Environmental Economics 4910

Problem Set 3 (Ex. 3 in PS2)

Ex. 3: Self-enforcing agreements (based on lecture notes)
This exercise builds on the lecture notes available online (semestersiden) which we will discuss 25/2. It is a good preparation for that lecture to work through this exercise (but we may postpone discussing it in the seminar until a later seminar; that will depend on time).

Consider the repeated prisoner's dilemma where the benefit from consuming energy y_i is given by (Note that the benefit of energy is negative, such t hat it becomes increasing in y_i)

$$-\frac{b}{2}\left(Y_i - y_i\right)^2$$

where Y_i is some exogenous bliss point, and energy can come from fossil fuel g_i or renewable energy sources r_i

$$y_i = g_i + r_i.$$

You can threat r_i as exogenously fixed for the time being. The variable g_i does NOT need to be binary, as in the lecture, in this case it is a continuous variable.

There are n countries. Each unit of g_i gives the environmental cost c_i:

$$u_i = -\frac{b}{2}\left(Y_i - g_i - r_i\right)^2 - c_i \sum_{i=1}^{n} g_i.$$

Let δ be the common discount factor.

(1) What is the noncooperative equilibrium, or the "business as usual" equilibrium (the equilibrium if there were only one period) in this game?

(2) What is the first-best level for g_i?

(3) Suppose the equilibrium under (1) is the threat point which all countries revert to after a country has free-rided, or defected, in the repeated prisoner's dilemma game. Under which condition can the first best level for g_i be sustained? How does this possibility depend on r_i?

(4) Now, suppose the countries try to sustain a self-enforcing agreement with no pollution at all, $g_i = 0$. What is the condition for when this agreement is possible? How does this possibility depend on r_i? What is the smallest r_i which makes this agreement possible to sustain?

(5) Compare the r_i which you just derived to the first-best level of r_i for the agreement where every country emits zero ($g_i = 0$) when the investment cost is kr_i, and when the investment is made once and for all (before the repeated game starts, and never thereafter). For which countries are the condition you

derived in (4) binding (i.e., requiring country i to invest a different amount in r_i than what is first best)?

(6) Return to the setting where r_i is exogenous. In fact, simplify by setting $r_i = r$, $c_i = c$, and $Y_i = Y$. Suppose the countries try to have a self-enforcing agreement where they emit only g. What is the smallest g which is possible to sustain as a self-enforcing agreement, under the threat that if one country deviates, then every country will play as in the business-as-usual equilibrium forever after? On what does this smallest level of g depend?