Economics 101

Fall 2014

Homework #5

Due Thursday, Dec 11, 2014

**Directions:** The homework will be collected in a box **before** the lecture. Please place your name, TA name and section number on top of the homework (legibly). Make sure you write your name as it appears on your ID so that you can receive the correct grade. Late homework will not be accepted so make plans ahead of time. **Please show your work.** Good luck!

**Please realize that you are essentially creating “your brand” when you submit this homework. Do you want your homework to convey that you are competent, careful, and professional? Or, do you want to convey the image that you are careless, sloppy, and less than professional. For the rest of your life you will be creating your brand: please think about what you are saying about yourself when you do any work for someone else!**

**1. Monopoly**

Suppose Steepery Tea Bar is a monopolist in producing bubble teas in Madison. The market demand curve for bubble teas faced by this monopolist is given as P = 10 – (1/8)QD. The tea bar’s total cost is given by TC = (1/32)Q2 + 32 and the marginal cost is given by MC = (1/16)Q. Use this information to answer the following questions.

a. What is the equation for the marginal revenue (MR) curve for Steepery Tea Bar?

Since the demand curve faced by the monopolist is linear, the marginal revenue (MR) curve for the monopolist will have the same P-intercept as the demand curve and will have twice the slope of the demand curve. Thus, MR = 10 – (1/4)Q.

b. What are the equations for the average total cost (ATC) and average variable cost (AVC)?

The average total cost for the monopoly is total cost divided by quantity: ATC = TC/Q = {(1/32)Q2 + 32}/Q = (1/32)Q+ 32/Q. The average variable cost for the monopoly is variable cost divided by quantity. The variable cost is total cost minus fixed cost which is the total cost evaluated at zero quantity: VC = TC – FC = TC – TC(Q = 0) = (1/32)Q2 + 32 – 32 = (1/32)Q2. Thus the average variable cost is AVC = VC/Q = (1/32)Q2/Q = (1/32)Q.

c. What is the profit maximizing production quantity QM for Steepery Tea Bar if the monopolist only charges one price? What price PM will it charge? Calculate the value of this monopolist’s profits?

To find the profit maximizing production quantity and price for the single price monopolist we need to set MC = MR. We know that MC = (1/16)Q and MR = 10 – (1/4)Q from part a). Equating (1/16)Q and 10 – (1/4)Q gives QM = 32 cups of bubble tea. To find the equilibrium price for the single price monopolist, substitute QM = 32 into the demand equation: PM = 10 – (1/8)(32) = $6 per cup of bubble tea. The total revenue for the single price monopolist is TR = PM \*QM = ($6 per cup of bubble tea)(32 cups of bubble tea) = $192 and the total cost for the single price monopolist is TC = (1/32)(32)2 + 32 = 32 + 32 = $64. Hence, the profit for single price monopolist = TR – TC = $192 - $64 = $128.

d. Compute the consumer surplus and producer surplus for the monopolist.

CS = (1/2) ($10 per cup - $6 per cup)\*32 cups = $64

PS = (1/2) ($2 per cup - $0 per cup)\*32 cups + ($6 per cup - $2 per cup)\*32 cups = $32 + $128 = $160

e. Now suppose there is a new juice bar, Jamba Juice, that opens across the street from Steepery Tea Bar. Though it does not provide bubble teas, the juices and smoothies Jamba Juice makes are alternatives to bubble teas. Therefore, the demand for bubble teas decreases by 20 cups at every given price. Write down the equation for Steepery Tea Bar’s new demand curve. Then, calculate the new profit maximizing production quantity Q’M and price P’M for Steepery Tea Bar. Calculate the monopolist’s new profit. Assume the monopolist only charges one price.

To get the new demand curve, we shift the old demand curve to the left by 20 units which would reduce the Q-intercept of demand curve by the same amount. Write the old demand curve in Q-intercept form: QD = 80 – 8P. Thus, the new demand curve is QD = 80 – 8P – 20 = 60 – 8P. In order to get the equation for the new marginal revenue curve, we write the new demand curve in P-intercept form: P = (15/2) – (1/8) QD. Recall marginal revenue curve will have the same P-intercept as the demand curve and will have twice the slope of the demand curve. Thus, MR = (15/2) – (1/4)Q. Again to find the profit maximizing production quantity and price for the single price monopolist we need to set MC = MR. We know that MC = (1/16)Q and MR = (15/2) – (1/4)Q here. Equating (1/16)Q and (15/2) – (1/4)Q gives Q’M = 24 cups of bubble tea. To find the equilibrium price for the single price monopolist, substitute Q’M = 24 (cups of bubble tea) into the new demand equation: P’M = (15/2) – (1/8)(24) = $4.5 per cup of bubble tea. The total revenue for the single price monopolist is TR’ = P’M \*Q’M = ($4.5 per cup of bubble tea)(24 cups of bubble tea) = $108 and the total cost for the single price monopolist is TC’ = (1/32)(24)2 + 32 = 18 + 32 = $50. Hence, the new profit for single price monopolist = TR’ – TC’ = $108 - $50 = $58.

f. Now, suppose the fixed cost for Steepery Tea Bar decreases to $20 when the equipment needed to produce bubble tea gets cheaper. Given this information, what is the equation for the new TC curve for Steepery Tea Bar? Calculate the new profit maximizing production quantity, price, and profit for Steepery Tea Bar given the new TC curve and the demand curve in e).

The equation for new total cost curve is TC = VC + FC’ = (1/32)Q2 + 20 since VC = (1/32)Q2 and FC’ = 20. Though TC changes, marginal cost does not change since changes in fixed cost will not alter marginal cost. Neither does marginal revenue, as the demand curve is unchanged. Again to find the profit maximizing production quantity and price for the single price monopolist we need to set MC = MR. As neither MC nor MR changes, the profit maximizing production quantity and price are the same as the ones in part h): Q’’M = 24 (cups of bubble tea) and P’’M = $4.5 per cup of bubble tea. The total revenue for the single price monopolist is TR’’ = P’’M \*Q’’M = ($4.5 per cup of bubble tea)(24 cups of bubble tea) = $108 and the total cost for the single price monopolist is TC’’ = (1/32)(24)2 + 20 = 18 + 20 = $38. Hence, the new profit for single price monopolist = TR’’ – TC’’ = $108 - $38 = $70.

**2. Natural Monopoly**

Comcast is a natural monopoly for cable TV and internet in C’ville. Suppose the following information about Comcast operations is true.

Marginal Revenue = 100 - 20Q

Total Cost = 100 + 12Q + Q2

Marginal Cost = 12 + 2Q

a. Find the equation for the average total cost (ATC) of Comcast.

The average total cost for Comcast is total cost divided by quantity: ATC = TC/Q = (100 + 12Q + Q2)/Q = 100/Q + 12 + Q

b. Using the equation you got from part (a) to fill in the below table.

|  |  |
| --- | --- |
| Quantity | ATC |
| 1 |  |
| 2 |  |
| 4 |  |
| 5 |  |
| 10 |  |

|  |  |
| --- | --- |
| Quantity | ATC |
| 1 | 113 |
| 2 | 64 |
| 4 | 41 |
| 5 | 37 |
| 10 | 32 |

c. Based on your calculations in part (b), does Comcast experience economies of scale when the quantity is below 10?

Yes, Comcast does experience economies of scale because its ATC decreases as quantity goes up.

d. Assume the market demand function faced by Comcast is linear. Given the above information, what is the equation for the market demand curve?

Since the demand curve faced by Comcast is linear, the marginal revenue (MR) curve for the monopolist has the same P-intercept as the demand curve and will have twice the slope of the demand curve. Thus, the demand curve is given by P = 100 –10Q.

e. Suppose now that there is no government regulation whatsoever. If there is no regulation, what the price and quantity will Comcast choose? Is this the socially optimal quantity and price? Explain your answer. (*Hint*: we identify the socially optimal amount of the good as being that amount of the good where the price the consumer pays for the last unit of the good is exactly equal to the marginal cost of producing that last unit of the good.)

In this case of no government regulation, Comcast would act as a single monopolist. It would determine its profit maximizing output by setting MR=MC. Since the demand curve faced by the monopolist is linear, the marginal revenue (MR) curve for the monopolist will have the same P-intercept as the demand curve and will have twice the slope of the demand curve. Thus, MR = 100 – 20Q. Equating 100 - 20Q and 12 + 2Q gives Q=4. Plugging Q=4 into demand function results in P = 100 – 10(4) = 60. This is not socially optimal because MC = 12 + 2(4) = 20 which is smaller than the price the consumers pays at Q = 4.

f. Now suppose the government imposes the regulation that Comcast must produce the socially optimal amount of output. What quantity will Comcast produce and what price will it charge given this type of regulation?

The socially optimal amount of the good is where MC = demand. Or, where the additional cost of producing the last unit is exactly equal to the price an individual is willing to pay for this last unit. Equating 12 + 2Q and 100 – 10Q gives Q = 22/3. To find the equilibrium price for Comcast, substitute Q = 22/3 into the demand equation: P = 100 – 10(22/3) = 80/3.

g. Based on (f), is there a need for a subsidy to keep Comcast in business under this regulation? If yes, what must the natural monopoly receive from the government in order to be willing to produce the socially optimal amount of the good? (*Hint*: calculate the profit of Comcast under part (f).)

Under part (f), the total revenue for Comcast is TR = P \*Q = (80/3)(22/3)= $ 1760/9 and the total cost for Comcast is TC = 100 +12(22/3) + (22/3)2 = 100 + 88 + 484/9 = $2176/9. Hence, the profit for Comcast = TR – TC = $1760/9 - $2176/9 = - $416/9. There is a need for government subsidy because Comcast’s profit is now negative. Comcast will need to receive a subsidy from the government equal to the $416/9 in order to be able to stay in business and produce the socially optimal amount of the good.

h. Calculate Comcast’s consumer surplus (CS) and producer surplus (PS) under part (e). Is there any deadweight loss (DWL)? If yes, how much is DWL?

CS = (1/2)($100 per unit - $60 per unit)(4 units) = $80

PS = ($60 per unit - $20 per unit)(4 units) + (1/2)($20 per unit - $12 per unit)(4 units) = $176

There is a deadweight loss associated with producing this level of output since P is greater than MC when Comcast produces 4 units. The DWL measures the total surplus that is given up in a market. We can calculate the DWL as follows: DWL = (1/2)($60 per unit - $20 per unit)(22/3 units – 4 units) = $200/3.

The deadweight loss represents the loss in consumer surplus and the loss in producer surplus that occurs when the monopolist restricts his production level and charges a higher price than would occur in the socially optimal case.

**3. Price Discrimination**

Suppose that there are three groups of people who take buses to commute in Richmond, VA. The first group is students, the second group is professors, and the third group is professionals. The demand for each group is given by the following equations:

Demand of students: P = 8 - (1/2)Qs

Demand of professors: P = 16 - 2Qprof

Demand of professionals: P = 20 - Qpro

The city bus company has constant marginal cost at MC = $4, and total cost at TC = 4Q + 10.

a. Assume that the bus company can perfectly distinguish people’s identities as students, professors, or professionals. This means that the bus company can charge different people different prices based upon which group they belong to. Calculate the quantity of bus rides that students will buy and the price they will pay per bus ride.

To maximize the profit generated from students, the company will set its MC equal to MRs. Since the demand curve faced by the monopolist is linear, the marginal revenue (MR) curve for the monopolist will have the same P-intercept as the demand curve and will have twice the slope of the demand curve. Thus, MRs = 8 - Qs. Thus we have 8 - Qs = 4. So Q­s = 4. Ps = 8 – 2 = 6

b. Continuing with the assumptions that we had in part (a), calculate the quantity of bus rides that professors will buy and the price they will pay per bus ride.

To maximize the profit generated from professors, the company will set its MC equal to MRprof. Thus, we have MC = MRprof and MRprof = 16 - 4Qprof. So 16 - 4Qprof = 4. Qprof = 3, Pprof = 16 - 2\*3 = 10.

c. Continuing with the assumptions that we had in part (a), calculate the quantity of bus rides that professionals will buy and the price they will pay per bus ride.

Again use MC = MRpro and MRpro = 20 - 2Qpro. We have 20 - 2Qpro = 4 and thus Qpro = 8 and Ppro = 20 – 8 = 12.

d. Given the quantities and prices you have calculated in parts (a) through (c), what is the value of total profit for the bus company when it sells bus tickets to students, professors, and professionals? That is, calculate the value of this company’s profits when it charges different prices to each of the groups it serves and produces different quantities of the good for each of the groups.

Revenue from students: Ps\*Qs = 6\*4 = $24; revenue from professors: Pprof\*Qprof = 10\*3 = $30; revenue from professional: Ppro\*Qpro = 12\*8 = $96. Thus total revenue is $24 +$30 + $96 = $150. Total cost = 4\*(Qs + Qprof + Qpro) + 10 = 4\*(4+ 3 + 8) + 10 =4\*15 +10 = $70. So total profit is $150 - $70 = $80.

e. Now for the sake of comparison let’s assume that the bus company cannot distinguish people’s group identities perfectly. The only thing the bus company can do is to check whether the passenger is a student or not. Given this information, what would be the bus company’s optimal pricing strategy now? You need to find specific prices and quantities.

The company should select two different price and quantity pairs: a pair of price and quantity for students only and another pair for other people. In the case of students, nothing has changed so Q­s = 4 and Ps = 6 as before.

For the other price and quantity pair we need to compute a market demand curve that is comprised of the professionals and the professors. This will entail adding these two demand curves together horizontally. From professors we have Qprof =8 – (1/2)P; from professionals we have Qpro = 20 - P. Add the quantity up we have

Q = 0 for P ≥ 20; neither professors nor professionals will demand bus rides if the price is greater than or equal to $20

Q = 20 – P for 16 ≤ P ≤ 20; only professionals will demand bus rides in this price range

Q = 28 - (3/2)P for 0 ≤ P ≤ 16; both professionals and professors will demand bus rides in this price range

In slope-intercept form, the added-up demand is

P ≥ 20 for Q = 0; neither professors nor professionals will demand bus rides if the price is greater than or equal to $20

P = 20 – Q for 0 ≤ Q ≤ 4; only professionals will demand bus rides over this domain of quantities

P = (56/3) - (2/3)Q for 4 ≤ Q ≤ 28; ; both professionals and professors will demand bus rides over this domain of quantities

The added-up marginal revenue is therefore

MR ≥ 20 for Q = 0;

MR = 20 – 2Q for 0 ≤ Q ≤ 4;

MR = (56/3) - (4/3)Q for 4 ≤ Q ≤ 14;

Observe that

MR ≥ 20 for Q = 0;

12 ≤ MR ≤ 20 for 0 ≤ Q ≤ 4;

0 ≤ MR ≤ 40/3 for 4 ≤ Q ≤ 14;

Since MC is constant at $4, MC can be equated to MR only when 2 ≤ Q ≤ 14. Set MC = MR, we have 4 = (56/3) - (4/3)Q. So Qprof+pro = 11, Pprof+pro = (56/3) - (2/3)(11) = 34/3.

f. Calculate the total profit in part (e) when the bus company charges one price and quantity pair to students and another price and quantity pair to the other consumers in the market for bus rides. How does this new level of profits compare to the level of profits you calculated in (d)?

From part (e), revenue from students: Ps\*Qs = 6\*4 = $24 and revenue from professors and professionals: Pprof+pro\*Qprof+pro = (34/3)\*11 = $374/3. Thus total revenue is $24 +$374/3= $446/3. Total cost = 4\*(Qs + Qprof+pro) + 10 = 4\*(4 + 11) +10 = $70. So total profit is $446/3 - $70 = $236/3 which is smaller than $80 in part (d).

**4. Game Theory**

Nicky and Kendrick are musicians who each want to play a huge concert for their group of friends on New Year’s Day. Nicky knows that Kendrick wants to have his own concert, and Kendrick knows that Nicky wants her own concert. The problem is that if they both have a concert at the same time, half their friends will go to each, and neither of them wants a half-full concert.

Here is the payoff matrix providing a measure of the benefits that Nicky and Kendrick each receive depending upon whether they play a concert or not. In each cell the first number refers to Nicky’s benefit while the second number refers to Kendrick’s benefit.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Kendrick | |
|  |  | No Concert | Concert |
| Nicky | No Concert | 0, 0 | -5, 10 |
| Concert | 10, -5 | -10, -10 |

1. Is there any strictly dominant strategy for Nicky?

No.

In this case, Nicky’s best strategy depends on what Kendrick does. If Kendrick has no concert, then the best decision for her is to play a concert. But If Kendrick does play a concert then the best decision for her is to have no concert.

1. Is there any strictly dominant strategy for Kendrick?

No.

Kendrick’s best strategy depends on what Nicky does, in the same way as in part (a).

1. (Is there an equilibrium outcome that we can predict for this game?) Can we predict for sure what will happen in the game?

No.

Whichever combination of Concert/No Concert that the musicians choose, one of them would be able to get a higher payoff by switching their strategy.

Kendrick decides that rather than having a huge concert in a big arena, he could instead hold his concert in a small neighborhood theater. With this new venue choice, the new payoff matrix is given below.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Kendrick | |
|  |  | No Concert | Concert |
| Nicky | No Concert | 0, 0 | -5, 7 |
| Concert | 10, -5 | -10, 7 |

1. With the new payoffs, is there a dominant strategy for Kendrick?

Yes.

Regardless of whether Nicky plays a concert or not, Kendrick gets the highest payoff by having his own concert. He is able to sell out his smaller venue no matter what, so he gets his payoff of 7 either way. Kendrick’s dominant strategy is to play a concert.

1. What outcome can we predict for this game now?

With the new payoffs, Kendrick will play a concert for sure, and Nicky knows this. Nicky will compare her payoffs from having a concert given that Kendrick will be having one, and will choose not to play a concert, since payoff of -5 > -10.

**5. Public Goods**

Consider a community that has two residents, Leslie and Ron. Leslie and Ron would both like to have some public parks in their community and they are trying to decide on the optimal number of parks to build, and what price they should each contribute for each park. Luckily they are both willing to reveal their preferences and so we do not have to worry about the free rider problem. Leslie’s demand for parks is given by the equation Q = 6 – 2P and Ron’s demand for parks is given by the equation P = 3/2 – (1/4)Q. The marginal cost of providing a park is $3.

1. On your homework paper draw three graphs vertically one above the other. The first graph should be labeled “Leslie’s demand”; the second graph should be labeled “Ron’s demand”; and the third graph should be labeled “Market demand”. On each graph the horizontal axis should be labeled “Quantity of Parks” while the vertical axis should be labeled “Price of Parks”. Now in each graph draw in the demand curve corresponding to your label. Remember that the market demand curve will be a vertical summation of the individual demand curves since a public good is non-rival.

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1. Write an equation for the market demand curve for the public good.

Leslie: P = 3 – (1/2)Q

Ron: P = 3/2 – (1/4)Q

Market: P = 9/2 – (3/4)Q

1. What is the optimal number of parks for the community? Show how you found this number.

To find the optimal number, find the market demand when the price equals marginal cost.

MC = 3

P = 9/2 – (3/4)Q

3 = 9/2 – (3/4)Q

Q = 2 parks

1. Since Leslie and Ron each get benefits from the parks, they will each contribute towards the cost. Given her demand, how much will Leslie contribute per park? How much will Ron contribute per park? Why do Leslie and Ron contribute different amounts?

The marginal cost of each park is $3, which must be paid by Leslie and Ron. From part (c), we know that the optimal number of parks is Q = 2. We can plug Q = 2 into the individual demand curves to find each person’s willingness to pay for 2 parks.

Leslie: P = 3 – (1/2)(2)

P = 2

Ron: P = 3/2 – (1/4)(2)

P = 1

So Leslie is willing to contribute $2 per park when 2 parks are built, and Ron is willing to contribute $1 per park. $2 + $1 = $3 = MC, so together they cover the full cost of the parks. Because Leslie and Ron have different demand curves, or willingness to pay for parks, their contributions are different. This only works because both of them are honestly reporting their individual demand for parks.

1. Now think about what would happen if Leslie and Ron were unable to share the same parks. Now each of them would have to build their own private park, and pay the full cost. How many parks are Leslie and Ron willing to pay for individually? How many total parks would be built? *(Remember: we can’t build negative parks.)*

If Leslie has to pay the full cost of $3, she would be willing to pay for:

3 = 3 – (1/2)Q

Q = 0 parks

If Ron has to pay $3, he would be willing to pay for:

3 = 3/2 – (1/4)Q

Which gives Q less than zero, so he wouldn’t pay for any parks either.

So if Leslie and Ron cannot share the benefits and costs of the parks, none will be built in the community.

**6. Externalities**

For this problem, we want to think about the market for greenhouse gas emissions, which are a byproduct of burning fossil fuels. The suppliers of greenhouse gas emissions include companies that produce electricity, as well as everyone who drives in cars, flies in airplanes, etc. These uses of energy provide a marginal private benefit (MPB) to consumers, since we value being able to turn on the lights and travel. These energy sources have a marginal private cost (MPC) as well, since we must purchase the gasoline and coal used in our cars, airplanes, and power plants. We can write these marginal cost and benefit curves as equations that depend on Q, the quantity of greenhouse gas emissions:

MPB = 200 – Q

MPC = Q

The production of these emissions also causes changes to the atmosphere, which imposes some external costs on society as a whole, as people make costly adjustments to the changing climate. Let’s say these external costs are estimated to be $20 per unit of greenhouse gas emissions. This external cost is currently not being internalized in the market.

1. Given the MPB and MPC curves, what is the market quantity of emissions Q that will be produced?

Market will set MPB = MPC

200 – Q = Q

200 = 2Q

Q = 100

1. Is the current level of market production of emissions the socially optimal amount? Explain your answer.

No.

The socially optimal level of emissions should be the level at which Marginal Social Benefit equals Marginal Social Cost, MSB = MSC. The marginal private cost does not take in to account the external cost being caused by the emissions, so the market will produce emissions at a quantity above the socially optimal amount.

1. What are the values of consumer surplus (CS), producer surplus (PS), and the external costs given the current level of emission production? Calculate Total Surplus as (CS + PS - external costs). Draw a graph illustrating each of these concepts in the market for greenhouse gas emissions.

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TS = CS + PS – external costs

= (1/2)(100)(100) + (1/2)(100)(100) – 100(20)

= 8000

1. The marginal cost to society, or the marginal social cost (MSC), as a whole from producing emissions is the sum of MPC and the marginal external cost. Write down the equation for Marginal Social Cost, MSC = MPC + marginal external cost, and draw it on a graph with MPC and MSB. What is the socially optimal quantity of emissions? *(Note that because there is no external benefit from producing emissions, MPB = MSB.)*

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MSC = Q + 20

At social optimal, MSC = MSB

Q + 20 = 200 – Q

2Q = 180

Q = 90

1. Your graph should now include MPC, MSC, and MPB = MSB. The graph should look familiar to you! It resembles a market with an excise tax. What per-unit tax would the government have to put on each unit of greenhouse gas emissions in order for the market equilibrium quantity of emissions to equal the socially optimal quantity?

In order to for the market quantity to equal the socially optimal quantity, the government could impose a tax of $20 per unit of emissions, which is equal to the external cost imposed by the emissions. Forcing producers to pay a tax equal to the size of the external cost they generate forces them to internalize the social cost that the emissions generate.