AAE / ECON / Env. St. 343
Homework #8 Solutions

Provide short answers to the 7 questions below.

Suppose there is a pollutant which affects two countries, A & B. The benefits of reducing this pollutant are equal to 120 if both countries reduce, 60 if one country reduces, and 0 if neither country reduces. The costs of reducing the pollutant are equal to 115. These numbers apply to both countries.

1. The president of country A proposes to cooperate with country B by reducing pollution for 4 years. However, in year 5, the president wants to deviate and not reduce pollution. As an advisor to the president, you must give your recommendation as to whether this is a strategy which will yield a net gain for country A. What is your recommendation if the discount rate equals 5%? What if the discount rate equals 10%?

If A deviates in period 5, then B will play a grim-trigger strategy and deviate for each remaining period. Therefore, A's present value from deviating in period 5 is composed of the following:
One-time free-riding gain: $(1.05)^{-5}[60-5]=43.1$
A loss from retaliation for each period after period 5: $(1.05)^{-5}[-5/.05]= -78.4$
=> if r = 0.05, then deviating in period 5 gives country A net benefits of 43.1-78.4= -35.3.

If r = 0.1, A's present value from deviating in period 5 is composed of the following:
One-time free-riding gain: $(1.1)^{-5}[60-5]=34.2$
A loss from retaliation for each period after period 5: $(1.1)^{-5}[-5/.1]= -31$
=> if r = 0.1, then deviating in period 5 gives country A net benefits of 34.2-31= 3.2.
A is better off deviating in period 5 if r=0.1, but not if r=0.05.

2. Explain why repeated games are more apt to lead to cooperation than a one-turn game or a game with only a few turns. Is this relevant for international environmental agreements? Explain.

In repeated games the likelihood of cooperation between players is higher because there is the potential for retaliation (i.e. a credible threat) against any player who doesn't cooperate. If the game only lasts a few turns then the likelihood of cooperation is smaller because players are typically better off diverging from cooperation on the last turn. Discounting assures that the last turn is irrelevant in an infinitely repeated game. This is relevant for international agreements because a credible threat of retaliation offered with infinitely repeated games makes it more likely that a cooperative outcome can be sustained.

Now, suppose we have 3 countries (A, B, C) who are interested in reducing a trans-boundary pollutant. The following table presents the value of various coalitions of the three countries.

Coalition of Countries	Value of Coalitions
A	50
B	80
C	40
A,B	200
A,C	250
C,B	300
A,B,C	500

Adopting the notation from the book, let V() indicate the value of the game to a coalition and π() represent the individual payoff from a coalition.

3. Suppose an international agreement is proposed between the three countries (V(A, B, C)=500) with the following individual payoffs: π (A)=120; π (B)=310; π (C)=70. Is this a stable agreement? Explain.

An agreement is stable if the following constraints are satisfied: 1. budget constraint, 2. individual rationality constraint, 3. group rationality constraint.

Since π(A) + π(C) = 120 + 70 = 190, the group rationality constraint is violated because countries A and C can earn V(A,C) = 250 and have incentive to form their own coalition without B.

4. Propose an alternative international agreement that includes all three countries and satisfies the conditions for a stable solution.

The agreement in #4 failed because A and C would be better off in their own coalition away from B. One way to achieve a stable agreement is to increase the individual payouts to A and C by taking some of B's payout and redistributing it to A and C. Let's take away 110 from B and redistribute this payoff between A and C. So the agreement could be as follows: π (A)=150; π (B)=200; π (C)=150. This agreement satisfies the budget constraint, individual rationality constraint, and the group rationality constraint. Therefore it is a stable agreement. There are many other combinations that could also lead to a stable agreement.

The next 3 questions refer to the following reading:

Stavins, R.N. 2004. "Forging a More Effective Global Climate Treaty." *Environment*, 46(10): 22-31.

5. Is the author of this article an advocate of the "broad-then-deep" strategy of reducing climate change? Explain.

The broad-then-deep strategy is for a broad coalition of countries to make small cuts in greenhouse gasses today, and progressively deeper cuts in the future. The author of this article is an advocate of "broad-then-deep" and proposes a three-tier approach to climate change, including increased participation of developing countries and an extended path of time-targets for emissions reductions. The increased participation of developing countries is clearly a call for broadening the coalition while the extended time path is a call for small cuts today and deeper future cuts.

6. In the section on expanding participation, the author refers to "emissions leakage". Explain this concept and its relevance to expanding participation of developing countries.

If developing countries are left out of a climate change agreement, then they could potentially develop a comparative advantage in the production of goods which use significant amounts of carbon dioxide. CO2-polluting industries may then be induced to locate in developing countries to exploit their lower pollution standards. Therefore, by leaving developing countries out of an agreement, their emissions of greenhouse gases may actually increase relative to what it was in the absence of an agreement.

7. Explain how market-based policies can make participation in international agreements more likely.

Cooperative game theory tells us that countries are more likely to participate in a cooperative agreement if their net payouts of doing so are higher. Net payouts are equal to the benefits of participating minus the costs of participating (i.e. costs of reducing pollution). So, policies which lower the costs of participating will increase the likelihood of a stable coalition. As the article points out, tradable pollution permit (TPP) programs for CO2 are expected to reduce the costs of cleaning up greenhouse gasses by 25 to 50%, thereby increasing the likelihood of a stable coalition.