
Instructions: This problem set is due in class on Wednesday, October 13. If you get stuck, you are encouraged to ask questions of the instructor or the tutors. Jeff has office hours Friday 1:00–2:00pm, Monday 3:00–4:00pm, and Tuesday 10:0–11:00am in Vollum 229. Tutors will be available at work sessions Monday and Tuesday 7–10pm in the Dorothy Johansen House. Individual tutoring (at no cost for up to one hour per week) can be arranged through the Office of Student Services.

1. Regulation of Monopoly. Regulus Grimm is a city planner in Reelihumid, Georgia, a medium-sized city. The city is considering a proposal to award an exclusive contract to Clear Vision, Inc., a cable television carrier. Mr. Grimm has discovered that an economic consultant hired a year before has generated the demand, marginal revenue, total cost and marginal cost functions given below:

$$\text{Demand: } P = 28 - 0.0008Q$$

$$\text{Marginal Revenue: } P = 28 - 0.0016Q$$

$$\text{Total Cost: } TC = 120,000 + 0.0006Q^2$$

$$\text{Marginal Cost: } MC = 0.0012Q,$$

where Q = the number of cable subscribers and P = the price of basic monthly cable service. Conditions change very slowly in Reelihumid so that Mr. Grimm considers the cost and demand functions to be reasonably valid for present conditions. Mr. Grimm knows relatively little economics and has hired you to help formulate a regulatory policy based on this information. Use both graphs and numbers to present your answers.

- a. What price and quantity would be expected if CVI is allowed to operate completely unregulated?

According to the formula at the beginning of the problem set, marginal revenue is $28 - 0.0016Q$. Setting $MR = MC$ yields $0.0012Q = 28 - 0.0016Q$, or $0.0028Q = 28$, or $Q = 10,000$. In order to serve 10,000 customers, CVI can charge a price of $28 - 0.0008 \times 10,000 = 28 - 8 = \20 .

- b. Mr. Grimm has asked you to recommend a price and quantity that would be socially efficient. Recommend a price and quantity to Mr. Grimm using economic theory (in graphs and simple language) to justify your answer.

Social efficiency occurs where price = marginal cost. Setting the demand curve equal to the marginal cost function gives $28 - 0.0008Q = 0.0012Q$, or $28 = 0.0020Q$, so $Q = 14,000$. To serve 14,000 subscribers, CVI would have to charge $28 - 0.0008 \times 14,000 = \16.80 .

- c. Compare the economic efficiency implications of (a) and (b) above. How much would the citizens gain if the optimal regulation is imposed? How much would CVI lose?

Consumer surplus is the triangle above the price line under the demand curve. The demand curve intersects the vertical axis at \$28, so the height of the CS triangle under profit-maximization is $\$28 - \$20 = \$8$. The width of the triangle under monopoly is 10,000, so the total consumer surplus is $\frac{1}{2} \times \$8 \times 10,000 = \$40,000$. At the socially efficient point, the height of the triangle is $\$28 - \$16.80 = \$11.20$ and the width is 14,000, so consumer surplus is $\frac{1}{2} \times \$11.20 \times 14,000 = \$78,400$. Consumers gain $\$78,400 - \$40,000 = \$38,400$ from optimal regulation.

The loss to CVI from regulation can be determined either by direct evaluation of profit or from the producer surplus. At the profit-maximizing point, CVI has total revenue of $\$20 \times 10,000 = \$200,000$ and total cost of $120,000 + 0.0006 \times (10,000)^2 = \$180,000$, so profit is \$20,000. At the regulated socially efficient point, total revenue is $\$16.80 \times 14,000 = \$235,200$ and total cost is $120,000 + 0.0006 \times (14,000)^2 = \$237,600$, so they make a loss of \$2,400. The cost of the regulation to CVI is $\$20,000 - (-\$2,400) = \$22,400$. Using the producer surplus method, we calculate the area above the MC curve, below the price line, and between the vertical axis and the quantity produced. For the profit-maximizing point, this is a trapezoid because the price line is above the MC curve. The trapezoid is 10,000 units wide, the left edge (along the axis) is \$20 high (because the MC curve passes through the origin), and the right edge is the difference between price and marginal cost at 10,000 units produced: $\$20 - 0.0012 \times 10,000 = \8 . The area of the trapezoid is then $\frac{1}{2} \times 10,000 \times (\$20 + \$8) = \$140,000$. Note that producer surplus is profit (\$20,000) plus fixed cost (\$120,000). At the social optimum, the producer surplus area is a triangle with height \$16.80 and width 14,000, which is $\frac{1}{2} \times \$16.80 \times 14,000 = \$117,600$. Again, this is profit (-\$2,400) plus fixed cost (\$120,000). And again, the difference in surplus between the profit-maximization point and the socially optimal point is $\$140,000 - \$117,600 = \$22,400$.

You might worry that CVI would leave the market if it continues to make losses. They might adjust their fixed inputs in the long run, which could lower ATC along the LRAC curve. If not, you might have to adopt a regulation strategy that allows them to break even ($P = ATC$) rather than one that pursues allocative efficiency ($P = MC$). Dividing TC by Q yields $ATC = ATC = 120,000/Q + 0.0006Q$. Setting this equal to price gives $120,000/Q + 0.0006Q = 28 - 0.0008Q$. Multiplying both sides of the equation by Q yields $120,000 + 0.0006Q^2 = 28Q - 0.0008Q^2$, which simplifies to $0.0014Q^2 - 28Q + 120,000 = 0$. This is a quadratic equation. It has two real solutions (because the linear demand curve intersects the parabolic ATC curve twice). The relevant one is the larger of the two: $Q = 13,780$. At this quantity, consumers will pay \$16.976. Consumer surplus at this point is $\frac{1}{2} \times (28 - 16.976) \times 13,780 = \$75,955.36$, which is a \$35,955.36 gain from unregulated monopoly but a \$2,444.64 smaller gain than the efficient production level. Profit is zero and producer surplus is equal to FC = \$120,000 at this point.

2. Regulation. The MegaZap Electric Company produces and distributes electricity to residential customers in the metropolitan area. This monopoly firm is regulated, as are other investor owned electric companies. The company faces the following demand and marginal revenue functions:

$$P = 0.04 - 0.01Q$$

$$MR = 0.04 - 0.02Q$$

Its marginal cost function is:

$$MC = 0.005 + 0.0075Q,$$

where Q is in millions of kilowatt hours and P is in dollars per kilowatt hour.

- a. How much will MegaZap produce and what price will it charge if it is unregulated?

Setting $MR = MC$, $0.04 - 0.02Q = 0.005 + 0.0075Q$, or $0.035 = 0.0275Q$. $Q = 0.035/0.0275 = 1.2727$ mkwh. At this quantity, they can sell at a price of $P = 0.04 - 0.01 \times 1.2727 = \$0.02727/\text{kwh}$.

- b. What would be the efficient price and quantity? Is it feasible for a well-informed regulator to set this price?

The efficient price and quantity occurs at the level of output where $P = MC$, which means $0.04 - 0.01Q = 0.005 + 0.0075Q$, or $0.035 = 0.0175Q$, so $Q = 0.035/0.0175 = 2$ mkwh. The price at the efficient level of output is $P = 0.04 - 0.01 \times 2 = \$0.02/\text{kwh}$. It would be feasible for the regulator to set this price as long as it exceeds average variable cost in the short run or average total cost in the long run.

- c. How much additional social benefit will be achieved through regulation? Regulation is not free; analysts and monitors must be paid. What is the most that the citizenry should pay to regulate MegaZap?

The social benefit from regulation is the area between the demand and marginal-cost curves over the range of output from the monopoly output (1.2727) and the efficient level of output (2). Since both the demand curve and the marginal-revenue curve are linear, this area is a triangle. Its area is half the width times the height. The width is $2 - 1.2727 = 0.7273$ mkwh and the height is the difference between the price at $Q = 1.2727$, which is 0.02727, and the marginal cost at that level of output, $MC = 0.005 + 0.0075 \times 1.2727 = 0.01455$. The difference is $0.02727 - 0.01455 = \$0.01272/\text{kwh}$. The area is thus $\frac{1}{2} \times 0.7273\text{mkwh} \times \$0.01272/\text{kwh} = \$0.004626\text{m} = \$4,626$. If it costs more than this amount to implement the regulation (including the deadweight loss of taxation to pay for it), society as a whole is better off just letting the utility maximize its profit.

But this takes into account MegaZap's losses from regulation. From the perspective of the consumers only, they might be willing to pay up to the amount of consumer surplus captured by regulation, which would be a trapezoid of height $\$0.00727/\text{kwh}$, width at the top equal to 1.2727mkwh, and width at the bottom equal to 2mkwh. This area is $\frac{1}{2} \times \$0.00727/\text{kwh} \times 3.2727\text{mkwh} = \$11,896$.

3. Price Discrimination. Calloway Shirt Manufacturers sells knit shirts in two sub-markets. In one market, the shirts carry Calloway's popular label and breast logo and receive a substantial price premium. The other sub-market is targeted toward more price conscious consumers who buy the shirts without a breast logo, carrying the name Archwood. The

retail price of the shirts carrying the Calloway label is \$42.00 while the Archwood shirts sell for \$25. Calloway's market research indicates a price elasticity of demand for the higher priced shirt of -2.0 , and an elasticity for the Archwood shirts of -4.0 . Moreover, the research suggests that both elasticities are constant over broad ranges of output.

- a. Are Calloway's current prices optimal? Why or why not?

Let P_C = Calloway price, P_A = Archwood price, ε_C = Calloway elasticity, and ε_A = Archwood elasticity. For an optimal price ratio the following conditions must hold.

$$\frac{P_C}{P_A} \text{ must } = \frac{\left(1 + \frac{1}{\varepsilon_A}\right)}{\left(1 + \frac{1}{\varepsilon_C}\right)}$$

$$\frac{P_C}{P_A} = \frac{42}{25} = 1.68$$

$$\frac{\left(1 + \frac{1}{\varepsilon_A}\right)}{\left(1 + \frac{1}{\varepsilon_C}\right)} = \frac{\left(1 + \frac{1}{-4}\right)}{\left(1 + \frac{1}{-2}\right)} = \frac{\frac{3}{4}}{\frac{1}{2}} = \frac{3}{2} = 1.5$$

Thus the current price is not optimal.

- b. Management considers the \$25 price to be optimal and necessary to meet the competition. What price should the firm set for the Calloway label to achieve an optimal price ratio?

Given the elasticities, the price ratio should be 1.5. This, if $P_A = \$25$, then P_C must = \$37.50.

4. Efficiency of Monopoly and Price Discrimination. The industry demand curve for a particular market is:

$$Q = 1800 - 200P.$$

The industry exhibits constant long-run average cost of \$1.50 per unit at all levels of output, regardless of the market structure. Calculate market output, price (if applicable), consumer surplus, and producer surplus (profit) for each of the scenarios below. Compare the economic efficiency of each possibility.

- a. Perfect Competition

Since LAC is constant, LMC is also constant and equal to LAC at \$1.50. Under competition, output is where $P = LMC$. The demand curve gives $P = 9 - 0.005Q$. Setting this equal to LMC of 1.50 gives $1.50 = 9 - 0.005Q$, or $Q = 1500$ with $P = 1.50$. Consumer surplus is that area of the triangle above the market price (1.50) and below the demand curve. The demand curve is a line, so the area is a triangle with width equal to the quantity 1500 and height equal to the difference between the intercept 9 and the market price 1.50. Thus, the

area is $\frac{1}{2} \times \$7.50 \times 1500 = \$5,625$. Producer surplus is zero because the marginal-cost (supply) curve is horizontal at the market price, so there is no area.

b. Pure Monopoly (Hint: $MR = 9 - 0.01Q$)

A monopoly firm will set $MR = LMC$, or $9 - 0.01Q = 1.50$, or $Q = 750$. Price is $9 - 0.005 \times 750 = \$5.25$. The consumer surplus is the triangle above 5.25 and below the demand curve from output of zero to 750. This triangle has height of $9 - 5.25 = 3.75$ and width of 750, so its area is $\frac{1}{2} \times 3.75 \times 750 = \$1,406.25$. Producer surplus is the firm's profit, which is the difference between price (5.25) and constant marginal cost (1.50) multiplied by the quantity (750), which is the area of the rectangle between market price and MC: $3.75 \times 750 = \$2,812.50$. Total surplus is thus $\$1,406.25 + \$2,812.50 = \$4,218.75$.

c. First-Degree Price Discrimination

Under first-degree price discrimination, the price (at the margin) and quantity are the same as under competition, but the surplus of \$5,625 goes to producers rather than consumers.

Both competition and first-degree price discrimination are efficient (in the sense of the socially optimal amount of the good being produced), but pure monopoly is not.