Taxation and Externalities

- **Much recent discussion of policy towards externalities, e.g., global warming debate/Kyoto**

- **Increasing share of tax revenue from environmental taxation – 6 percent in OECD**

- **Environmental taxation has specific features:**

  (i) Aimed at improving environment

  (ii) Environment itself is a public good

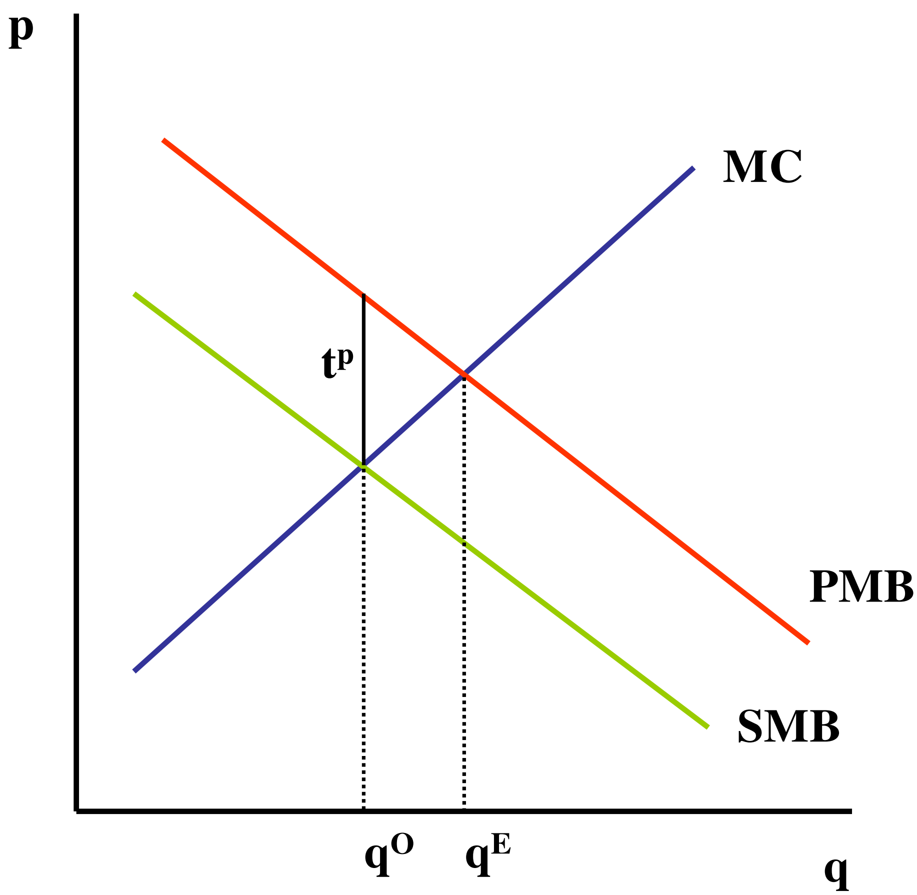
  (iii) As a public good, environment subject to uncoordinated decisions of many agents

  (iv) With no market, results in externalities

- **Distortion can be corrected with a Pigovian tax placed on consumption of a "dirty" good (see Figure 1)**

- **Consumption creates a private marginal benefit (PMB), and a marginal loss due to pollution, the sum generating social marginal benefit (SMB)**

Figure 1



Social optimum where SMB=MC, private optimum where PMB=MC, the latter resulting in excessive consumption of the dirty good, $q^E > q^O$

- **If government sets a specific tax t^P on consumption of the dirty good, t^P=SMB(q^O)-PMB(q^O), then the market equilibrium will be PMB(q)- t^P=MC(q)**

- **t^P the Pigovian tax, brings economy to the first-best optimum, the tax being the marginal loss due to pollution, the tax internalizing the externality**

- **In general equilibrium, several issues arise with taxation of externalities:**

  (i) If other taxes exist, what happens with a Pigovian tax(es)?

  (ii) Is there a "double dividend"? Can green taxes be used to reduce other distortionary taxes as well as improve the environment (Pearce, 1991)?

- **Following Salanie (2003), use a general equilibrium setting similar to the Ramsey taxation problem**

- **I households have utility functions $U_i(X^i, L^i)$, all with identical productivities facing taxes t_k on n consumption goods, and a tax rate τ on their labor**

- **Firms j produce one unit of good j from one unit of labor, and if wage is normalized to 1, its consumer price is $(1+t_k)$**

- **Household i faces a budget constraint:**

$$\sum_{i=1}^{k}(1+t_k)X_k^i = (1-\tau)L^i + T^i \qquad (1)$$

where T^i is a lump-sum transfer. Government has to raise taxes to finance lump-sum transfers, and also pay G units of labor

- **Assume good 1 is dirty, whose total consumption damages the environment, where $e=f(X_1)$, and f is a smooth decreasing function, the utility function becoming $U_i(X^i, L^i, e)$, U^i increasing in e**

- **Assume I is large so that each household neglects its own impact on e; production sets are not affected by quality of the environment; and goods k>1 are clean**

Optimal Green Taxes:

(i) <u>First-best case</u>, with a set of Pareto weights v_i, and maximizing:

$$\sum_{i=1}^{I} v_i U_i(X^i, L^i, e) \qquad (2)$$

given e=f(X_1), and the production constraint:

$$\sum_{k=1}^{n} X_k + G \leq \sum_{i=1}^{I} L^i \qquad (3)$$

The first-order condition on k=1 is:

$$v_i \frac{\partial U_i}{\partial X_1^i} + \sum_{j=1}^{I} v_j \frac{\partial U_j}{\partial e} f'(X_1) = \mu \qquad (4)$$

For other goods, k>1:

$$v_i \frac{\partial U_k^i}{\partial X_k^i} = \mu \qquad (5)$$

and for labor L^i:

$$v_i \frac{\partial U_i}{\partial L^i} + \mu = 0 \qquad (6)$$

Substitute (6) into (4) and (5), for clean goods k>1:

$$-\frac{\partial U_i / \partial X_k^i}{\partial U_i / \partial L^i} = 1 \qquad (7)$$

and for k=1:

$$-\frac{\partial U_i / \partial X_1^i}{\partial U_i / \partial L_i} - \left(\sum_{j=1}^{I} \frac{\partial U_j / \partial e}{\partial U_j / \partial L^j} \right) f'(X_1) = 1 \qquad (8)$$

(8) differs from standard first-order condition, as marginal rate of substitution between the dirty good and leisure is corrected for by marginal disutility caused by extra consumption of dirty good, i.e., left-hand side of (8) is the social marginal rate of substitution

Assume government can redistribute through lump-sum transfers, Pareto optimum can be decentralized using appropriate tax system, consumer prices are q, and net wage is (1-τ)
For all i and k:

$$-\frac{\partial U_i / \partial X_k^i}{\partial U_i / \partial L^i} = \frac{q_k}{1 - \tau} \qquad (9)$$

Suppose $\tau=0$ and $q_k=1+t_k'$, then we can choose $t_k'=0$ for $k>1$, and:

$$t_1' = \left(\sum_{j=1}^{I} \frac{\partial U_j / \partial e}{\partial U_j / \partial L^j} \right) f'(X_1) \tag{10}$$

Since $\partial U_j / \partial L^j < 0$ and f is decreasing, the tax $t_1'>0$, i.e., the Pigovian tax in general equilibrium when the government can use arbitrary lump-sum transfers

(ii) <u>Second-best case</u>, if government has to use uniform lump-sum transfers, first-best no-longer attainable, and it has to choose a vector of tax t' rates on goods, where the tax rate on wages is set at zero, and a uniform lump-sum transfer T, to maximize a Bergson-Samuelson social welfare function:

$$W(V^1, ..., V^I) \tag{11}$$

subject to:

$$IT + G \leq \sum_{k=1}^{n} t_k' X_k \tag{12}$$

Each indirect utility function $V^i(q,e,T)$ is defined by maximizing the utility function $U^i(.)$ subject to the budget constraint $q.X^i \le L^i + T$

Assuming that demand functions for various goods are independent of e, the first-order condition for q_k is:

$$\sum_{i=1}^{I} \frac{\partial W}{\partial V^i}\left(\frac{\partial V^i}{\partial q_k} + \frac{\partial V^i}{\partial e} f'(X_1)\frac{\partial X_1}{\partial q_k}\right)$$

$$= -\lambda\left(X_k + \sum_{l=1}^{n} t_l' \frac{\partial X_l}{\partial q_k}\right) \tag{13}$$

Denote α_i as the marginal utility of income of i, and $\beta_i = \alpha_i \, \partial W / \partial V^i$ as their social marginal utility of income, then:

$$\sum_{i=1}^{I} \beta X_k^i = \lambda\left(X_k + \sum_{l=1}^{n} t_l' \frac{\partial X_l}{\partial q_k}\right)$$

$$+\left(\sum_{i=1}^{I} \frac{\partial W}{\partial V^i}\frac{\partial V^i}{\partial e}\right) f'(X_1)\frac{\partial X_l}{\partial q_k} \tag{14}$$

Now denote $\Gamma = \frac{1}{\lambda}\sum_{i=1}^{I}\frac{\partial W}{\partial V^i}\frac{\partial V^i}{\partial e}$, and define a new tax system on goods by $t''_k = t'_k$ for k>1, and $t''_1 = t'_1 + \Gamma f'(X_1)$

The first-order condition becomes:

$$\sum_{i=1}^{I}\beta X_k^i = \lambda\left(X_k + \sum_{l=1}^{n} t''_l \frac{\partial X_l}{\partial q_k} \right) \qquad (15)$$

Where (15) is similar to the commodity taxation result, except for the definition of t´´

Let $t_1^P = \Gamma f'(X_1) > 0$, it follows that the optimal commodity taxes only vary from the Ramsey optimal rates t^R by the addition of the Pigovian tax t_1^P to the tax rate for the dirty good:

$$t''_1 = t_1^R + t_1^P \text{, and } t''_k = t_k^R \text{ for k>1}$$

Result due to Sandmo (1975) implies that government should not attempt to tax complements to dirty good(s) more heavily in second-best optimum

(iii) Is there a double-dividend?

What if the green tax t_1 is increased and tax on labor τ is cut to maintain government revenue constraint?

Assume initial point is not optimal, and that there is only one representative consumer, with no lump-sum transfer. Utility function $U(X, L, e)$ is maximized subject to, $\sum_{k=1}^{n}(1+t_k)X_k = (1-\tau)L$

Since $de = f_1'(X_1)dX_1$, the tax reform changes utility:

$$dU = U_X'.dX + U_L'dL + U_e'f'(X_1)dX_1 \qquad (16)$$

If α is the marginal utility of income, then $U_X' = \alpha(1+t)$ and $U_L' = -\alpha(1-\tau)$, then dividing through by α:

$$\frac{dU}{\alpha} = (1+t).dX - (1-\tau)dL - t_1^p dX_1 \qquad (17)$$

where $t_1^p = \dfrac{U_e'f'(X_1)}{\alpha}$ is the Pigovian tax

The production constraint is $\sum_{k=1}^{n} X_k + G = L$, so it follows that $\sum_{k=1}^{n} dX_k = dL$, and the normalized change in utility is:

$$\frac{dU}{\alpha} = t.dX + \tau dL - t_1^p dX_1 \qquad (18)$$

The final term on the right-hand side is the *first dividend* due to improvement in the quality of the environment, while the first and second-terms on the right-hand side is the *second dividend* $D = t.dX + \tau dL = \sum_{k=1}^{n} t_k dX_k + \tau dL$

To get an intuition of whether there is a double dividend, assume in fact taxes are optimal, then by definition dU=0, but as the first-dividend is always positive, the second dividend must be negative

Now start from Ramsey optimal taxes when there is no externality, then by definition the second dividend is zero. It follows that the second dividend can only be positive when the original tax system favors the polluting good more than the Ramsey-optimal tax system

To be more precise, given D, and the government's budget constraint of:

$$\mathbf{G = \sum_{k=1}^{n} t_k X_k + \tau L} \quad \textbf{(19)}$$

As only t_1 and τ are modified, revenue staying constant, then:

$$\mathbf{dt_1 X_1 + \sum_{k=1}^{n} t_k dX_k + \tau dL + L d\tau = 0} \quad \textbf{(20)}$$

so that $D = -X_1 dt_1 - L d\tau$, but no conclusion can be drawn as $dt_1>0$ and $d\tau<0$
To simplify, assume externalities are separable in the utility function and that utility over X and L is Cobb-Douglas:

$$\mathbf{U(X,L,e) = \tilde{U}\left(\prod_{k=1}^{n} X_k^{\gamma_k} (1 - L)^{1-\gamma}, e\right)} \quad \textbf{(20)}$$

where $\gamma = \sum_{k=1}^{n} \gamma_k$. Computation shows $L=\gamma$, and therefore does not depend on tax rates, and for each k,

$$\mathbf{X_k = \gamma_k \frac{1 - \tau}{1 + t_k}} \quad \textbf{(21)}$$

Differentiating:

$$dX_k = -X_k \frac{dt_k}{1+t_k} - \gamma_k \frac{d\tau}{1+t_k} \qquad (22)$$

Substituting in the differentiated government budget constraint:

$$dt_1 X_1 - t_1 X_1 \frac{dt_1}{1+t_1} - \sum_{k=1}^{n} \frac{\gamma_k t_k}{1+t_k} d\tau + \gamma d\tau = 0 \qquad (23)$$

or using $\gamma = \sum_{k=1}^{n} \gamma_k$,

$$X_1 \frac{dt_1}{1+t_1} + \sum_{k=1}^{n} \frac{\gamma_k}{1+t_k} d\tau = 0 \qquad (24)$$

Substitute in for $-X_1 dt_1 = d\tau(1+t_1)\sum_{k=1}^{n} \frac{\gamma_k}{1+t_k}$ in the expression for D, and using $\gamma = \sum_{k=1}^{n} \gamma_k$ again, then:

$$D = d\tau \sum_{k=1}^{n} \gamma_k \frac{t_1 - t_k}{1+t_k} \qquad (25)$$

With a Cobb-Douglas utility function, all the Ramsey taxes, t_k's, are equal. If government already has a green tax, then, $t_1 > t_k$ for all $k > 1$, and since $d\tau < 0$, it follows that the double-dividend is negative in this case

Ramsey taxation by definition is optimal, and the Pigovian tax is good for the environment (the first dividend), but it is more distortionary than the labor tax

Note, in LDCs, the starting point may be where $t_1 < t_k$ for some $k>1$, so that the tax system subsidizes dirty goods relative to clean goods, hence $D > 0$