ECON 4910 Environmental economics; spring 2015

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Lecture note 11: Climate policy II (subsidies and RPSs)

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Please bring lecture note to lecture.

Reading:
Fischer (2009), section 3 (to 3.4)
Hoel (2012), sections 1-8
EEAG (2012), section 6.3.3

Model (similar to Hoel)
Assume fossil (x) and non-fossil (y) energy are perfect substitutes

Social welfare

$$W = F(x+y) - c(x) - b(y) - vx \tag{1}$$

where $F'' < 0$, $c'' > 0$ and $b'' > 0$. Assume $c'(0) = b'(0) = 0$ so that we always get an interior solution.

Social optimum (without learning externalities):

$$F'(x+y) = c'(x) + v$$
$$F'(x+y) = b'(y)$$

Market
Demand given by $\max F(x+y) - p \cdot (x+y)$:

$$F'(x+y) = p \tag{2}$$

Supply given by $\max p \cdot (x+y) - c(x) - tx - b(y) + sy$:

$$p = c'(x) + t \tag{3}$$
$$p = b'(y) - s \tag{4}$$

Combining demand and supply and differentiating gives

$$\begin{pmatrix} F'' - c'' & F'' \\ F'' & F'' - b'' \end{pmatrix} \begin{pmatrix} dx \\ dy \end{pmatrix} = \begin{pmatrix} dt \\ -ds \end{pmatrix}$$

implying

$$dx = \frac{1}{H}\left[(F'' - b'')\, dt + F'' ds\right] \tag{5}$$
$$dy = \frac{1}{H}\left[-F'' dt - (F'' - c'')\, ds\right] \tag{6}$$
$$d(x+y) = \frac{1}{H}\left[-b'' dt + c'' ds\right] \tag{7}$$

where

$$H = c''b'' - c''F'' - b''F'' > 0 \tag{8}$$

It follows that

	x	y	$x+y$
t up	$-$	$+$	$-$
s up	$-$	$+$	$+$

Optimal policy

First-best may be achieved by setting $t = v$ and $s = 0$. But what is optimal subsidy if for some reason $t < v$? From the derivation in Hoel section 4 we find

$$s = (v - t)\,(-x_y(y,t)) \tag{9}$$

where

$$x_y(y,t) = \frac{F''}{-F'' + c''} < 0 \tag{10}$$

Note that $s < v$ even if $t = 0$. It follows from this and the results above that *carbon emissions with an optimal subsidy are higher than they are with an optimal tax.*

Extensions:

- Hoel section 5: Many uses of fossil energy and many renewable substitutes
- Hoel section 6: Some fossil energy use is regulated with quotas
- Hoel section 7: The production of non-fossil energy also has a climate impact (e.g. biofuel)

Renewable portfolio standard (RPS)

Assume that $t = s = 0$ but that producers by regulation are required to have

$$y \geq \alpha(x + y)$$

which is equivalent to

$$\begin{aligned} y &\geq Ax \\ A &\equiv \frac{\alpha}{1-\alpha} \end{aligned}$$

Producers must now maximize profits $p \cdot (x + y) - c(x) - b(y)$ s.t. the constraint $y \geq Ax$ where A is exogenous. This gives

$$p = c'(x) + \lambda A \tag{11}$$

$$p = b'(y) - \lambda \tag{12}$$

where λ is the Lagrangian in $L = p \cdot (x + y) - c(x) - b(y) + \lambda [y - Ax]$ and is positive for the non-trivial case where the constraint $y \geq Ax$ is binding. The four equations (2), (11), (12) and $y = Ax$ determine the four endogenous variables x, y, p and λ. Notice that this equilibrium is identical to the tax-subsidy equilibrium given by (2), (3), (4) with $t = \lambda A$ and $s = \lambda$. Hence imposing the constraint $y = Ax$ is equivalent to a tax-subsidy combination satisfying $t = \frac{y}{x}s$, i.e. $tx = sy$, which is a revenue neutral tax-subsidy combination.

From our results above it follows that compared to no regulation, an RPS gives lower x and higher y. The effect on $x + y$ (and hence on p)

is ambiguous. This is clear from (7): For b'' sufficiently small $x + y$ will increase, while for c'' sufficiently small $x + y$ will decline. See Fischer for a further discussion.