Econ 362 - Government Regulation of Business
College of William and Mary
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Midterm 2 - Solutions

You have until 3:20pm 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. (15 points) Suppose that electricity rates in Virginia were regulated for several years under traditional rate of return regulation. State regulatory agencies are considering a switch to usng price caps to regulate electricity rates in an attempt to get utility companies to make greater efforts to reduce costs.

   (a) Aside from adjusting prices to account for cost savings, what other factors should regulators incorporate into the price changes under a price cap system?

   Prices will need to adjust for factors that would influence the rate of return for the firm including inflation and the price of inputs. Prices should rise with inflation, rise with an increase in the prices of inputs and fall with a decrease in the price of inputs.

   (b) Suppose that regulators look at the rate at which electricity generation costs have fallen over the past several years controlling for changes in input prices to determine the rate at which technological innovation takes place in the industry. Explain why this would underestimate the rate of technological change that will take place under a price cap system.

   Under traditional rate of return regulation, a firm has little incentive to find ways to reduce costs. Whenever a firm does reduce its costs, prices will be adjusted during the next rate case to pass these cost savings along to the consumer, meaning that the firm will not see an increase in long run profits from innovations that reduce costs. Consequently, the firm will make very little effort to innovate leading to a low rate of technological change. Under a price cap system, the firm has much stronger incentives to innovate. First, because technological progress is built into the price changes, if the firm does not innovate its rate of return will fall as the prices fall over time. Innovation is necessary for the firm to maintain its profits. Second, any additional innovation beyond the expected level of innovation will translate into increased firm profits. Because the path of the prices is independent of the realized innovation, prices will not be adjusted to pass the cost savings of innovation on to the consumers; the firm retains the benefits of innovation. Given these stronger incentives to innovate, the rate of technological change will be higher under price cap regulation than under

traditional rate of return regulation. The rate of technological progress taking place under traditional rate of return regulation would therefore underestimate the amount of progress that would take place under price cap regulation.

2. (25 points) Suppose that Apple is considering spending an amount X on research and development to find a cheaper way to produce iPads. The market demand for iPads is given by:

$$D(p) = 2000 - 2p \tag{1}$$

Currently, Apple's marginal costs of producing an iPad are \$200. If Apple spends X on research and development, the marginal costs of producing an iPad will be reduced to \$100.

(a) Find the price Apple will charge for an iPad if they decide not to engage in any research and development. Assume that Apple is the only producer of iPads.

Apple will produce where marginal revenue equals marginal cost in order to maximize profit. To get the marginal revenue curve, we first need to find revenue as a function of quantity. To do this we need the inverse demand function $p(y)$:

$$y = D(p) = 2000 - 2p$$

$$2p = 2000 - y$$

$$p(y) = 1000 - \frac{1}{2}y$$

Now we can use this to find revenue as a function of y and then marginal revenue as a function of y:

$$R(y) = p(y) \cdot y$$

$$R(y) = (1000 - \frac{1}{2}y) \cdot y$$

$$R(y) = 1000y - \frac{1}{2}y^2$$

$$MR(y) = \frac{dR(y)}{dy}$$

$$MR(y) = 1000 - y$$

Now we can find Apple's monopoly quantity be setting marginal revenue equal to marginal cost:

$$MR(y) = MC(y)$$

$$1000 - y = 200$$

$$y = 800$$

Plugging this quantity back into the inverse demand function will give us the price that Apple will charge:

$$p(800) = 1000 - \frac{1}{2} \cdot 800$$

$$p(800) = 600$$

So Apple will sell 800 iPads at a price of \$600 per iPad.

(b) What is the largest value of X for which Apple would decide to engage in research and development? Assume that Apple is the only producer of iPads and any innovations they make will be relevant only to the production of iPads (the innovation would not be helpful to manufacturers of other tablets).

To figure out how much Apple is willing to invest in research and development, we need to determine how much profits would increase when innovation takes place. First, let's calculate the profits prior to any innovation taking place. We already know that Apple will be charging \$600 per iPad and that marginal costs are \$200 on each iPad, so Apple is making a profit of \$400 per iPad. So total profits will be:

$$\pi_{\text{before}} = 400 \cdot 800$$

$$\pi_{\text{before}} = 320000$$

Now we have to consider what the profits would be after innovation. After innovation, the marginal costs would be reduced to \$100, so the new profit maximizing quantity of iPads would be:

$$MR(y) = MC(y)$$

$$1000 - y = 100$$

$$y = 900$$

At a quantity of 900, customers are willing to pay $1000 - \frac{1}{2} \cdot 900$ or \$550. So Apple's profits after innovation will be:

$$\pi_{\text{after}} = (550 - 100) \cdot 900$$

$$\pi_{\text{after}} = 405000$$

So the change in profits from innovation would be:

$$\Delta\pi = \pi_{\text{after}} - \pi_{\text{before}}$$

$$\Delta\pi = 405000 - 320000$$

$$\Delta\pi = 85000$$

Given that innovation will lead to an increase in profits of \$85,000, Apple would be willing to spend up to \$85,000 on research and development in order for that innovation to take place.

(c) Suppose that costs of research and development are \$50,000 higher than the cutoff you found in part (a), meaning that Apple would not choose to engage in research and development. The government is interested in maximizing total surplus in the market for iPads and is considering subsidizing Apple's R&D costs. Should the government subsidize Apple by contributing \$50,000 toward research and development costs? Use numerical evidence to support you answer.

First, note that if the government contributes \$50,000 toward the R&D costs, Apple's profits will be the same after innovation minus their spending on research and development as they were before innovation. So the producer surplus component of total surplus will not be changing. Therefore, what we need to check is whether consumer surplus will go up by enough to justify the \$50,000 R&D subsidy. The consumer surplus before innovation takes place will be:

$$CS_{\text{before}} = \frac{1}{2}(1000 - 600)(800 - 0)$$

$$CS_{\text{before}} = 160000$$

Consumer surplus after the innovation takes place will be:

$$CS_{\text{after}} = \frac{1}{2}(1000 - 550)(900 - 0)$$

$$CS_{\text{after}} = 202500$$

So the change in consumer surplus will be:

$$\Delta CS = CS_{\text{after}} - CS_{\text{before}}$$

$$\Delta CS = 202500 - 160000$$

$$\Delta CS = 42500$$

By spending \$50,000, the government would increase total surplus by \$42,5000. So the net benefit of the spending is negative. The government should not subsidize the research and development costs of Apple.

(d) How would you expect your answers for parts (b) and (c) to change if Apple's innovations were useful to other electronics manufacturers? You do not need to give exact numbers but you should explain which results would change and what direction they would change in.

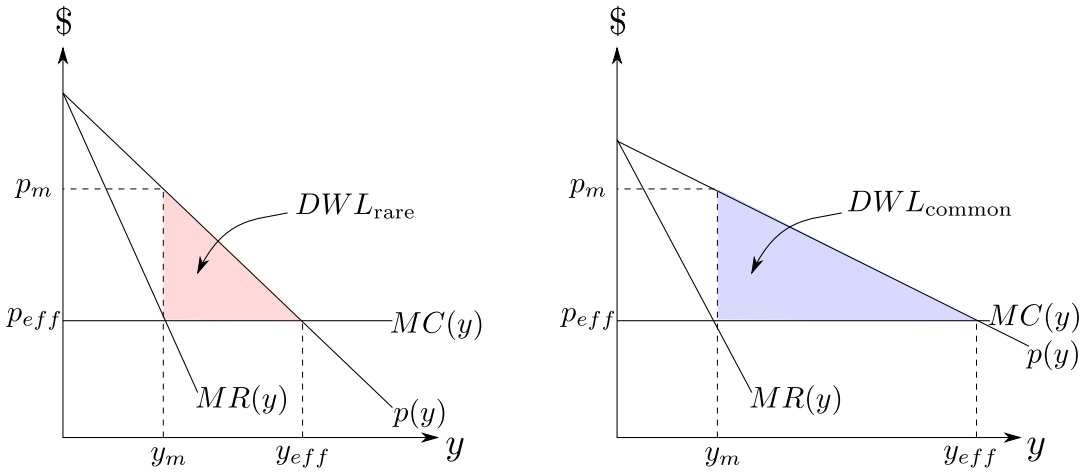
If Apple's innovations are useful to other electronics manufacturers, the direct effect of Apple's innovation will be lowering the marginal costs for other manufacturers. Some of these manufacturers will be firms making competing products (other tablets, ultrabooks, etc.). If marginal costs fall in these markets, prices would also fall meaning that the prices of substitutes for the iPad would fall, reducing the demand for iPads. This reduced demand for iPads would reduce Apple's potential profits from innovation, reducing the amount Apple is willing to spend on research and development.

However, from the regulators perspective innovation is now more worthwhile because it will increase total surplus in these other markets for electronics. The regulator would be willing to spend more subsidizing Apple's research and development costs, possibly making the \$50,000 subsidy in the previous part socially efficient (the change in consumer surplus in the market for iPads plus the change in total surplus in these other electronics markets may now exceed \$50,000).

3. (25 points) Suppose that Congress is considering making patent lengths industry specific. The legislators are debating the patent lengths for drugs that treat rare diseases and for drugs that treat common conditions. Assume that very few drugs currently exist to treat the rare diseases, making demand for a new drug very inelastic. Also assume that many drugs already exist for common conditions, making demand for a new drug for a common condition very elastic (but still greater than zero).

   (a) Given the differences in the elasticity of demand for the two types of drugs, which type should have the longer patent life? Your answer should be based on the difference in elasticity and you should assume that the goal in each market is to set the patent length to maximize total surplus. Be certain to fully explain your answer (graphs of the two markets may be helpful).

   The graph below shows the two different markets. On the left is the market for a drug treating a rare disease and on the right is the market for a drug treating a common condition. The key difference is that the demand in the rare disease market is more inelastic than demand in the common condition market leading to a steeper demand curve in the rare disease market. On each graph, the monopoly price and quantity as well as the efficient price and quantity are labelled. To simplify the analysis, I have constructed the graphs so that the monopoly price, quantity and profits are identical between the two graphs.



   Notice that the more elastic demand curve leads to a larger change in quantity going from the monopoly outcome to the competitive outcome which implies a larger deadweight loss (the shaded region on the graph) while the patent is in effect. This suggests that the marginal costs of extending a patent an additional year (in terms of the deadweight loss) are larger for the drug treating a common condition. Therefore the point at which the marginal cost of extending the patent length equal the marginal benefits of extending the patent length will be at a shorter patent length for the common condition drug than the rare disease drug. Based solely on the elasticities of the two demand curves, common

condition drugs should have shorter patent lengths.

(b) Suppose that companies choose to devote all of their research and development to just one type of drug. If the patent lengths are the same for each type of drug, would you expect a company to invest in developing a drug for a rare disease or a drug for a common condition? Be certain to fully explain your answer including clearly stating any additional assumptions you are making about demand for the drugs.

There are a variety of ways you could answer this question for full credit. Your response will be graded on the correctness and completeness of the economic logic you present. The key thing to think about is the relative size of the markets. One possible assumption is that the number of people suffering from rare diseases and therefore the demand for drugs treating rare diseases is very small and the demand for a drug treating a common condition would be very large. This would suggest that the potential monopoly profits during the patent period would be much larger in the common condition drug market leading the firm to research drugs for common conditions.

Alternatively, you could assume that because many alternative drugs exist for common conditions the demand for a new drug would actually be quite low. So while the overall set of consumers for a rare disease drug might be small, the firm would capture the entire market. The set of consumers for a common condition drug might be quite large but the segment of consumers interested in switching to a new drug might be quite small. If this were the case, the firm may want to invest in researching rare disease drugs.

(c) Is the outcome in part (b) efficient? Is it equitable? Be certain to explain your reasoning.

Your answer to this question will depend on how you answered the previous part. First let's consider whether the firm's focus on common condition drugs (or rare disease drugs) is more efficient than having the firm focus on rare disease drugs (or common condition drugs). For efficiency, we're concerned with generating the biggest possible increase in total surplus. The firm is going to choose the market in which the monopoly profits are largest. This will also be the market in which total surplus is the largest. So the firm is making the efficient choice as to which drug type to research.

(*Note: To see this more formally, note on the graphs above with constant marginal costs,* $y_{eff} = 2y_m$ *and* p_m *is halfway between* p_{eff} *and the vertical intercept of the demand curve, so total surplus at the efficient quantity is* $\frac{1}{2}(\overline{p} - p_{eff})y_{eff}$ *or* $(p_m - p_{eff}) \cdot 2y_m$ *which is just double the monopoly profits. So choosing the market with higher monopoly profits will also mean choosing the market with greater total surplus at the efficient quantity.*)

As for equity, there are a variety of ways to answer. The key is that your answer should address the fairness of the firm's decision. For example, one possible argument would be the following. If the firm chose to research common condition drugs, you might argue that this is not equitable because patients suffering from common conditions have alternatives available while patients suffering from rare diseases have no alternatives and everyone should have access to treatment regardless of the prevalence of their condition.

4. (10 points) Explain two different reasons that traditional rate of return regulation could lead to higher operating costs in the long run for a natural monopoly at any given quantity than the firm would have producing the same quantity under no regulation.

   The first main reason that costs are higher under traditional rate of return regulation is that the firm has very minimal incentives to find ways to reduce costs. If the firm manages to reduce costs, rather than getting to earn higher profits the prices will be adjusted to pass the cost savings along to the customer and return the firm to its original rate of return. In the absence of regulation, the firm could earn higher profits by reducing costs. This will lead to the firm making a greater effort to reduce costs under no regulation than under traditional rate of return regulation.

   The second reason is that the way traditional rate of return regulation works can distort input prices. Spending on capital counts toward the rate base but spending on labor does not. By allowing the firm to earn a return on capital investments the effective price of capital is reduced. This will lead the firm to move away from the cost-minimizing combination of capital and labor to the a combination with more capital and less labor that, while maximizing the firm's profits given the way prices are set by the regulator, does not minimize its costs.

5. (25 points) James City County is accepting bids for the local cable franchise. There are several cable companies all with the same average cost and marginal cost curves. The average cost function for each firm is:

$$AC(y) = 100 - \frac{1}{20}y \tag{2}$$

where y is the number of customers the firm serves. The inverse demand function function for cable in James City County is:

$$p(y) = 200 - \frac{1}{5}y \tag{3}$$

where y is the number of customers who would subscribe to cable if the price were $p(y)$. The franchise will be auctioned off in the following way. The auctioneer will start by announcing a price of \$200 per customer. If multiple firms are willing to provide service at this price, the price will be lowered by a penny. This will continue until there is only one firm remaining. This firm will get the franchise and must provide service to whoever wants it at the lowest price reached during the auction process.

   (a) Given the average cost function above, is it efficient for James City County to only grant a single firm the cable franchise or would it be more efficient to allow multiple firms to have franchises? Be certain to fully explain your answer using the information given in the problem.

   Let's assume we want to serve y customers. If we use one firm to serve those customers, average cost per customer will be $100 - \frac{1}{20}y$ (just the average cost of an individual firm). Now let's suppose that we instead use n firms, so each firm would serve $\frac{y}{n}$ customers. The average costs per customer served would then be:

$$AC(\frac{y}{n}) = 100 - \frac{1}{20}\frac{1}{n}y$$

   Looking at the function above, when n increases the second term gets smaller in magnitude. Since the second term has a minus sign in front of it, this will lead to the overall value of $AC(\frac{y}{n})$ getting larger. In other words, average cost per customer increases as the number of firms increase. The benefits to the customer do not change (the demand curve is not a function of n). So if benefits stay the same but costs increase as n goes up, total surplus will decrease as n increases.

   (b) What price will result from the bidding process? How many customers will subscribe to cable at this price?

   Firms will stay in the bidding as long as they would earn profits greater than or equal to zero. So the price will drop to the breakeven price of the firms during the bidding process. To find this breakeven point, we can set price equal to average cost:

$$p(y) = AC(y)$$

$$200 - \frac{1}{5}y = 100 - \frac{1}{20}y$$

$$100 = \frac{3}{20}y$$

$$y = \frac{2000}{3}$$

The price that corresponds to this quantity can be found by plugging the quantity back into the inverse demand function:

$$p(\frac{2000}{3}) = 200 - \frac{1}{5}\frac{2000}{3}$$

$$p(\frac{2000}{3}) = \frac{200}{3}$$

So the price resulting from the bidding process will be \$66.67 and the number of subscribers will be 667.

(c) Suppose that James City County modifies the auction process in the following way. The format of the auction stays the same and the winner of the auction must still provide service to whoever wants it at the lowest price reached during the auction. However, in addition to providing service at this price, the cable company must also pay a fee to the county equal to 20% of its total revenues (so if the firm charges p, they actually get to keep $0.8p$). With the addition of this fee, what price will result from the auction and how many customers will subscribe to cable?

The firms will still remain in the auction until they reach their breakeven price. However, that breakeven price is now where the price net of the fee just covers the average costs:

$$\frac{4}{5}p(y) = AC(y)$$

$$\frac{4}{5}(200 - \frac{1}{5}y) = 100 - \frac{1}{20}y$$

$$160 - \frac{4}{25}y = 100 - \frac{1}{20}y$$

$$60 = \frac{11}{100}y$$

$$y = \frac{6000}{11}$$

Plugging this quantity back into the inverse demand function will give us the price charged to customers:

$$p(\frac{6000}{11}) = 200 - \frac{1}{5}\frac{6000}{11}$$

$$p(\frac{6000}{11}) = \frac{1000}{11}$$

So 545 customers will subscribe to cable and pay a price of \$90.91 for service. The cable company will keep 80 percent of that, or \$72.73.

(d) Explain why the result in part (c) is less efficient than the result from part (b). Your answer should include a calculation of the change in total surplus resulting from the introduction of the fee.

Notice that in both cases, firm profits are zero because of the nature of the bidding process. So producer surplus is not changing as a result of the fee. What is changing is consumer surplus and the revenue obtained by the local government. First let's consider how consumer surplus has changed. Consumer surplus is simply the area under the demand curve, above the price up to the equilibrium quantity. So the change in consumer surplus going from the outcome in part (b) to the outcome in part (c) is equal to:

$$\Delta CS = CS_{\text{fee}} - CS_{\text{no fee}}$$

$$\Delta CS = \frac{1}{2}(200 - p_{\text{fee}})(y_{\text{fee}} - 0) - \frac{1}{2}(200 - p_{\text{no fee}})(y_{\text{no fee}} - 0)$$

$$\Delta CS = \frac{1}{2}(200 - \frac{1000}{11})(\frac{6000}{11} - 0) - \frac{1}{2}(200 - \frac{200}{3})(\frac{2000}{3} - 0)$$

$$\Delta CS = -14692$$

So there is a large loss in consumer surplus. However, there is also the gain in revenue for the government. We need to see if this gain more than offsets the loss in consumer surplus. The revenue for the government collected in the form of the fee is:

$$\text{fee} = \frac{1}{5} \cdot p_{\text{fee}} \cdot y_{\text{fee}}$$

$$\text{fee} = \frac{1}{5} \cdot \frac{1000}{11} \cdot \frac{6000}{11}$$

$$\text{fee} = 9917$$

So the overall change in total surplus is:

$$\Delta TS = \Delta PS + \Delta CS + \text{fee}$$

$$\Delta TS = 0 - 14692 + 9917$$

$$\Delta TS = -4785$$

Instituting the fee is creating a deadweight loss of \$4,785.