

ECON/FRE 374 – Problem Set 3

Instructions: a) Your grade on this problem set will be determined by *randomly* grading a single problem from the set below. It is thus important to do each question carefully as any one problem could determine your grade. b) Problem sets are to be handed in at the beginning of class. Please do not upload your problem sets in webct. c) Any problem set received after the time it is due will not be graded. d) Please label and mark all graphs clearly.

Questions (each question is potentially worth 10 points):

Question 1

Suppose local governments in Brazil harvest heavily the Amazon forest. Their marginal net benefit is represented by $MB = 900 - X$, where X is the number of harvested acres of forest. The world's community is affected by this over-harvesting and has a marginal damage of $MD = \frac{1}{2} X$. (Using graphs would certainly help answering the questions.)

In the absence of possible bargaining,

a. what is the number of harvested acres? **900**

The local governments harvest until the marginal net benefit of the last acre harvested is 0. Then, $0 = 900 - X$.

b. what are the total net benefits to local governments? **405 000**

The total benefits are the triangle area under the MB line. Then, $(900 \cdot 900) / 2 = 405\,000$.

Suppose it is possible to bargain and there is no enforceability problem. The United Nations offer a compensation to local governments for them to limit the harvested acres to the point where social surplus is maximised.

c. what is the minimal amount the local governments are willing to accept? **45 000**

The optimal amount of harvested acres is where $MB = MD$ (the damage here is the cost). Then, $900 - X = \frac{1}{2} X$ which leads to $X = 600$.

By reducing the harvested acres from 900 to 600, local governments lose net benefits. The amount lost is $300 \cdot (900 - 600) / 2 = 45\,000$.

Hence, to accept the compensation, they have to get at least 45 000.

d. what is the maximal amount the UN are willing to offer? **112 500**

The total damages at 900 are 202 500 ($= 900 \cdot 450 / 2$). The total damages at 600 are 90 000 ($= 600 \cdot 300 / 2$).

By the reduction, the world's community is avoiding damages of 112 500 (= 202 500 – 90 000).

The UN are then willing to pay at most 112 500.

e. Name 2 broad reasons why the world's community would be damaged by the decrease in the Amazon forest.

- CO₂ reduction
- Existence value (of the forest and of biological diversity)
- Option value
- Bequest value

Question 2

Suppose the government wants to clean up a beach in a federal park and build some facilities. The government's objective is to increase the national social surplus. There is no congestion problem. What are the net benefits of this project if you know the following information:

- The marginal cost of a visit is 1, but there is no entry fee.
- The Canadian marginal benefit is $MB^C = 1000 - X$, where X is the number of Canadian visitors.
- The marginal benefit for the foreign tourists is $MB^F = 10000 - Y$.
- The international image of Canada improves by an amount estimated at 5000.
- The cost of the infrastructure is 100 000.
- The natural state of the area will be degraded by a fixed amount of 50 000.

Identify clearly benefits and costs in your analysis.

344 000

Benefits

- Surplus from Canadian consumers (area under the MB line): 500 000 (= 1000*1000/2)
- International image value: 5000
- Total: 505 000

Costs

- Cost of visits (Canadian visitors): 1000 (= 1000 visitors * 1)
- Cost of visits (Foreign visitors): 10 000 (= 10 000 visitors * 1)
- Infrastructure cost: 100 000
- Natural cost: 50 000
- Total: 161 000

Net benefits = Benefits – Costs = 344 000

Notes:

- Benefits from foreign visitors are not included since the government cares about the **national** social surplus.

- Even if there is no entry fee, each visitor creates an extra cost of 1. It has to be included in the analysis.

Question 3

A railway crosses a farmer's land. Every time one train passes on the land, the sparkles released by the locomotive set an acre of land on fire and the farmer loses this portion of crop. The more the trains that pass, the lower the amount of profits the farmer makes. Let X be the number of trains that pass per summer and let Y be the number of acres of crop the farmer has. The railway company's total profits are $24X - X^2$, and the farmer's total profits are $30Y - Y^2 - XY$. Let us consider the outcome under various assumptions about institutional rules and about bargaining between the railway company and the farmer.

a. Suppose that no bargains can be struck between the railway company and the farmer and that each can decide on its own level of activity.

Calculate the number of trains per summer that maximises profits for the company.

Given that number of trains, calculate the number of acres that maximizes the farmer's profits, total profits of the company, total profits of the farmer, and the sum of their profits.

Number of trains: $X = 12$

Profits = $\max(x) 24X - X^2$

The Marginal profit is $24 - 2X = 0$. Then $X = 12$.

Number of acres: $Y = 9$

Profits = $\max(y) 30Y - Y^2 - XY$

The marginal profit is $30 - 2Y - 12X = 0$. Then $Y = 9$.

Company's profits = $144 = 24(12) - (12)^2$

Farmer's profits = $81 = 30(9) - (9)^2 - (12)(9)$

Sum of profits = 225

b. Suppose that a local ordinance makes it illegal to operate trains because they impose an externality on the farmer. Then no trains pass. How many acres will be planted and what is the farmer's profit?

Number of acres: $Y = 15$

Profits = $\max(y) 30Y - Y^2$

The FOC is $30 - 2Y = 0$. Then $Y = 15$.

Farmer's profits = $225 = 30(15) - (15)^2$

c. Suppose that a law is passed that makes the company liable for all damages to the farmer. Since the farmer's profits are $30Y - Y^2 - XY$ and his profits would be $30Y - Y^2$ if no trains were operated, the total amount of damages awarded to the farmer will be XY . Therefore if the company operates X trains and the farmer plants Y acres, then the company's profits after it has paid damages will be $24X - X^2 - XY$. The farmer's profits including the amount he receives in payment of damages will be $30Y - Y^2 - XY + XY = 30Y - Y^2$.

Complete the following statement: To maximize his net profits, the farmer will choose to plant **15...** acres no matter how many trains are operated. To maximize its profits, net of damages, the company

will choose to operate 4.5... trains. Total profits of the farmer will be 225... and total profits of the company will be 20.25.... The sum of their profits will be 245.25....

Note: In the case you wonder how the company can operate half a train, you can compute profits at the number of trains 4 or 5 and see what is the optimal solution.

d. What do you conclude from these calculations?

When property rights are defined and bargaining is possible, the optimal solution is reached and aggregated profits are maximised. In a. no bargaining was possible. In b. property rights are defined (given to the farmer), but no bargaining was possible. In c. property rights are defined and bargaining is possible, then the social surplus (aggregated profits) is maximised.

Question 4

Suppose the Department of Fisheries and Oceans and is trying to increase the ability of salmon to spawn in a Maple Ridge stream over the next four years. There are two ways of doing this: clearing debris from the stream every year; or building fish ladders that last the four years. Building fish ladders is expensive but it only has to be done once and it helps more fish upstream. Specifically, the timing of the costs and benefits of each option is outlined in Table 1. All values are in thousands of dollars.

Table 1: Timing of costs and benefits of each project

Clearing Debris			Building Ladders		
Year	Costs	Benefits	Year	Costs	Benefits
0	15	30	0	150	45
1	15	30	1	0	45
2	15	30	2	0	45
3	15	30	3	0	45
4	15	30	4	0	45

a. Calculate the net present value of each project and determine which option is best if the discount rate is 10%. What project should be chosen?

$$NPV(\text{clearing debris}) = (30-15) + (30-15)/(1.1) + (30-15)/(1.1)^2 + (30-15)/(1.1)^3 + (30-15)/(1.1)^4$$

$$NPV(\text{building ladders}) = (45-150) + 45/(1.1) + 45/(1.1)^2 + 45/(1.1)^3 + 45/(1.1)^4$$

b. Do the same for a discount rate of 5%. What project should be chosen?

$$NPV(\text{clearing debris}) = (30-15) + (30-15)/(1.05) + (30-15)/(1.05)^2 + (30-15)/(1.05)^3 + (30-15)/(1.05)^4$$

$$NPV(\text{building ladders}) = (45-150) + 45/(1.05) + 45/(1.05)^2 + 45/(1.05)^3 + 45/(1.05)^4$$

c. Explain what a low discount rate means.

A low discount rate allows the future benefits (or cost) to vanish slower. The lower the discount rate, the more weight on the future.