Review Solutions: Final Challenge
Environmental Economics: ECO 345

Question 1

a. Standards have no RRE. The TIE generally increases optimal emissions. Overall optimal emissions therefore exceeds E.

b. Taxes have a RRE which decreases optimal emissions. The TIE generally increases optimal emissions. Overall optimal emissions relative to E is therefore ambiguous, but in practice the TIE tends to dominate.

c. There is no revenue recycling effect since permits are given away. The tax interaction effect tends to decrease optimal emissions, since less SO_2 encourages working through less sick days. Overall, then the optimal emissions are below E.

Question 2

Environmental regulation tends to raise the price of the underlying dirty good (e.g. electricity). Higher goods prices means wages buy less, which makes working less attractive. Households reduce labor supply, which reduces labor tax revenues. The government must therefore raise labor tax rates to make up the revenue, which induces a welfare loss.

Question 3

a. Not consistent. Marginal costs will rise by more than marginal benefits and so emissions will increase.

b. Consistent. Marginal costs will rise by less than marginal damage equal to willingness to pay. Emissions will decrease.

c. Not consistent. Economic growth will result in more pollution causing factories, but the EPA still will not be able to enforce environmental laws, so pollution will increase.

d. Not consistent. Growth results in more pollution causing factories, and since each country has an incentive to free ride, countries will not take steps to reduce pollution.

Longer Questions

Question 4

a. We have ignoring the RRE and TIE:

$$30 - e = e, \;\; \rightarrow \;\; e = 15. \tag{1}$$

I will just draw one graph with all 3 effects:

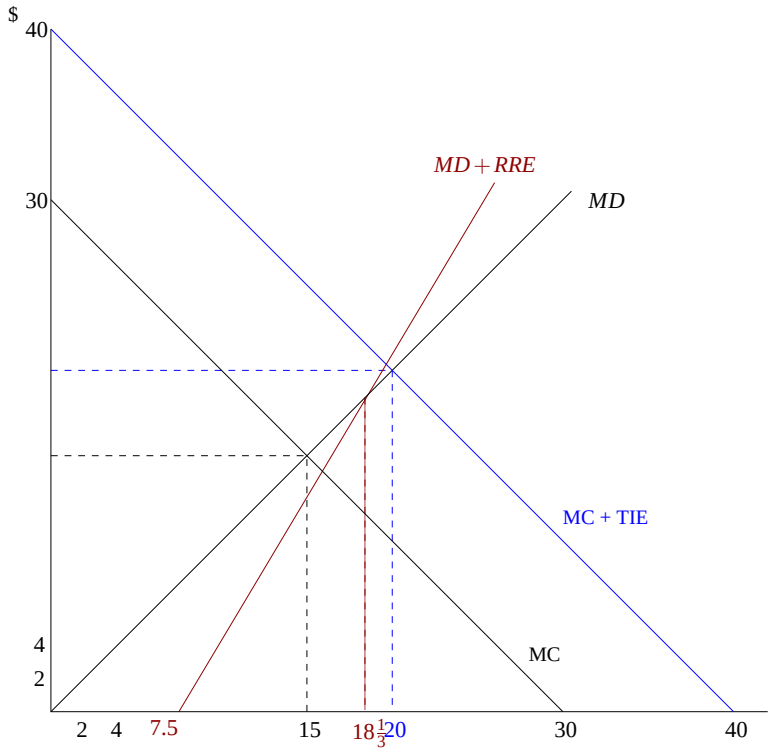

Figure 1: Double Dividend graph.

b. We have:

$$30 - e + 10 = e, \quad \rightarrow \quad e = 20. \tag{2}$$

On the graph, the TIE shifts marginal costs to the right: We must account for an extra cost, which is the TIE.

c. Since for each dollar of revenue, we have a welfare gain of one half, the marginal revenue gain is:

$$\text{marginal welfare gain } = \frac{1}{2} MR = \frac{1}{2}(30 - 2e) = 15 - e. \tag{3}$$

$$30 - e + 10 = e - (15 - e)\,. \tag{4}$$

$$e = 18\frac{1}{3}. \tag{5}$$

On the graph, I have added the RRE to the MD, but one could also subtract it from

the MC. We have:

$$MD + RRE = e - (15 - e) = 2e - 15. \tag{6}$$

The red line graphs $MD + RRE$.

d. No double dividend exists here, since $18\frac{1}{3} > 15$.

Question 5

a. We have following the procedure from the second quiz:

$$e_L = 20 - MC, \tag{7}$$

$$e_F = 40 - 2MC, \tag{8}$$

$$e = 60 - 3MC. \tag{9}$$

Since $MC = MD$:

$$e = 60 - 3\left(4 + e\right), \tag{10}$$

$$e^* = 12. \tag{11}$$

Issue 12 permits.

b. The price of permits equals the marginal damage, so:

$$P' = 4 + e = 4 + 12 = 16. \tag{12}$$

Each firm must be indifferent between buying a permit at price 16 and reducing, so:

$$P' = 16 = MC_L = 20 - e_L, \tag{13}$$

$$e_L = 4. \tag{14}$$

$$P' = 16 = MC_F = 20 - \frac{1}{2}e_F, \tag{15}$$

$$e_f = 8. \tag{16}$$

The equimarginal principle holds as each firm must be indifferent between buying a permit and reducing, and both pay the same price for permits.

c. For emissions in the absence of reguation, we have:

$$0 = MC_L = 20 - e_L, \tag{17}$$

$$e_{L,0} = 20. \tag{18}$$

$$0 = MC_F = 20 - \frac{1}{2}e_F, \tag{19}$$

$$e_{F,0} = 40. \tag{20}$$

The large firm reduces from 20 to 4 and the fringe from 40 to 8. Total compliance costs are:

$$CC = \frac{1}{2}(40 - 8) \cdot 16 + \frac{1}{2}(20 - 4) \cdot 16. \tag{21}$$

$$CC = 256 + 128 = 384. \tag{22}$$

d. Notice that the large firm pays 128 in compliance costs and sells 8 permits to the fringe. We have:

$$\pi = 16 \cdot 8 - 128 = 0. \tag{23}$$

e. The large firm sets:

$$MR = 20 - e_F = MC_L = 20 - e_L = 20 - (12 - e_F), \tag{24}$$

$$e_F = 6. \tag{25}$$

The monopolist restricts sales to the fringe relative to the competitive case of $e_F = 8$, so as to increase the price and make more profits.

f. We have:

$$e_L = 12 - e_F = 12 - 6 = 6. \tag{26}$$

$$MC_L = 20 - e_L = 20 - 6 = 14. \tag{27}$$

$$MC_F = 20 - \frac{1}{2}e_F = 20 - \frac{1}{2}6 = 17. \tag{28}$$

The equimarginal principle does not hold. The monopolist is not selling enough permits.

g. We have:

$$CC = \frac{1}{2}(40 - 6)\,17 + \frac{1}{2}(20 - 6)\,14, \tag{29}$$

$$CC = 289 + 98 = 387. \tag{30}$$

Compliance costs rise slightly.

h. We have:

$$P' = MC_F = 17, \tag{31}$$

$$\pi = -CC_L + P'e_F = -98 + 17 \cdot 6 = 4. \tag{32}$$

The large firm's profits rise slightly by taking into account the affect of how much it sells on the price.

i. We have:

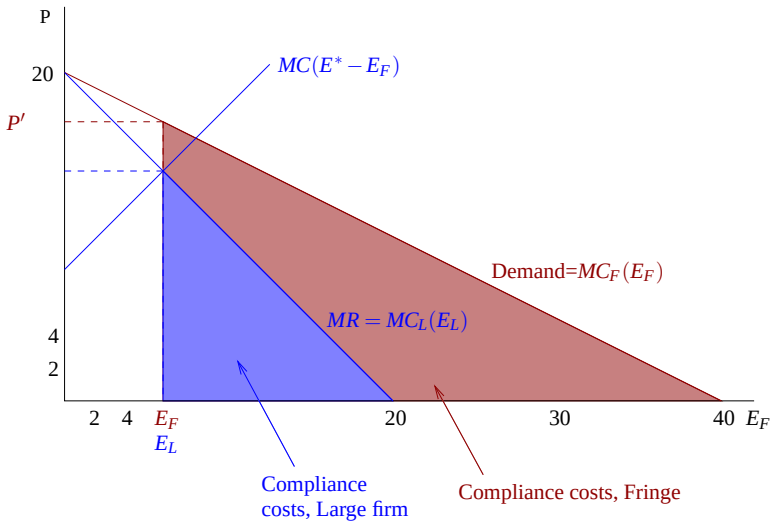

Figure 2: Permit market, impervect competition.

Note that it happens that marginal revenue $MR = 20 - e_F$ happens to equal $MC_L = 20 - e_L$. This is an artifact of the problem and is not true generally. Compliance costs of the fringe include the blue triangle. Note that the problem is the same as a standard of 6.

Question 6

a. We have for the LDC:

$$MC = 4 - e, \tag{33}$$

$$MD = \frac{2}{3}(e - 2), \tag{34}$$

$$4 - e = \frac{2}{3}e - \frac{4}{3}, \quad \rightarrow \quad e = 3.2. \tag{35}$$

$$0 = 4 - e_0, \quad \rightarrow \quad e_0 = 4. \tag{36}$$

So we have for the LDC $e_L = 3.2$.

We have for the middle country:

$$MC = 5 - e, \tag{37}$$

$$MD = e - 1, \tag{38}$$

$$5 - e = e - 1, \ \rightarrow \ e = 3. \tag{39}$$

$$0 = 5 - e_0, \ \rightarrow \ e_0 = 5. \tag{40}$$

So we have for the middle country $e_m = 3$.

We have for the middle country:

$$MC = 6 - e, \tag{41}$$

$$MD = 2e, \tag{42}$$

$$6 - e = 2e, \ \rightarrow \ e = 2. \tag{43}$$

$$0 = 6 - e_0, \ \rightarrow \ e_0 = 6. \tag{44}$$

So we have for the high income country $e_h = 2$.

b. The graph is:

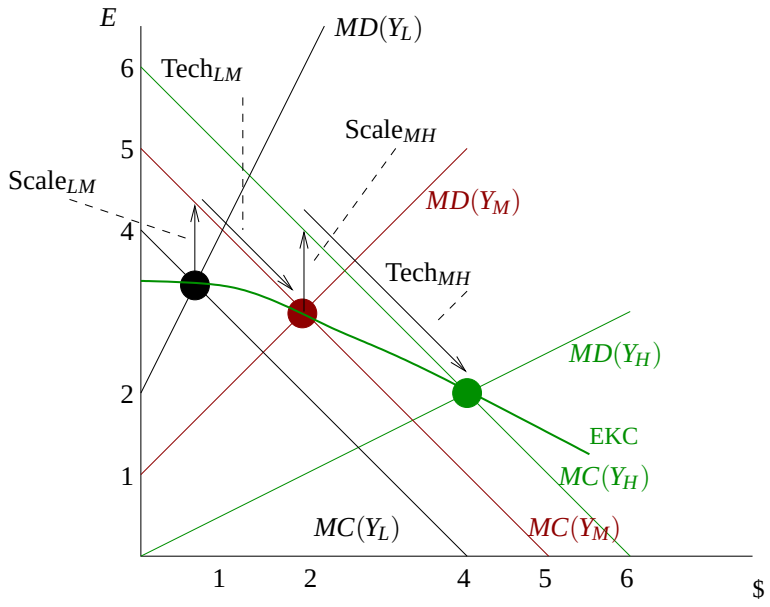

Figure 3: EKC.

c. No, pollution decreases over time.

d. The scale and technique effect from low to medium are:

$$MC_L = 4 - e_L = 4 - 3.2 = 0.8 = MC_M = 5 - e, \quad \rightarrow \quad e = 4.2, \tag{45}$$

$$\text{Scale} \ = e - e_L = 4.2 - 3.2 = 1. \tag{46}$$

$$\text{Technique} \ = e - e_M = 4.2 - 3 = 1.2. \tag{47}$$

For the middle to large, we have:

$$MC_m = 5 - e_m = 5 - 3 = 2 = MC_H = 6 - e, \quad \rightarrow \quad e = 4, \tag{48}$$

$$\text{Scale} \ = e - e_m = 4 - 3 = 1. \tag{49}$$

$$\text{Technique} \ = e - e_h = 4 - 2 = 2. \tag{50}$$

e. All calculations are the same, except $e_L = e_0 = 4$ and $e_m = e_0 = 5$. Now an EKC exists, as pollution rises to 5 before falling to 2.

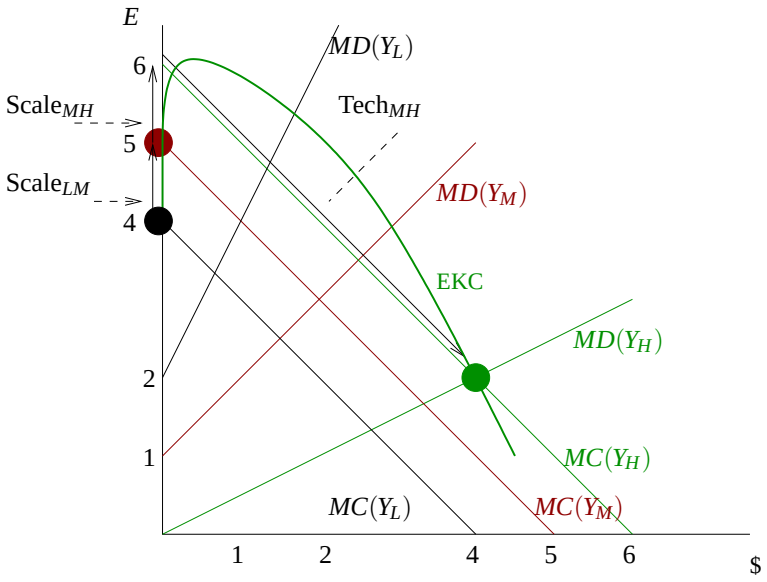

Figure 4: EKC, weak institutions.

f. In this case, increasing income in the developing country will largely result in more pollution. To decrease pollution requires the institutions to be reformed.