

14.23 **Spring 2003**
Problem Set 4 solutions

1. Tradeable permits

- (a) (10 points) The cost of this approach is \$60 for Plant A and \$300 for Plant B; the total cost is thus \$360.
- (b) (10p) It is cheaper to reduce emissions at Plant A, so Plant A will sell a permit to Plant B. Plant A will end up reducing emissions by 2 tons and plant B will not reduce at all. Total cost is $2 \times \$60 = \120 . Note that the cost of the permit (assumed \$75) is just a transfer of income from B to A, so it does not affect the total cost.
- (c) (10p) First of all, neither plant can be worse off under tradeable permits, since trading is voluntary! If either firm refused to trade at the assumed price \$75 then we'd be back at the solution for part b).

Total cost is lower by $\$360 - \$120 = \$240$ under the tradeable permits program. The effect on Plant A profits under the tradeable permits program are $\$75 - \$120 = -\$45$, so it is better off by \$15 than under the "command and control" approach. Plant B profits are reduced by the cost of the permit, \$75 so it benefits by $\$300 - \$75 = \$225$ compared to the command and control approach.

Notice that the assumed price of \$75 is a particular solution to a bargaining problem. Any permit price between \$60 and \$300 would make both plants better off under trade.

2. Emission Reduction

- (a) (8p) If the residents have the rights, then their minimum acceptance for allowing pollution would be \$10 million. Since the maximum the company will pay is \$4 million, no contract will happen. The company will install the pollution abatement equipment and eliminate the pollution, so there will be no need for any negotiation with the residents and there will be no transfers. The company would not want to shut down the plant since even after paying for the scrubber it is still making a profit of \$46 million.
- (b) (8p) If the firm has the rights to pollute, then their minimum payment to install abatement equipment must be the cost of the equipment, \$4 million. The maximum the residents will pay is \$10 million. Due to equal bargaining power, the parties split the gains from trade exactly fifty-fifty, so the residents pay $4 + (10 - 4)/2 = 7$ \$ million. Compared to part a), only the transfers are different.

- (c) (8p) Ideally we would want to know the willingness-to-pay (WTP) of affected residents for eliminating or reducing the pollution. There are broadly two types of methods for studying this: one based on surveys, where residents are asked how much they would be willing to pay, and the other based on property values, where the effect of pollution is compared between otherwise comparable areas but with different levels of pollution. Both methods have their problems. Residents don't have good incentives to answer the surveys truthfully, or even to take the time to think about the answer. The main problem with the property value method is the difficulty of finding otherwise comparable areas that only differ in their pollution level. Either way, there is no reason why the studies would tend to over- or underestimate the WTP. That's why it is unclear (ie a matter of taste) whether to over- or understate the WTP when making actual policy decisions.
- (d) (8p) Taken literally, a rule that does not take costs into account is simply impossible to follow. There is no limit on how much money could be spent on reducing every type of pollution. Even if there was some finite cost for using all existing technologies to reduce pollution, ever more effective methods can always be invented, if the price tag is capped at infinity.
- (e) (8p) If the residents own the rights, then the firm does not have the option to just install the scrubbers without having to deal with the residents. Even with scrubbers, there is some amount of pollution left,¹ so the residents still have the right to demand the plant to shut down if they want their air to be totally pure. They can use this power to extract some of the firm's profits. Notice that if the residents refuse a deal, then firm gets zero profits and residents get zero damage. The minimum price that the residents would accept is 0.1 million. The maximum price that the firm would pay (above which it would prefer to shut down) is $50 - 4 = 46$ \$ million. By assumption of equal bargaining power, the price is half way between these, so the transfer from the firm to the residents is $(0.1 + 46)/2 = 23.05$ \$ million.
- If the firm owns the rights, then the only difference to part b) is that the scrubber reduces the damage to residents by 9.9 instead of 10 million. The firm can make the residents pay $4 + (9.9 - 4)/2 = 6.95$ (\$ million).

¹In reality, the best scrubbers can remove up to 97% of SO₂.

3. Option value and environmental regulation.

- (a) (4p) If there is development, the payoff now is 10. The payoff is also 10 in the future, no matter what happens. The total expected payoff is 20.
- (b) (4p) With no development now, the payoff is 5. If there is warming, then there is a payoff of 50 with probability q , and if there is no warming, then the land will be developed, for a payoff of 10 with probability $1 - q$. The expected payoff is then $5 + 10(1 - q) + 50q = 15 + 40q$.
- (c) (6p) Development will occur now if the expected payoff from developing is higher than that from not developing, or if $20 > 15 + 40q$, which happens iff $q < 1/8$.
- (d) (6p) If not developing means that there can never be development, then the payoff in the cool future is only 5, since land cannot be developed then. The expected payoff is, then $5 + 5(1 - q) + 50q = 10 + 45q$. Development will happen if $q < 2/9$
- (e) (6p) The value of the option V is be the difference in payoff between the case where one has the option to develop later, and the case where one doesn't. If development would happen in stage 1 in any case, then the option has no value, so $V = 0$ if $q < 1/8$. If $1/8 < q < 2/9$, then in the absence of the option, there is development in stage 1 and the payoff is 20, but in the case with the option development is (at least) delayed and the payoff is $15 + 40q$. The value of the option is then $V = 40q - 5$. If $q > 2/9$, then there would be no development in the first stage even without the option. The value of the option to develop in stage 2 is $V = 15 + 40q - (10 + 45q) = 5 - 5q$, for $q > 2/9$.
- (f) (4p) It's likely to make policy more conservative than it would be if one assumed that one could not develop later. Developing could be an irreversible mistake, while overtly stringent conservation can always be reversed later.

