ECON4910 Environmental economics, Spring 2010

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Lecture 11/12: Stock pollution and issues related to climate

Stock pollution problems

Reading list:
Perman et al. (2003). Sections 6.9 and ch. 16. (You do not need to know all the details of sections 16.1-16.3; the lecture will mainly focus on sec. 16.4.)

Hoel et al. (2009). Section 2.1 including Appendix.

It is very useful but not absolutely necessary that you have some knowledge of optimal control theory.

Summary of main theory in Perman (much of this is also covered in section 2.1 in Hoel et al. 2009)

1) Notation:
   - M is a flow
   - A is a stock
   - α is rate of depreciation. Two cases:
     i. $\alpha > 0$
     ii. $\alpha = 0$
2) Stocks and flows; benefit of flow $B(M)$ and cost/damage of stock $D(A)$. Three case:
   a. $D'(A) > 0$ and $D''(A) > 0$ for all A.
   b. $D'(A) > 0$ and $D''(A) = 0$ for all A. I.e. $D(A) = kA$ where k is a positive constant
   c. $A(t) \leq \bar{A}$ for all t and $D(A) = kA$ for $A(t) < \bar{A}$, where $k \geq 0$.
3) The social optimum. Box 16.3 in Perman sec. 16.4
4) The optimal emission tax from equation (16.12) in Perman sec. 16.4. Define $q = -\mu$. It follows from (16.12) that

   (*) $$q(t) = \int_t^\infty e^{-(r+\alpha)(\tau-t)} D'(A(\tau)) d\tau$$

5) The steady-state equilibrium (for $\alpha > 0$). Perman Sec. 6.9 and 16.4.1.
6) More on the three possibilities of the D-function.

Derivation of (*) using optimal control theory (sketch):

Max $\int_0^{\infty} e^{-rt}\left[B(M(t)) - D(A(t))\right]dt$

s.t.

$\dot{A}(t) = M(t) - \alpha A(t)$

Current value Hamiltonian

$H = B(M) - D(A) + \mu\left[M(t) - \alpha A(t)\right]$

Optimal solution satisfies

$$\frac{\partial H}{\partial M} = 0$$

$$\dot{\mu}(t) - r\mu(t) = -\frac{\partial H}{\partial A}$$

Defining $q(t) \equiv -\mu(t)$ this gives

$B'(M(t)) = q(t)$ and the development of q is given by

$\dot{q}(t) = (r+\alpha)q(t) - D'(A(t))$ which implies that

$$q(t) = e^{(r+\alpha)t}K + \int_t^{\infty} e^{-(r+\alpha)(\tau - t)} D'(A(\tau))$$

where K is some constant. However, the transversality conditions imply that K=0, giving (*)

Climate change and climate policy: some important issues

1) The physics of climate change (short introduction)
2) Consequences and costs of climate change (Stern Review)
3) Policy and policy instruments

    Hoel et al. (2009), sections 2.1 and 2.4

4) Economic models for evaluating alternative paths of GHG emissions

    Hoel et al. (2009), sections 3.1 and 3.2

5) Costs of reducing emissions of greenhouse gases (GHGs)

    Hoel et al. (2009), sections 3.9 and 4.6

6) The discount rate

    Hoel et al. (2009), section 2.2

    Dasgupta

Measurements

Emissions (flow): 1 tonne C = 3,67 tonnes CO_2

Concentration in atmosphere (stock): 1 Gt (=10^9 tonnes) C = 0,47 ppm (parts per million)

Note difference between CO_2 and CO_2-equivalents

Some numbers (baseline estimates)

Pre-industrial (<1800)	Emissions (Gt CO_2-e)	Concentration (ppm CO_2-e)
Pre-industrial (<1800)		280
Today (≈ 2005)	45-50	430
Stern estimate 2035	65	560
IPCC 2030 (p. 6)	40 - 75	
IPCC 2100 (p. 6)	30 – 160	
Nordhaus 2105; only CO_2 (Figures V-6 and V-7)	73	700
To achieve max 3 degrees warming	<10	560

Some results from IPCC (tables 1, 2, 4, 5 and 6)

Pre-industrial (<1800)	Stabilization at 445-535 Gt CO_2-e	Stabilization at 535-590 Gt CO_2-e
Long-run temperature increase	2.0 – 2.8	2.8 – 3.2
Peak year for CO_2 emissions	2000 - 2020	2010 - 2030
% emission reduction 2000 – 2050	-80 to -30	-30 to +5
Costs 2030 (% GDP)	<3	0.2 – 2.5
Costs 2050 (% GDP)	<5.5	0 – 4.0
Marginal cost 2030 (dollars per tonne CO_2)	100 ?	