ECONOMICS 238OC1 MIDTERM EXAM – VERSION A SOLUTIONS

Dr. Karen Huff February 24, 2019
TIME ALLOWED: 1.5 Hours CLOSED BOOK

[5 each] 1. Each of the following statements is either **True** or **False**. State which each is and briefly, but precisely explain your answer. Your explanation is the most important part of your answer.

(a) Natural resource economics is the study of the residuals from production and consumption which considers how to reduce the flow of residuals so they cause less damage to the natural environment and depletion of natural capital.

False; natural resource economics studies how to efficiently extract/harvest/use natural capital inputs over time. The description given in the question applies to environmental economics.

(b) The more public an environmental good is, the more likely private property rights can be used to achieve the socially optimal level of emissions through bargaining.

False; because public goods face the problem of non-excludability, this makes it difficult to assign property rights and successful bargaining is not possible in the absence of clearly defined property rights.

[5 each] 2. Briefly define and explain **TWO** of the following concepts as they relate to this course.

These definitions can be found in either the textbook readings or the online lesson notes.

3. Suppose that the market for some private good involves external costs caused by pollution resulting from its production. The inverse supply and demand for this good are described by linear functions as follows:

$P_C = 500 - 0.5Q_D$

$P_P = 20 + 2Q_S$

P_C and P_P are the prices paid by consumers and received by producers respectively. Q_D and Q_S are the quantities demanded and supplied, respectively. Because of pollution emitted in its production, there is $20 dollars of damage done every time one unit of the good is produced.

[2] (a) Solve for the free market equilibrium price and quantity of this market.

Set demand equal to supply to solve for the market clearing quantity, Q_M:

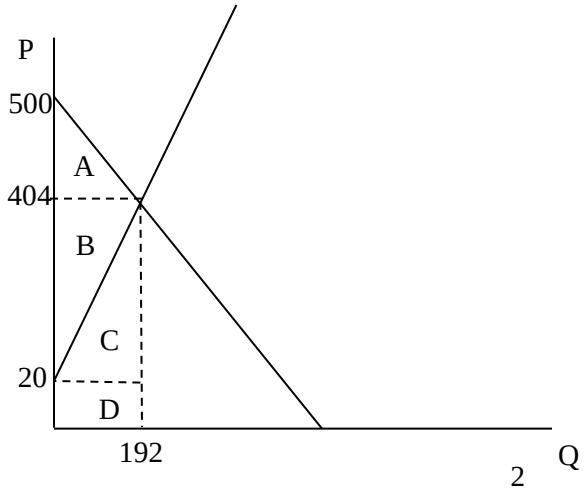
$500 - 0.5Q_M = 20 + 2Q_M$
$480 = 2.5\ Q_M$
$Q_M = 192$

Substitute the equilibrium quantity into either the demand or supply equation to solve for the market price:

$500 - 0.5(192) = 404 = P_M$

The free market equilibrium quantity is 192 and the equilibrium price is $404.

[4] (b) Calculate the total social benefits, total social costs (showing both the total private cost and total damage cost components) and total net social benefits associated with the free market equilibrium. Remember that $20 in damages occurs for each unit of output. Show your calculations and explain the steps briefly in your own words. (You may want to sketch a diagram to help you visualize the areas being calculated.)



In terms of the above diagram (which is not drawn to scale), we can calculate the labelled areas as follows:

A = ½ (500 − 404) × 192 = 9,216
B = ½ (404 − 20) × 192 = 36,864
C = ½ (404 − 20) × 192 = 36,864
D = 20 × 192 = 3,840

Total Social Benefits equal the area under the Marginal Social Benefit curve (the demand curve): TSB = A + B + C + D = $86,784

Total Social Costs will equal Total Private Costs plus Total Damage Costs.

Total Private Costs equal the area under the Marginal Private Cost curve (the supply curve note how this is no longer the MSC curve due to the presence of damages from production): TPC = C + D = $40,704

Total Damage Costs equal the per unit damages times the level of output: TDC = 20 × 192 = 3,840

TSC = TPC + TDC = 40,704 + 3,840 = 44,544

Total Net Social Benefits equal the Total Social Benefits minus the Total Social Costs: TNSB = 86,784 – 44,544 = $42,240

[1] (c) Is the free market equilibrium the social optimum? Explain why or why not.

The free market equilibrium is not the social optimum in this market because there is a negative production externality of $20/unit of output. Since firms do not take this externality into consideration, they produce an amount of output that exceeds the social optimum.

[3] (d) Now suppose that the government imposes a tax of $25 per unit of the good. Calculate the equilibrium quantity and prices under the tax, showing your work.

When a tax is imposed it drives a wedge between the price consumers pay and the price producers receive that can be explained by the following equation:

$P_C = P_P + tax$

At the new equilibrium:

$Q_S = Q_D = Q_t$ where the subscript t stands for tax.

Use the relationship between prices with a tax described above to solve for output under the tax:

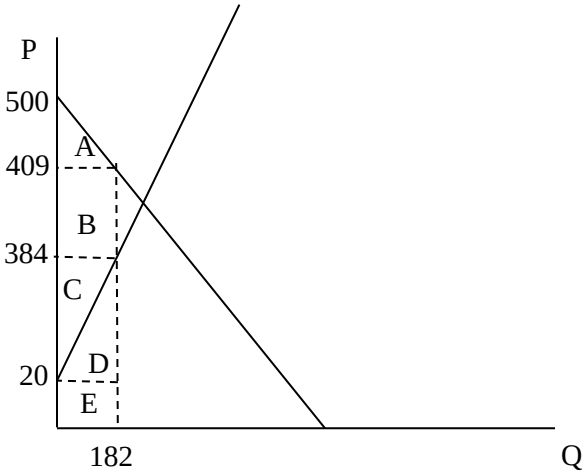
$P_C = P_P + tax$
$500 - 0.5Q_t = 20 + 2Q_t + 25$
$455 = 2.5Q_t$
$Q_t = 182$

We now must solve for consumer and producer prices separately since the tax drives a wedge between them:

$P_{Ct} = 500 - 0.5(182) = \$409$
$P_{Pt} = 20 + 2(182) = \$384$

With a $25 tax, the output is 182 and the consumer price is $409 and the producer price is $384.

[4] (e) Calculate the total social benefits, total social costs (showing both the total private cost and total damage cost components) and total net social benefits associated with the $25 tax equilibrium. Show your calculations and explain the steps briefly in your own words (you may find sketching a diagram helpful).



In terms of the diagram (which is not drawn to scale), we can calculate the labelled areas as follows:

A = ½ (500 − 409) × 182 = 8,281
B = (409 − 384) × 182 = 4,550
C = ½ (384 − 20) × 348 = 33,124
D = ½ (384 – 20) × 348 = 33,124
E = 20 × 182 = 3,640

Total Social Benefits equal the area under the Marginal Social Benefit curve (the demand curve):
TSB = A + B + C + D + E = $82,719
Total Social Costs will equal Total Private Costs plus Total Damage Costs.

Total Private Costs equal the area under the Marginal Private Cost curve (the supply curve note how this is no longer the MSC curve due to the presence of damages from production): TPC = D + E = $36,764

Total Damage Costs equal the per unit damages times the level of output:
TDC = 20 × 182 = 3,640

TSC = TPC + TDC = 36,764 + 3,640 = $40,404

Total Net Social Benefits equal the Total Social Benefits minus the Total Social Costs:
TNSB = 82,719 – 40,404 = $42,315

[1] (f) Does the $25 tax result in the social optimum? If not, what government intervention would result in the social optimum?

No, the $25 tax does not result in the social optimum. Although TNSB rises under the $25 tax equilibrium, it would be even higher if the government charged a lower tax equal to $20/unit so that it equals the per unit damages.

4. You work for a renewable energy start-up that is considering building a small scale wind farm in a scenic area. The initial construction costs are estimated to be $1,150,000. Following start-up, annual maintenance costs of $12,000 are expected throughout the lifespan of the plant. In the 10th year, the wind farm will need to be dismantled and the site restored, at an estimated cost of $100,000. Every year after the initial construction year, while the plant is in operation, the site is projected to produce electricity with a market value of $210,000.

The following table presents the discount factors (calculated based on a discount rate of 5%), the benefits and costs of the project over its lifespan.

Table 1: Proposed Wind Farm Data

Year	Discount Factors	Benefits	Costs
0	1	0	1,150,000
1	0.95	210,000	12,000
2	0.91	210,000	12,000
3	0.86	210,000	12,000
4	0.82	210,000	12,000
5	0.78	210,000	12,000
6	0.75	210,000	12,000
7	0.71	210,000	12,000
8	0.68	210,000	12,000
9	0.64	210,000	12,000
10	0.61	0	100,000

All costs and benefits are relative to doing nothing.

[7.5] (a) Use the given discount factors to conduct a cost-benefit analysis of the proposed wind farm by computing the net present value of the project. Be sure to show your calculations. Based on your analysis, would you recommend building the wind farm?

NPV = -1,150,000 + 0.95(210,000 - 12,000) + 0.91(210,000 - 12,000)

+ 0.86(210,000 - 12,000) + 0.82(210,000 - 12,000) + 0.78(210,000 - 12,000)

+ 0.75(210,000 - 12,000) + 0.71(210,000 - 12,000) + 0.68(210,000 - 12,000)

+ 0.64(210,000 – 12,000) + 0.61(-100,000)

NPV = 194,800

Based on these calculations, I would recommend that the wind farm project be built since it generates a positive net present value and would be better than doing nothing.

[7.5] (b) Local citizens object to the proposed wind farm because of the perceived negative visual impact it will have on their community. A study suggests that paying compensation of $1,000 per affected household per year will solve the problem of local resistance to the project. Recalculate your cost benefit analysis showing the impact of a $1,000 compensation package to be paid to 20 local households annually during the years it is in operation (years 1-9). Show your net present value calculations. Is the wind farm still a feasible project if your firm is required to compensate 20 households during each of years 1 through 9?

To see if the wind farm is feasible when compensation is required, we need to recalculate the Net Present Value of the net cash flows including compensation. The annual cost of compensating the 20 households is $20,000 to be added to the maintenance costs for years 1-9.

NPV = -1,150,000 + 0.95(210,000 - 32,000) + 0.91(210,000 - 32,000)

+ 0.86(210,000 - 32,000) + 0.82(210,000 - 32,000) + 0.78(210,000 - 32,000)

+ 0.75(210,000 - 32,000) + 0.71(210,000 - 32,000) + 0.68(210,000 - 32,000)

+ 0.64(210,000 – 32,000) + 0.61(-100,000)

NPV = 52,800

Based on these calculations, I would still recommend that the wind farm project be undertaken since even with the compensation payments, the net present value is positive and better than doing nothing.

5. Suppose a chemical factory discharges waste products into a river resulting in significant damages to a local fishery. The marginal damage to the fishery (measured in terms of the value of lost fish stocks) is represented by the equation:

MDC = 15E

The chemical factory can reduce its effluent flows by treating its waste products. Its marginal abatement cost (MAC) function is given by the equation:

MAC = 2,000 - 5E.

[5] (a) What level of emissions will occur if the chemical factory is not regulated? What would the total abatement costs for the chemical factory be if emissions are controlled and reduced to zero?

In the absence of regulation, marginal abatement costs will equal zero:

MAC = 0 = 2,000 – 5E

E = 2,000/5 = 400

In the absence of regulation, emissions will equal 400 units. The total abatement cost if all 400 units of emissions were abated will be equal to the area under the MAC curve:

TAC = ½(400 × 2,000) = $400,000

Total abatement costs if all emissions are required to be abated would be $400,000.

[4] (b) If no liability laws are in place, calculate and explain what damages will the chemical factory inflict on the fishery?

With no liability laws, the chemical company will emit 400 units of emissions (level of emissions corresponding to MAC = 0). At this level of emissions, the total damage cost will be equal to the area under the MDC curve:

TDC = ½(400 ×6,000) = $1,200,000

With no liability laws in place, total damage costs from the chemical company will be $1,200,000.

[5] (c) If the government puts in place a liability law that requires the chemical factory to compensate the fishery for the damages it causes, what level of emissions will take place and what are the total costs of compliance for the chemical company? Explain your answer.

The chemical factory will minimize their total compliance cost which equals total damage compensation to be paid plus total abatement cost if they reduce emissions to the socially efficient level. This corresponds to the level of emissions that equates MAC and MDC:

2,000 – 5E = 15E

E = 2,000/20 = 100

The socially efficient level of emissions is 100 units. The total compliance cost (TCC) of the chemical factory will equal the total abatement cost to reach emissions of 100 units, plus the total damages payable to the fishery which will equal the TDC when emissions are 100 units. Note that when emissions equal 100, this implies abatement of 300 units.

TCC = TAC + TDC = ½(300 × 1,500) + ½(100 × 1,500) = 225,000 + 75,000 = $300,000

The total compliance cost of the chemical factory will be $300,000.

[6] (d) If the fishery has the property right to use the river, what bargaining will result in the socially efficient equilibrium? What are the net gains experienced by each party? Explain your answer.

Since the fishery has the right to clean water, the chemical factory will need to pay a "bribe" to the fishery to allow it to emit the socially efficient level of emissions which is equal to 100 units of emissions. At this level of emissions, the MDC = MAC = $1,500.

The factory will need to pay the fishery $1,500 per unit of emissions it discharges into the river. This "bribe" is equal to: 1,500 × 100 = $150,000.

The net gain to the fishery is equal to the bribe it receives from the factory minus the damages resulting from 100 units of emissions which equals: $150,000 – 75,000 = $75,000.

The net gain to the chemical factory is equal to the reduction in total abatement cost it has to undertake from moving from zero emissions to the socially efficient level of emissions minus the bribe it pays to the fishery which equals: 400,000 – 225,000 – 150,000 = $25,000.