

Practice Final Exam Solution
Spring 2004

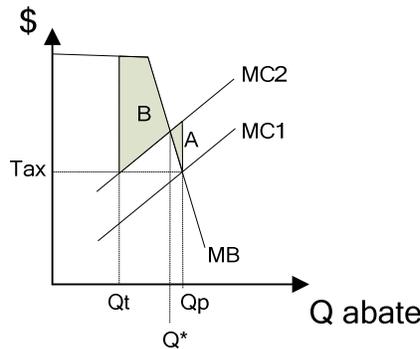
Please note that these answers are written out in more detail than would be expected on the exam. For example, an excellent answer to question 1a would consist of the two graphs and a couple of sentences explaining what they show.

1. Essay Questions

(a) Taxes versus permits under uncertainty

In the presence of uncertainty, taxes and permits may not be equally efficient and there are circumstances in which one policy would be strongly preferred to the other. If the marginal benefit curve is very steep (as it would be for a threshold pollutant) and the marginal cost curve is relatively flat, a permit policy would be preferred; on the other hand, if the MB curve is flat and the MC curve is steep, a tax policy would be better. The threshold case is illustrated by the diagram below:

Steep MB: Threshold Pollutant

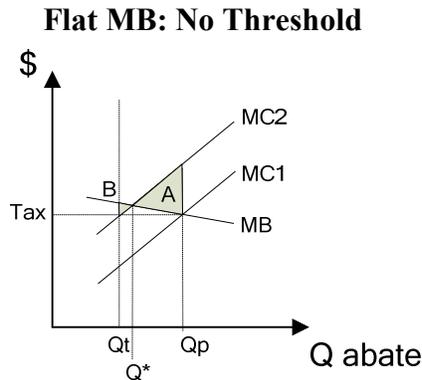


If marginal costs are expected to be MC1 when the policy is designed, a permit system could be established by issuing permits equal to the initial amount of pollution less the desired amount of abatement, Q_p . If a tax policy were used instead, the tax would be set as shown.

If it were subsequently discovered that marginal costs were much higher, as shown by MC2, the optimal amount of abatement would drop to Q^* . Under a permit system, abatement would remain at Q_p , which is a little too high. The DWL would be given by area A in the diagram. Under a tax system, abatement would drop to Q_t , which is much too low. The DWL would be given by area B in the diagram. The permit system works better because it keeps the amount of abatement near the threshold; the tax policy is bad because it allows large variations in abatement in response to fluctuations in costs.

In the opposite case, where MB is flat and MC is steep, a tax system works better because it keeps the cost of the last unit abated close to the MB of that unit. The diagram below compares

taxes and permits when MB is flat: the loss under a permit policy would be area A while the loss under a tax policy would be area B.



The downside of the permit policy, area A, is substantially larger than the downside of the tax policy.

(b) Reserves of a resource

At a price of \$25, only grades A and B would be profitable to extract.

Proven reserves would equal the amounts of A and B (deposits with $MEC < \$25$): $100 + 200 = 300$ tons. Identified subeconomic reserves would be equal to $C + D + E + F$ (deposits with $MEC > \$25$): $300 + 500 + 700 + 900 = 2400$ tons.

Since 80% of the relevant area remains to be explored (four times as much as the amount explored to date), we would infer that $4 * 300 = 1200$ tons of undiscovered economic reserves exist and that there are $4 * 2400 = 9600$ tons of undiscovered subeconomic reserves. Writing out the table:

| | | Geologic Certainty | |
|------|-------------|--------------------|--------------|
| | | Identified | Undiscovered |
| Cost | Economic | 300 | 1200 |
| | Subeconomic | 2400 | 9600 |

Three events that would increase proven reserves are:

- An increase in the price to \$30 or more. The 300 tons of grade C would become economic, causing proven reserves to increase to 600 tons.
- A decrease in the MEC of grade C to \$25 (or an across the board \$5 decrease in MEC). This would also make grade C economic.
- A discovery of new deposits of grade A or B totaling 300 tons. That would move 300 tons out of the “economic, undiscovered” category into proven reserves.

2. Controlling Multiple Source Air Pollution

(a) Finding the efficient level of abatement for each source

The first step is to find the equation for the MB curve. Some facts given in the problem:

$MB = A - B*Q$ where Q is the level of abatement

$MB = 200$ when $Q = 0$ (“emissions are uncontrolled” means $Q=0$)

$MB = 150$ when $Q = 25$ (emissions reduced from 100 to 75 means $Q = 25$)

Combining these:

$$200 = A - B*0$$

$$200 = A$$

$$150 = A - B*25$$

$$150 = 200 - B*25$$

$$- 50 = - B*25$$

$$B = 2$$

$$MB = 200 - 2*Q$$

Checking:

$$MB = 200 - 2*0 = 200 \text{ (ok)}$$

$$MB = 200 - 2*25 = 150 \text{ (ok)}$$

The next step is to find the equation for the overall MC curve. Facts from the problem:

$$MC1 = 2*Q1$$

$$MC2 = 4*Q2$$

For efficiency, we want $MC1 = MC2$. Since the two will be the same, we can drop the subscript.

Efficient cleanup thus requires:

$$MC = 2*Q1$$

$$MC = 4*Q2$$

Combine by solving for $Q1$ and $Q2$ and then summing to get Q , the total amount of abatement:

$$Q1 = MC / 2$$

$$Q2 = MC / 4$$

$$Q = Q1 + Q2$$

$$Q = (MC / 2) + (MC / 4)$$

$$Q = (3/4)*MC$$

$$MC = (4/3)*Q$$

Now find the point where $MB = MC$; that will be the efficient amount of abatement.

$$\begin{aligned} MB &= MC \\ 200 - 2*Q &= (4/3)*Q \\ 200 &= 2*Q + (4/3)*Q = (10/3)*Q \\ 60 &= Q \end{aligned}$$

Checking:

$$MB = 200 - 2*60 = 80$$

$$MC = (4/3) * 60 = 80$$

$$MB = MC \text{ (ok)}$$

The efficient amount of abatement is 60 units. Finding the allocation across sources:

$$Q_1 = MC / 2 = 80 / 2 = 40$$

$$Q_2 = MC / 4 = 80 / 4 = 20$$

$$\text{Checking: } Q_1 + Q_2 = 60 \text{ (ok)}$$

(b) Using tradable permits to equalize costs

The first step is to calculate each source's abatement costs:

$$\text{Abatement Cost 1} = (1/2)*40*80 = 1600$$

$$\text{Abatement Cost 2} = (1/2)*20*80 = 800$$

$$\text{Total cost} = 1600 + 800 = 2400$$

To equalize costs, each source would have to end up paying $\$2400/2 = \1200 . To achieve that, we would give more permits to source 1 that it will need in equilibrium and short change source 2 by the same amount. Source 2 would end up buying permits from source 1, which would compensate for part of source 1's abatement costs.

The permits will trade for \$80 (the MC at the efficient allocation of abatement), so the number of extra permits that need to be given to source 1 is $\$400/\$80 = 5$ (and source 2 would be given 5 too few). The distribution of permits to firms would thus be:

$$\text{Source 1: } 15 \text{ permits (50 units of emissions - 40 units of abatement + 5)}$$

$$\text{Source 2: } 25 \text{ permits (50 units of emissions - 20 units of abatement - 5)}$$

$$\text{Check: total permits} = 40; \text{ total abatement} = 100 - 40 = 60 \text{ (ok)}$$

$$\text{Overall Cost 1} = 1600 - 5*80 = 1200$$

$$\text{Overall Cost 2} = 800 + 5*80 = 1200$$

3. Travel Cost Method

(a) Number of visitors with a \$5 admission fee

Solve by completing columns 5-8 in the table:

| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|-------|-------------|---------|------------------|------------|----------|----------------|--------------|
| Zone | Travel Cost | Pop. | Initial Visitors | Visit Rate | New Cost | New Visit Rate | New Visitors |
| A | \$10 | 16,000 | 2,400 | 15% | \$15 | 10% | 1,600 |
| B | \$15 | 40,000 | 4,000 | 10% | \$20 | 5% | 2,000 |
| C | \$20 | 120,000 | 6,000 | 5% | \$25 | 0% | 0 |
| D | \$25 | 200,000 | 0 | 0% | \$30 | 0% | 0 |
| Total | | | 12,400 | | | | 3,600 |

With a \$5 entrance fee, the number of visitors would drop to 3,600.

(b) Daily value of the beach

$$P = A - B*Q$$

$$0 = A - B*12400$$

$$A = B*12400$$

$$5 = A - B*3600$$

$$5 = B*12400 - B*3600$$

$$5 = B*8800$$

$$B = 1/1760$$

$$A = (1/1760)*12400 = 7.0455$$

Value of the beach:

$$V = (1/2)*7.0455*12400$$

$$V = \$43,681 \text{ per day}$$

4. Oil Extraction

(a) Efficient allocation of oil; price, quantity and MSS in each period; use of the backstop.

Note: this problem is from an old exam and asks you to calculate “marginal user cost”, which is a term I mentioned only briefly this semester. It’s basically another name for MSS.

The first step is to see whether the backstop will ever be used. To do that, we need to find the equilibrium that would occur if the backstop didn’t exist.

Solving for the allocation of oil in the absence of the backstop:

Five periods: 1-5

Demand: $P_i = 80 - Q_i$

$MEC_i = \$20$

Interest rate is 0

Finding an equation for MSS:

$$MSS_i = P_i - MEC_i = (80 - Q_i) - 20 = 60 - Q_i$$

For efficiency, we want $MSS_1 = MSS_2 = MSS_3 = \dots = MSS_5$:

$$60 - Q_1 = 60 - Q_2 = 60 - Q_3 = \dots = 60 - Q_5$$

Canceling out the 60's and multiplying through by -1:

$$Q_1 = Q_2 = Q_3 = Q_4 = Q_5$$

Since the periods are identical and the interest rate is zero, the efficient allocation treats them all the same way.

The total amount available is 120 units. Since each period's consumption is equal, each Q should be one fifth of the total: $Q_i = 120/5 = 24$.

Using the demand curve to find each period's price:

$$P_i = 80 - Q_i = 80 - 24 = \$56$$

Solving for MSS_i :

$$MSS_i = 60 - Q_i = 60 - 24 = 36$$

Collecting the information into a table:

| Period | Q_i | P_i | MEC_i | MSS_i |
|---------------|-------------------------|-------------------------|---------------------------|---------------------------|
| 1 | 24 | 56 | 20 | 36 |
| 2 | 24 | 56 | 20 | 36 |
| 3 | 24 | 56 | 20 | 36 |
| 4 | 24 | 56 | 20 | 36 |
| 5 | 24 | 56 | 20 | 36 |
| Total | 120 | | | |

Because the price eventually goes above the backstop cost of \$40, the backstop will definitely be used.

Figuring out precisely *when* the backstop will be used is easier than it looks. The existence of the backstop guarantees that no one will ever pay more than \$40 for a unit of oil. At the same time, since the interest rate is zero, the behavior of oil owners guarantees that no one will ever pay *less* than \$40: since sellers know that eventually the price will rise to \$40, they won't part with their oil at a price lower than that. The price, therefore, will be \$40 in every period.

Calculating Q_i from the demand equation:

$$40 = 80 - Q_i$$

$$40 = Q_i$$

Each period will use 40 units of oil. Oil in the ground will be used first and will run out at the end of period 3 ($40+40+40=120$). Periods 4 and 5 will get oil strictly from the backstop. Total consumption over the 5 periods will be 200 units.

(b) Equilibrium when oil is common property

In this case, people will extract and sell oil until its price is driven down to MEC (\$20). That will happen in every period until the reservoir is exhausted. When the reservoir runs out, production will switch to the backstop and the price will rise abruptly to \$40.

We can figure out when the reservoir will be exhausted by calculating the extraction in each period using the demand curve:

$$P = \text{MEC} = 20$$

$$20 = 80 - Q_i$$

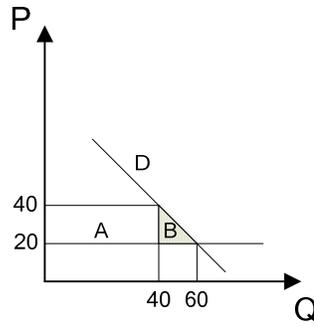
$$Q_i = 60$$

This shows that each period will use 60 units of oil until the reservoir is exhausted. Since it starts out with 120 units, it will be empty at the end of period 2. Periods 3, 4 and 5 will all use the backstop.

The difference between this outcome and part (a) is that periods 1 & 2 each use 20 units more oil, and that period 3 gets its oil from the backstop rather than the reservoir. Periods 4 and 5 are the same in both situations: all of the oil comes from the backstop.

This outcome is inefficient. One way to see that is by noticing that MSS in periods 1 and 2 is driven to \$0 even though a unit of oil in the reservoir would have a MSS of \$20 ($P-\text{MEC}$) in period 3.

Another way to see the inefficiency is to calculate the change in consumer and producer surplus. Oil owners lose all of their original PS: $\$20 \times 120 = \$2,400$. Oil consumers in periods 1 and 2 gain because they pay a lower price but the amount they gain is less than what the owners lose. The gain in CS is shown by areas A+B in the diagram below:



Calculating the size of A: $\$20 \times 40 = \800 ; calculating the size of B: $(1/2) \times 20 \times 20 = \200 ; total gain to consumers in the period: $\$1,000$. Since consumers in periods 1 and 2 both gain $\$1,000$, the total gain in CS is $\$2,000$. That's less than the amount that oil owners lose. The net welfare loss is $\$2000 - \$2400 = \$400$.