Topic 4

- Fish Game

- Tragedy of the Commons

    ▷ Introduction to Resource Economics
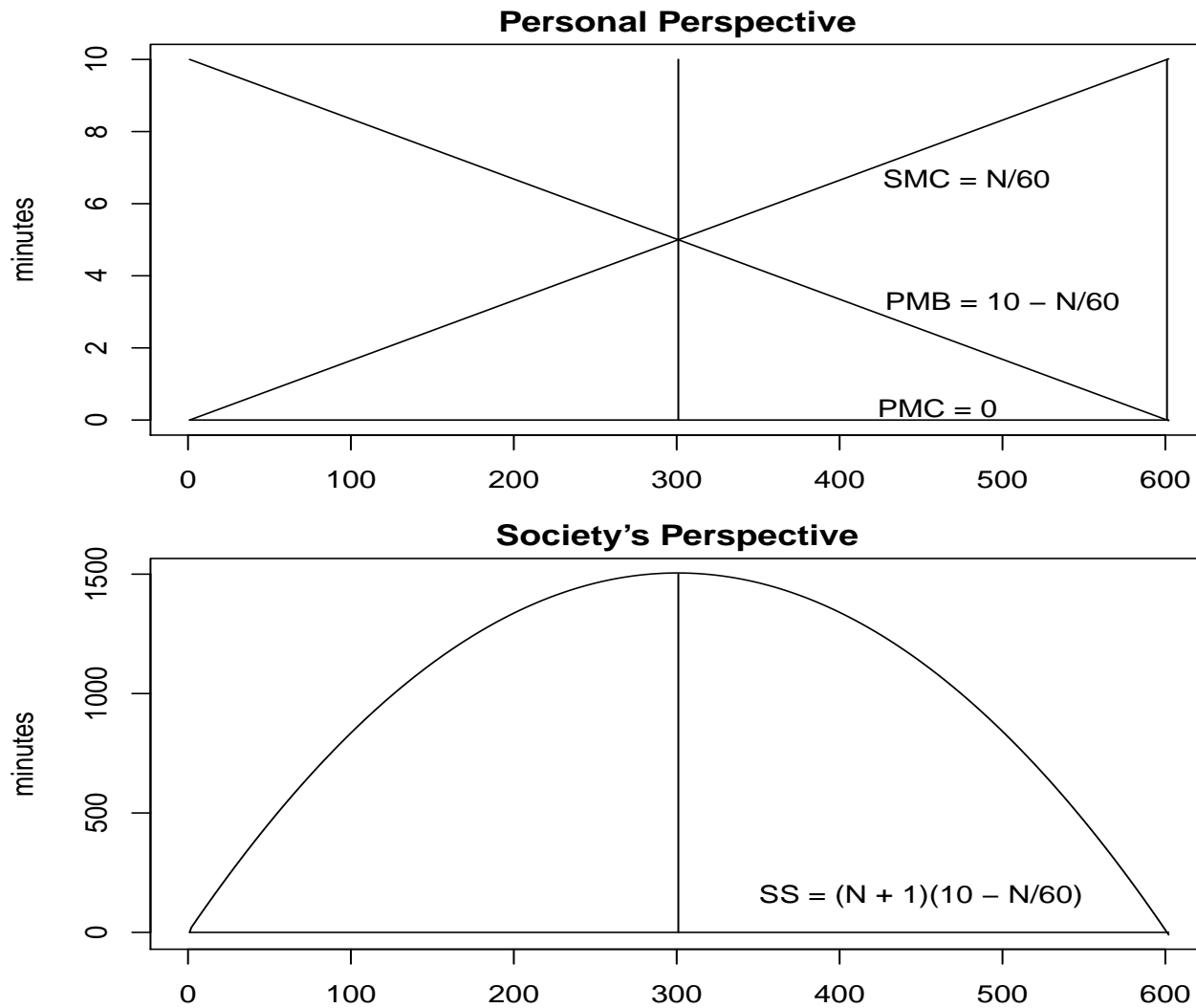

- Coase Theorem

Fish Game

- In class exercise

Tragedy of the Commons

- Each user of a resource imposes a negative externality on the other users

- Unrestricted use results in overexploitation of the resource because individuals will ignore the negative externality they impose on others

Freeway Example

- The personal marginal cost of each freeway driver is 0 as long as total freeway time is less than 40 min.

- Each freeway driver after the first costs all other freeway drivers 1 sec.

  ▷ SMC $= N/60$ min.

- The $(N + 1)$ st freeway driver saves 10 min. less congestion cost.

  ▷ PMB $= 10 - N/60$ min.

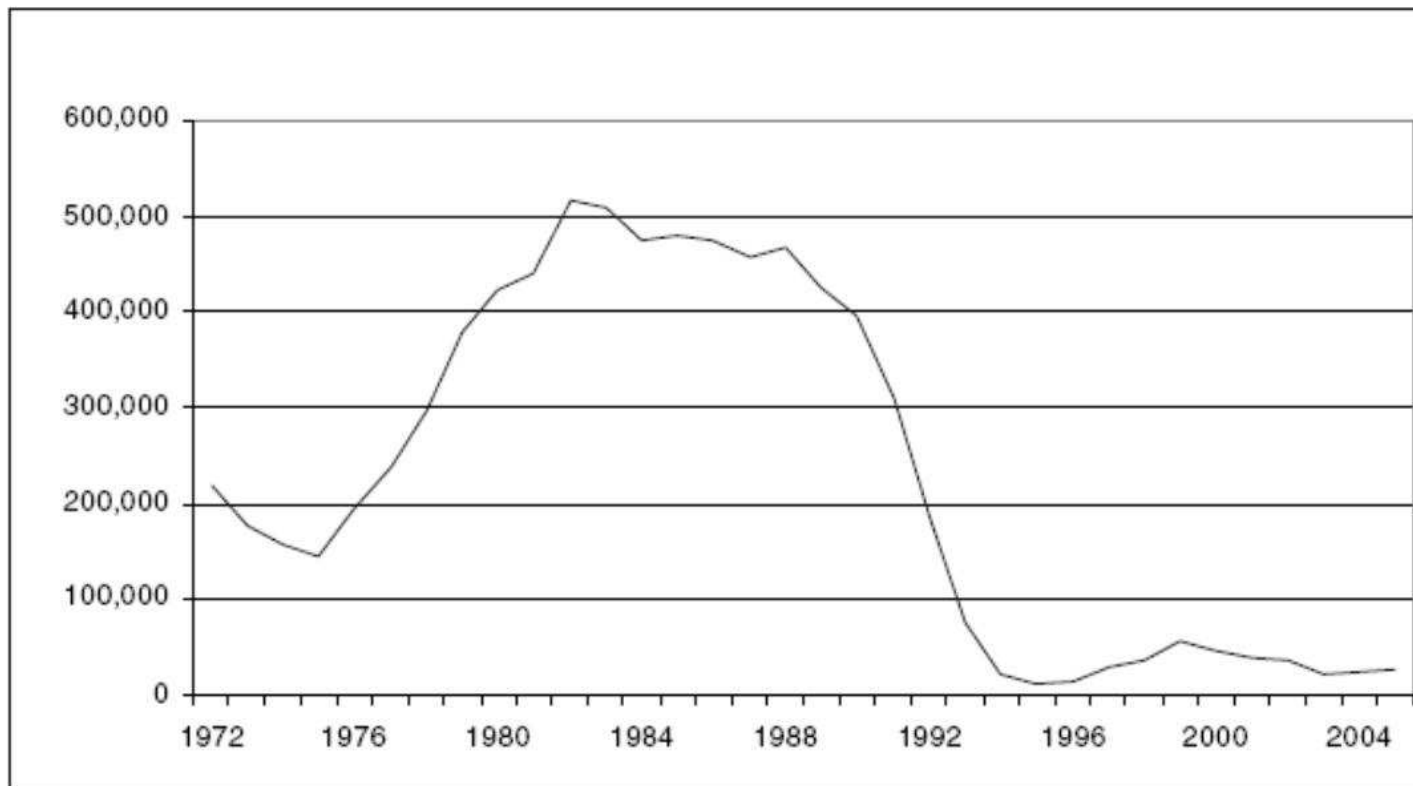- Social surplus of the freeway is SS $= (N + 1)(10 - N/60)$ min.

Freeway Example

Personal Perspective

SMC = N/60

PMB = 10 − N/60

PMC = 0

Society's Perspective

SS = (N + 1)(10 − N/60)

Social optimum $N + 1 = 301$, personal optimum $N + 1 = 601$

Real World Tragedy

Canadian Atlantic Codfish Landings (metric tones live weight)

Canadian Atlantic Codfish

- 1977 territorial limit increased from 12 to 200 miles (UN), so Canada could exclude foreign fishers

- Sonar fish locators and seafloor mapping increased ability to find fish

- Before the collapse, fishers noticed a decline in the maturity of the fish being landed

- Ultimately, 30,000 fishers lost their jobs
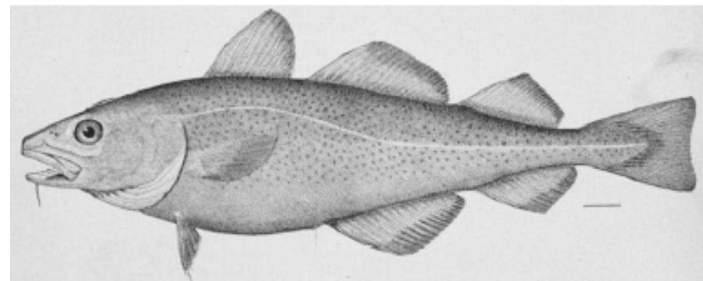
CODFISH

Coase Theorem

- Ronald Harry Coase – born in 1910 in U.K.

- Univ. of Buffalo, Univ. of Virginia, Univ. of Chicago

- "The Problem of Social Cost" (1960): suggests that well-defined property rights could overcome the problems of externalities

- Nobel Prize in Economics in 1991
  - ▷ "For his discovery and clarification of the significance of transaction costs and property rights for the institutional structure and functioning of the economy"

Coase Theorem Example

- Two competitively traded goods, but good 1 generates an externality on the production of good 2

- Cost of producing product 2 is higher when there is greater output of product 1

- Production costs (fixed costs are not sunk)

$$C_1(Q_1) = Q_1^2 + 8$$
$$C_2(Q_1, Q_2) = Q_2^2 + Q_1 Q_2 + 4$$

- How much **should** be produced?

- How much **will** be produced? (Depends on property rights.)

- Source: Kolstad, Charles D. (2000), *Environmental Economics,* New York, Oxford University Press

How Much Should Be Produced?

Market Prices	
P1	11
P2	10

Total surplus = P1 Q1 + P2 Q2 – C1(Q1) – C2(Q1,Q2)

Q1* = 4	Q2* = 3

	Q2						
Q1	**0**	**1**	**2**	**3**	**4**	**5**	**6**
0	0	5	12	17	20	21	20
1	2	6	12	16	18	18	16
2	10	13	18	21	22	21	18
3	16	18	22	24	24	22	18
4	20	21	24	25	24	21	16
5	22	22	24	24	22	18	12
6	22	21	22	21	18	13	6
7	20	18	18	16	12	6	-2
8	16	13	12	9	4	-3	-12
9	10	6	4	0	-6	-14	-24

How Much Will Be Produced?

Market Prices	
P1	11
P2	10

Firm 1 profit = P1Q1 - C1(Q1)
Firm 2 profit = P2Q2 - C2(Q1,Q2)

Q1* = 5.5			Q2* = 2.25

Q1	Profit 1	Q2	Profit 2
0.0	0.00	0.00	0.00
0.5	-2.75	0.25	-2.94
1.0	2.00	0.50	-2.00
1.5	6.25	0.75	-1.19
2.0	10.00	1.00	-0.50
2.5	13.25	1.25	0.06
3.0	16.00	1.50	0.50
3.5	18.25	1.75	0.81
4.0	20.00	2.00	1.00
4.5	21.25	2.25	1.06
5.0	22.00	2.50	1.00
5.5	22.25	2.75	0.81
6.0	22.00	3.00	0.50

No transfers, no bargaining. If were allowed, $Q_1 = 4$, $Q_2 = 3$, $\Pi = 25$.

Property Rights for the Recipient (Polluter Pays)

- How much would be produced if firm 2 had the right not to be damaged?

- Firm 1 must pay firm 2 for damage imposed

- Benchmark profit for firm 2, BM_2, is profit when $Q_1 = 0$.

- If firm 1 produces Q_1, then firm 1 must pay

$$BM_2 - \text{Profit}_2(Q_1)$$

thereby compensating firm 2 for the externality imposed.

Property Rights for the Recipient (Polluter Pays)

Market Prices

P1	11
P2	10

Firm 1 profit = P1·Q1 − C1(Q1) − (BM2 − Profit2(Q1))

Firm 2 profit = P2·Q2 − C2(Q1,Q2) + (BM2 − Profit2(Q1))

BM2 = max (P2·Q2 − C2(0,Q2)) = 21.0

Required Payment = 16.0

Q1* = 4

Q2* = 3

Q1	Implied Q2	Implied Profit 2	Required Payment	Profit 1		Q2	Profit 2
0.0	5.0	21.0	0.0	0.00		0.00	16.00
0.5	4.8	18.6	2.4	−5.19		0.50	14.75
1.0	4.5	16.3	4.8	−2.75		1.00	17.00
1.5	4.3	14.1	6.9	−0.69		1.50	18.75
2.0	4.0	12.0	9.0	1.00		2.00	20.00
2.5	3.8	10.1	10.9	2.31		2.50	20.75
3.0	3.5	8.3	12.8	3.25		3.00	21.00
3.5	3.3	6.6	14.4	3.81		3.50	20.75
4.0	3.0	5.0	16.0	4.00		4.00	20.00
4.5	2.8	3.6	17.4	3.81		4.50	18.75
5.0	2.5	2.3	18.8	3.25		5.00	17.00

Property Rights for the Polluter (Victim Pays)

- How much would be produced if firm 1 had the right to impose the externality but firm 2 could pay it to reduce its output (i.e. bargaining and transfers possible)?

- Firm 2 must pay firm 1 to limit production

- Benchmark profit for firm 1 is

$$BM_1 = \max_{Q_1} P_1 Q_1 - C_1(Q_1)$$

- If firm 2 wants firm 1 to limit its output to Q_1^L, it must pay firm 2

$$BM_1 - \text{Profit}_1(Q_1^L)$$

to compensate firm 1 for lost profits.

Property Rights for the Polluter (Victim Pays)

Market Prices

P1	11
P2	10

Firm 1 profit = P1 Q1 - C1(Q1) + (BM1 - Profit(Q1))

Firm 2 profit = P2 Q2 - C2(Q1,Q2) - (BM1 - Profit(Q1))

BM1 = max (P1 Q1 - C1(Q1)) = 22.25

Q1* = 4

Q2* = 3

Q1	Compensation	Profit 1
0.0	22.3	22.25
0.5	25.0	22.25
1.0	20.3	22.25
1.5	16.0	22.25
2.0	12.3	22.25
2.5	9.0	22.25
3.0	6.3	22.25
3.5	4.0	22.25
4.0	2.3	22.25
4.5	1.0	22.25
5.0	0.3	22.25

				Q2				
Q1	0	0.5	1	1.5	2	2.5	3	3.5
0.0	-22.25	-21.50	-17.25	-13.50	-10.25	-7.50	-5.25	-3.50
0.5	-25.00	-24.50	-20.50	-17.00	-14.00	-11.50	-9.50	-8.00
1.0	-20.25	-20.00	-16.25	-13.00	-10.25	-8.00	-6.25	-5.00
1.5	-16.00	-16.00	-12.50	-9.50	-7.00	-5.00	-3.50	-2.50
2.0	-12.25	-12.50	-9.25	-6.50	-4.25	-2.50	-1.25	-0.50
2.5	-9.00	-9.50	-6.50	-4.00	-2.00	-0.50	0.50	1.00
3.0	-6.25	-7.00	-4.25	-2.00	-0.25	1.00	1.75	2.00
3.5	-4.00	-5.00	-2.50	-0.50	1.00	2.00	2.50	2.50
4.0	-2.25	-3.50	-1.25	0.50	1.75	2.50	2.75	2.50
4.5	-1.00	-2.50	-0.50	1.00	2.00	2.50	2.50	2.00
5.0	-0.25	-2.00	-0.25	1.00	1.75	2.00	1.75	1.00

Coase Theorem Result

- Any assignment of property rights generates the optimal outcome

$P_1 = 11,\ P_2 = 10$	Q_1	Q_2	Profit 1	Profit 2	Total
Optimal (merge firms)	4	3			25
No Property Rights	5.5	2.25	22.25	1.06	23.31
Firm 1 Shut Down	0	5	0	21	21
Property Rights					
Polluter Pays	4	3	4	21	25
Victim Pays	4	3	22.25	2.75	25

Summary of blackboard presentation

(a) Merge firms

$$Q_1 = \frac{1}{3}(2P_1 - P_2)$$

$$Q_2 = \frac{1}{3}(2P_2 - P_1)$$

(b) No property rights

$$Q_1 = \frac{1}{2}P_1$$

$$Q_2 = \frac{1}{4}(2P_2 - P_1)$$

(c) Firm 1 shut down

$$Q_1 = 0$$

$$Q_2 = \frac{1}{2}P_2$$

Either (a) or (c) above is optimal; choose the one with larger profit:

$$\Pi_1 = P_1 Q_1 - Q_1^2 - 8$$

$$\Pi_2 = P_2 Q_2 - Q_2^2 - Q_1 Q_2 - 4$$

Optimal Shut Down of Firms

- If firm 1's product is less valuable, e.g., $P_1 = 8$, firm 1 should be shut down

$P_1 = 8$, $P_2 = 10$	Q_1	Q_2	Profit 1	Profit 2	Total
Optimal (Firm 1 shut down)	0	5			21
No Property Rights	4	3	8	5	13
Firm 1 Shut Down	0	5	0	21	21
Property Rights					
Polluter Pays	0	5	0	21	21
Victim Pays	0	5	8	13	21

Optimal Preservation of Firms

- If firm 1's product is slightly more valuable, e.g., $P_1 = 12$, firm 2 should still operate but would be driven out of business by the externality in the absence of property rights

$P_1 = 12$, $P_2 = 10$	Q_1	Q_2	Profit 1	Profit 2	Total
Optimal (merge firms)	4.5	2.5			29.25
No Property Rights	6	0	28	0	28
Firm 1 Shut Down	0	5	0	21	21
Property Rights					
Polluter Pays	4.5	2.5	8.25	21	29.25
Victim Pays	4.5	2.5	28	1.25	29.25

Computed to nearest $0.25 with Excel.

In Class Exercise

If $P_1 = 9$ and $P_2 = 10$, the following table results.

$P_1 = 9$, $P_2 = 10$	Q_1	Q_2	Profit 1	Profit 2	Total
Optimal (Firm 1 shut down)	0	5			21
No Property Rights	4.5	2.75	12.25	3.56	15.82
Firm 1 Shut Down	0	5	0	21	21
Property Rights					
Polluter Pays	?	?	?	?	?
Victim Pays	?	?	?	?	?

1. Fill in the cells marked with question marks.

2. What is the dead weight loss due to the externality?

Equivalent Property Rights Solutions

- Merge firms

  ▷ If the only externality is between two firms, then we can eliminate the inefficiency by merging the two firms.

- Polluter pays

- Recipient pays

- Policy of "polluter should pay," although common, is not necessarily justified on efficiency grounds

Coase Theorem

- The initial assignment of property rights regarding externalities does not matter for *efficiency* if and only if:

  ▷ everyone has perfect information

  ▷ no one has market power

  ▷ enforcement of agreements is costless

  ▷ firms maximize profit and consumers maximize utility

  ▷ there are no income or wealth effects

  ▷ there are no transaction costs

- If trading rights is easy and costless, then it does not matter for efficiency how they are initially distributed — rights will be traded so that they end up in the right hands

- With transaction costs, it does matter where rights are initially vested