translated into greater consumer surplus.

    The potential downside of more frequent rate cases for consumers is that it can lead to reduced incentives for firms to become more efficient. With a long lag between rate cases, when a firm innovates the cost savings translate into increased profits until the next rate case. As the period between rate cases shrinks the size of these potential profits from innovation decreases reducing the firm's incentive to innovate meaning there will be fewer reductions in costs that would ultimately translate into lower prices and greater surplus for consumers.

4. (30 points) The market for microchips is competitive and firms have no fixed costs and constant marginal costs of \$50 per additional microchip. Demand for microchips in a single time period is given by the following equation:

$$D(p) = 500 - 5p \tag{3}$$

Suppose that one firm is considering investing in developing a new method of manufacturing microchips that would lower marginal costs to \$25.

(a) If the firm could only keep knowledge of the new method private for one period, how much would the firm be willing to invest in the new method of manufacturing?

How much the firm is willing to invest depends on how large the profits will be for the firm once they develop the new manufacturing method. After they develop the manufacturing method, the firm will have a monopoly over the technology for one period. During that period, they would like to exploit this monopoly power by charging the monopoly price at which marginal revenue equals marginal cost:

$$MR = MC$$

The marginal revenue function can be derived by first getting the inverse demand function and then using that to write revenue as a function of the number of microchips M:

$$M = 500 - 5p(M)$$
$$p(M) = 100 - \frac{1}{5}M$$
$$R(M) = p(M)M$$
$$R(M) = (100 - \frac{1}{5}M)M$$
$$R(M) = 100M - \frac{1}{5}M^2$$
$$MR(M) = \frac{dR(M)}{dM} = 100 - \frac{2}{5}M$$

Now we can find the monoply quantity and price once the firm innovates:

$$MR = MC$$
$$100 - \frac{2}{5}M = 25$$
$$\frac{2}{5}M = 75$$
$$M = \frac{375}{2}$$
$$p(\frac{375}{2}) = 100 - \frac{1}{5}\frac{375}{2}$$
$$p(\frac{375}{2}) = \frac{125}{2}$$

So the firm would like to charge \$62.50 after innovating. However, this price is above what the original competitive market price would be (\$50). Even with a monopoly on the new technology, the firm cannot charge a price higher than \$50. So the firm will have to settle for charging \$50. At a price of \$50, they would sell $500 - 5 \cdot 50$ or 250 units. Total profits would be:

$$\pi = R(M) - C(M)$$

$$\pi = 50 \cdot 250 - 25 \cdot 250$$

$$\pi = 6250$$

The firm would be willing to spend any amount up to these profits of \$6250 to develop the new technology.

(b) Now suppose that the firm can apply for a patent that is T periods long. Write down an expression that gives the maximum amount the firm is willing to invest in research and development, $I(T, r)$, as a function of the patent length T and the interest rate r.

The profits we found in part (a) will be earned in each period during the life of the patent. The present value of net profits from the innovation will be the discounted sum of the profits over the lifetime of the patent minus the investment costs:

$$\pi = \sum_{t=0}^{T} \frac{6250}{(1+r)^t} - I(T, r)$$

The most that the firm is willing to invest will be where these profits just go to zero. Investing more than that would lead to a net loss. Setting π equal to zero will therefore give us the maximum amount the firm is willing to invest in research and development:

$$0 = \sum_{t=0}^{T} \frac{6250}{(1+r)^t} - I(T, r)$$

$$I(T, r) = \sum_{t=0}^{T} \frac{6250}{(1+r)^t}$$

Notice that the amount the firm is willing to invest is an increasing function of the patent length T and a decreasing function of the interest rate r.

(c) To simplify things, assume that the interest rate is zero. Determine the optimal patent length from a regulator's perspective if the research and development costs required to develop the new method of manufacturing are equal to \$150,000. Assume the regulator wants to maximize total surplus. Be certain to show all of your work.

The regulator would want the patent to be just long enough to encourage the firm to innovate. Any longer and total surplus would be reduced (more periods of deadweight loss due to the monopoly without any additional benefits in terms of greater innovation). So the regulator would choose T such that the amount the firm is willing to invest is just equal to \$150,000:

$$150000 = \sum_{t=0}^{T} \frac{6250}{(1+0)^t}$$

$$150000 = \sum_{t=0}^{T} 6250$$

$$150000 = 6250T$$

$$T = 24$$

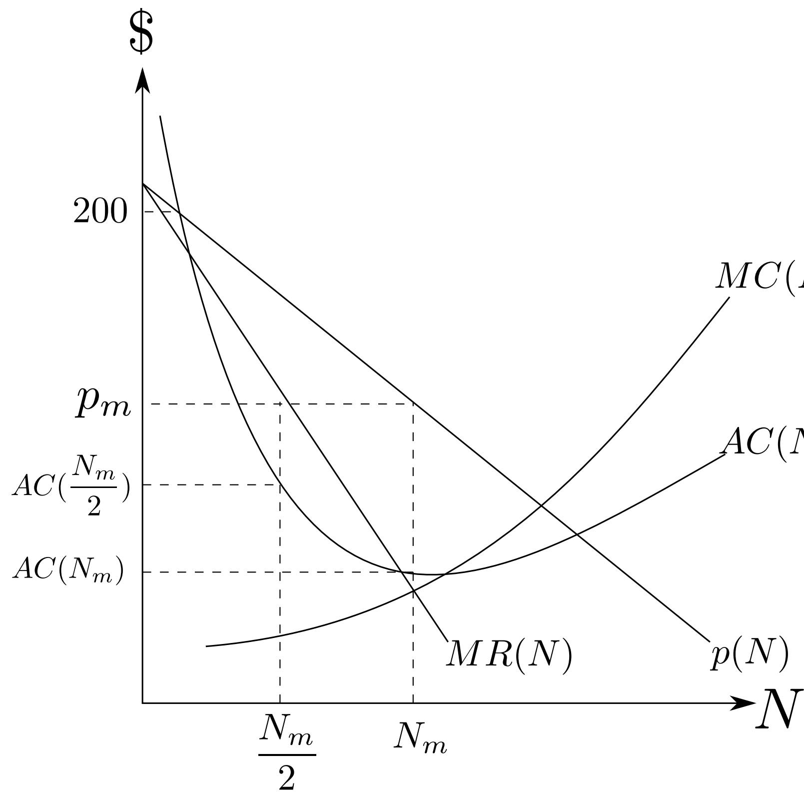
So the patent length should be 24 periods.

(d) Suppose that the regulator has only rough estimates of the numbers used to calculate the optimal patent length and therefore might be off by one year in either direction. Which side would the regulator rather error on, making the patent length one year too long or making it one year too short? Be certain to justify your answer.

The consequences of setting the patent to be a year too short are very different than the consequences of setting the patent to be a year too long. If the patent is set a year too short, the profits from the new manufacturing process will not cover the research and development costs of the firm. This will mean that the firm will not invest and the innovation will never take place. All of the additional surplus from the innovation, the additional producer surplus during the patent period and the additional consumer surplus after the patent ends, would be lost.

Making the patent one period too long would have much less severe consequences. The firm would still decide to invest in research and development as the profits will be larger than the research and development costs (adding a year to the patent increases the profits, so if profits were equal to R&D costs under the optimal patent, they will exceed R&D costs under a longer patent). So the innovation will take place. The only difference will be that there is one extra period of monopoly power meaning one extra period with a deadweight loss relative to the socially efficient price and quantity. Clearly this is a much better outcome than making the patent too short and forgoing all of the additional total surplus associated with the innovation.

5. (25 points) The graph below shows the demand curve for internet service and the average cost and marginal cost curves for a single internet provider with the number of customers, N, on the horizontal axis. Use the graph to answer the questions below.



(a) On the graph, label the price the internet provider will charge and the number of customers it will serve if it acts as a monopolist.

The internet provider will choose to provide service to the number of customers at which marginal revenue equals marginal cost. This is labelled as N_m on the graph. The price the firm will charge will be determined by the demand curve at this number of customers. This price is labelled as p_m on the graph.

(b) Suppose a second firm considers entering the industry. Will this firm enter and stay in the industry or will the original firm ultimately remain a natural monopoly? Use the graph and a written explanation to support your answer.

Notice that at N_m, the monopolist's average costs are below price meaning that the monopolist will be making positive profits. This would make the industry attractive to another firm. If the second firm were to enter and charge the same price the monopolist is currently charging, each firm would be providing service to $\frac{1}{2}N_m$ customers. Notice that average costs at $\frac{1}{2}N_m$ are still below p_m, so both firms would be making positive profits. Given these positive profits, the second firm would remain in the industry.

(c) Suppose that a regulator can give the original internet provider exclusive rights to operate in the city, preventing the second firm from attempting to enter. Explain one reason that the regulator might choose to block the entry of the second firm and one reason why the regulator might choose to allow entry of the second firm. Both reasons should relate to the regulator's goal of maximizing total surplus.

The main reason for giving a single internet provider exclusive rights is to try to keep average costs down. Consider the situation described above in which two firms provide service at a price of p_m. Consumer surplus is the same whether two firms are providing service at that price or one firm is providing service. However, the $AC(\frac{1}{2}N_m)$ is greater than $AC(N_m)$ which means that total costs will be greater by having two firms operate rather than one. This would lead to lower total surplus under multiple firms than under a single firm.

As for why the regulator may prefer to have multiple firms, there are several reasons you could discuss. One main reason is that multiple firms could lead to competition driving prices down for consumers and pushing the number of customers served closer to the socially efficient level. Another major reason would be that competition provides the incentives for firms to attempt to become more efficient. Firms finding cheaper and better ways to provide service would increase total surplus.

(d) The regulator decides to have a single firm provide service and chooses the firm by the following auction procedure. The regulator announces a price of $200 per customer and begins lowering the price by a dollar at a time. Firms remain in the auction as long as they are willing to provide service at the current price. When only one firm is left, that firm wins the right to be the internet provider for the city and must charge the last price announced in the auction and serve all customers who demand service at that price. Will this method of auctioning off a franchise lead to the socially efficient level of internet service, an inefficiently low level of service, or an inefficiently high level of service? Be certain to fully explain your answer. You can assume that all of the firms have cost functions identical to the ones shown on the graph.

Given the way the bidding works, the firms would stay in the auction all the way down to the second point of intersection between the average cost curve and the demand curve. At prices above this, price would be greater than average costs suggesting that the firms would earn positive profits if they won the auction. Notice that the point at which average cost intersects the demand curve is to the right of where marginal cost intersects the demand curve. So the quantity of service that will be provided as a result of the auction will be larger than the socially efficient quantity. Firms stay in the bidding because average cost is still below price on the last few units even though marginal cost is above price. On these last units, there is a deadweight loss to society due to providing service to customers for whom the marginal benefit of service is less than the marginal cost of service.