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Economics 410

The Maxwell School
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Exam 1

Spring 2007
Solution

Question 1 (S question 3 ; V question 5) (15 points)

A town is considering expanding its wastewater treatment plant. Without the expansion, the town has a 5% chance in every year of exceeding the system's capacity. When it does, raw sewage is released into a nearby lake causing $10 million of damage. Expanding the system would prevent the overflows but it would cost $6 million in construction costs (paid in year 0), plus it would cost $100,000 every year to maintain. You may assume that if the plant is built, it will begin operating in year 1 and will last forever. The interest rate is 5%.

Please calculate (a) the net present value of the expansion. On the basis of your results, (b) explain briefly whether or not the town should go ahead with the project. Be sure to show all your work.

(a) The benefit of the expansion is avoided cost.

The expected annual value is EV(B) = 0.05*($10M) + 0.95*($0) = $500K

Expansion last forever so the PV of benefits is $500K/0.05 = $10M

Costs include construction ($6M) plus maintenance.

PV of maintenance = $100K/0.05 = $2M

Total PV of costs = $6M + $2M = $8M

Net PV = $10M - $8M = $2M

(b) Proceed with the expansion because it's cheaper than covering the damages with an equivalent insurance policy, which would cost $10M. In other words it's Pareto efficient: the people who gain from the avoided damages gain more than enough ($10M) to compensate those who have to pay for the expansion ($8M).

Question 2 (S question 1; V question 2) (15 points)

A town of 20,000 residents has a pollution problem arising from production of a single good. It is known that the residents have identical W2P curves for the good of the form: $W2P_i = A - B*Q_i$, where the subscript *i* indicates individual *i*. It is also known that when the price of the good is $6, a typical person buys 40 units, and when the price is $4, a typical person buys 60. The supply of the good is perfectly elastic at $3 (that is, the MC is $3) but each unit also creates $2 worth of pollution.

Please compute (a) the market equilibrium, (b) the efficient equilibrium and (c) the welfare gain from moving from the market equilibrium to efficiency. Please note that you only have to calculate the two equilibriums and the DWL: you do not have to propose or discuss any policies in this question.

(a) Finding the values of A and B:

W2Pi = A – B*Qi

6 = A – B*40

A = 6 + B*40

4 = A – B*60

4 = (6 + B*40) – B*60

-2 = -20*B

B = 1/10

A = 6 + (1/10)*40

A = 10

W2Pi = 10 – (1/10)*Qi

Finding the market demand curve:

(1/10)*Qi = 10 – P

Qi = 100 – 10*P

QT = 20,000*Qi

QT = 20,000*(100-10*P)

QT = 2,000,000 -200,000*P

Finding the market equilibrium:

P = MC = $3

QT = 2,000,000 -200,000*$3

QT = 1.4M

(b) Finding the efficient equilibrium:

P = MSC = MC + MCext = $3 + $2 = $5

QT = 2,000,000 -200,000*$5

QT = 1M

(c) The welfare gain is the triangular area above the demand curve, below the MSC and between the 1M and 1.4M quantities:

DWL = (1/2)*(1.4M – 1M)*($5 - $3)

DWL = $400K

Question 3 (S question 5; V question 1) (15 points)

A pollutant is emitted by three sources. It is currently uncontrolled and each source emits 100 tons. The marginal benefit of abatement is known to be: MBA = 100 – 0.6*Qa. The marginal abatement cost curves for the three sources are the following: MAC1 = 2*Qa1, MAC2 = (1/3)*Qa2, and MAC3 = (2/3)*Qa3.

Please calculate (a) the efficient total amount of abatement and (b), (c) and (d) the amount of abatement that should be done by each source. Note that you only have to find the efficient pattern of abatement: you do not need to discuss a policy in this question.

(a) Finding the overall marginal cost of abatement curve:

Qa1 = MAC/2

Qa2 = 3*MAC

Qa3 = (3/2)*MAC

QaT = MAC*(1/2 + 3 + 3/2)

QaT = 5*MAC

MAC = (1/5)*QaT

Finding the efficient Q:

MBA = MAC

100 – 0.6*Qa = (1/5)*Qa

100 = 0.8*Qa

Qa = 125

(b), (c), (c) Finding the value of MAC (and MBA) at the efficient Q:

MAC = (1/5)*125 = $25

Inserting into the individual MAC equations to find each firm's abatement:

Qa1 = $25/2 = 12.5

Qa2 = 3*$25 = 75

Qa3 = (3/2)*$25 = 37.5

Question 4 (S question 2; V question 3) (15 points)

Three sources emit a pollutant. Each is initially emitting 100 tons. The marginal benefit of abatement is known to be $240 per ton, and the sources have the marginal abatement costs shown: MAC1 = 4*Qa1, MAC2 = 6*Qa2, MAC3 = 3*Qa3.

Design a tradable permit system that will achieve the efficient amount of abatement while spreading the total compliance cost equally across the three sources. Please calculate (a), (b) and (c) the number of permits that should be distributed to each source.

(a), (b), (c) Since the MBA is constant at $240, the efficient levels of abatement and emissions, and abatement costs, can be calculated independently:

Source 1:

$240 = 4*Qa1

Qa1 = 60

Compliance cost = (1/2)*60*240 = $7,200

Efficient emissions = 100 – Qa1 = 40 tons

Source 2:

$240 = 6*Qa2

Qa2 = 40

Compliance cost = (1/2)*40*240 = $4,800

Efficient emissions = 100 – Qa2 = 60 tons

Source 3:

$240 = 3*Qa3

Qa3 = 80

Compliance cost = (1/2)*80*240 = $9,600

Efficient emissions = 100 – 80 = 20 tons

Finding the equalized compliance cost:

Equal cost = ($7,200 + $4,800 + $9,600)/3 = $7,200

Permits to equalize cost:

Source 1: Q permits = 40 (just equal to its efficient emissions since source 1 already has the right compliance cost)

Source 2 needs to pay an additional $7,200-$4,800 = $2,400. Since the price of a permit will be $240 (equal to the MAC and MBA), that means it should have to buy 10 permits. Since it will need 60 in the end, it should be given 50 initially.

Source 3 needs to pay $2,400 less. That means it needs to be able to sell 10 permits. Since it will need 20 permits to cover its emissions, it should be given 30 initially.

Question 5 (S question 4; V question 4) (15 points)

Two sources of a pollutant were recently regulated. Just before regulation each was emitting 1000 pounds of the pollutant (2000 pounds total). The MBA for the pollutant is $40 per pound. At the time of regulation, the sources are believed to be able to abate at the following costs: MCA1 = (1/20)*Qa1, MCA2 = (1/10)*Qa2. A permit system was established and each firm was given exactly the number of permits that the regulator expected it to need at the efficient pattern of abatement. (No tweaking to equalize costs.) However, the projected MAC for source 1 turned out to be wrong. The true curve was MCA1 = (1/10)*Qa2.

Please calculate: (a) and (b) the original number of permits given to each firm, (c) the expected price of a permit, (d) the amount of abatement that would be efficient given the true MCA1, (e) the actual price of a permit, (f) and (g), the actual amount of abatement done by each source, (h) the value of any permit sales between the firms, and (i) the deadweight loss due to the policy.

(a), (b) When the system was designed, the abatement and emissions (and therefore the allocated permits) of each source were expected to be as follows.

Source 1:

MBA = MCA1

$40 = (1/20)*Qa1

Qa1 = 800

Source 1's permits = 1000 – 800 = 200

Source 2:

MBA = MCA2

$40 = (1/10)*Qa2

Qa2 = 400

Source 2's permits = 1000 – 400 = 600.

Total permits distributed = 200 + 600 = 800.

(c) The expected price of a permit is equal to MCA1=MCA2=MBA = $40.

(d) The efficient abatement given the true costs:

Source 1:

MBA = MCA1

$40 = (1/10)*Qa1

Qa1 = 400

Source 2's abatement is still 400, so the efficient total abatement is 800.

(e) The actual price of a permit will be higher than expected because the firms have only 800 permits and thus have to do 1200 units of abatement (as originally designed in the policy). Finding the price requires finding true overall marginal cost curve for abatement:

MCAi = (1/10)*Qai

Qa1 = 10*MCA

Qa2 = 10*MCA

QaT = Qa1 + Qa2 = 20*MCA

MCA = QaT/20

MCA = 1200/20 = $60

(f), (g) Each source will do half the total abatement, or 600 tons. In algebra:

Qa1 = 10*$60 = 600

Qa2 = 10*$60 = 600

(h) Since each firm is abating 600 tons, each will need 400 tons of permits. Source 1 was only issued 200 tons, so it will end up buying an additional 200 tons from source 2, which was issued 600. The value of the sale will be $60*200 = $12,000.

(i) The deadweight loss due to the policy is the triangular area under the true MCA curve, above the MBA curve, and between the efficient and actual levels of abatement (800 and 1200). It is equal to (1/2)*(1200-800)*($60-$40) = $4,000.