

Problem Set 5
ARE 201
December 2 2003

(This problem is inspired by *Trade, Politics and the Environment: Smokestack versus Tailpipe* by Carol McAusland. The point of the problem is to see how equilibrium taxes in a political economy model depend on whether the economy is open or closed, and on whether the environmental problem is associated with production or consumption of a good.)

Consider a partial equilibrium model in which γ dollars worth of damages are created by each unit of (either) production or consumption (but not both) of the good. The social planner gives more weight to producer interests than to the interests of other agents (consumers, taxpayers and people who are affected by environmental damages.) Let $D(p)$ and $S(p)$ be the demand and supply functions (marginal utility of consumption and marginal cost of production, respectively). If damages are caused by production, and the social planner uses a production tax t , the value of the planner's objective is

$$V(t; \alpha) = \alpha \int_p^P S(p) dp + \int_{P+t}^{\bar{p}} D(p) dp + (t - \gamma) S(P), \quad (1)$$

where P is the equilibrium price received by producers $\alpha > 1$ is a parameter that measures the planner's preference for producer surplus. (If the tax is t and the producer price is P , the consumer price is $P + t$.) The terms in equation (1) equal "weighted" producer surplus plus consumer surplus plus tax receipts minus environmental damages.

1) (a) In a closed economy (i.e., where demand equals supply) show that the optimal tax and the equilibrium producer and consumer prices do not depend on whether the planner uses a production or a consumption tax, or on whether environmental damages are caused by production or by consumption (i.e. whether damages are γD or γS). (b) Show that the formula for the optimal tax solves

$$t = \frac{1 - \alpha}{\eta} P + \gamma \quad (2)$$

where η is the elasticity of supply and P is the price that producers receive. Interpret this formula.

2. Now suppose that the economy is open, that the world price is P^w , and that environmental damages are caused by production. (a) Does it matter in this case whether the planner uses a production or a consumption tax? (b) Show that when the planner uses a production tax, the optimal tax solves

$$t = \frac{1 - \alpha}{\eta} P + \gamma \quad (3)$$

where $P = P^w - t$ is (as before) the equilibrium price received by producers. Simplify this expression to write the tax as a function of P^w . You should obtain

$$t = \frac{(1 - \alpha) P^w + \gamma \eta}{\eta + 1 - \alpha}$$

(c) When does opening a closed economy increase the equilibrium tax? (Assume that damage is caused by production and that the regulator uses a production tax.) Provide an intuitive explanation for this comparison.

3. Now suppose that the economy is open, that the world price is P^w , and that environmental damages are caused by consumption. Show that the equilibrium consumption tax is

$$t = \gamma. \quad (4)$$

Explain why the taxes differ depending on the source of the pollution and on whether the economy is open or closed. Note that when damages are caused by consumption and the regulator uses a consumption tax, opening a closed economy always increases the equilibrium tax.

4. In this model (where there is no uncertainty and no strategic behavior), a tax and a quota give the same result (a market price and output level), except for the possible difference in distribution. For example, if the quota rights are given to producers but the tax revenues are returned to society at large, the optimal tax and the optimal quota differ. However, if both the tax revenue and the revenue from selling quotas are treated in the same way, then the two policies give the same result. For example, if the regulator sets a quota and gives quota rights to producers, the optimal outcome is identical to the case where the regulator sets a tax and gives the tax revenue to producers.

Using this insight, find the optimal quota (or tax) when the regulator gives quota rights (or tax revenue) to producers. Suppose that the economy is closed.

The regulator's objective is

$$V(t; \alpha) = \alpha \left(\int_{\underline{P}}^P S(p) dp + tS(P) \right) + \int_{P+t}^{\bar{P}} D(p) dp - \gamma S(P). \quad (5)$$

In order to find the formula for the optimal tax, you need to differentiate the equilibrium condition

$$S(P) = D(P + t)$$

to find an expression for $\frac{dP}{dt}$. Using that expression show that the optimal tax is

$$t = \frac{\rho\gamma + (\alpha - 1)P}{\alpha(\rho - 1) + 1} \quad (6)$$

where ρ is the elasticity of demand (expressed as a positive number).

5) a) Suppose that: the economy is open, damages are caused by production, the regulator uses a production tax (or quota) and the regulator returns the tax revenue (or revenue from quota sales) to producers. Show that the optimal tax satisfies

$$t = \frac{\gamma}{\alpha}. \quad (7)$$

Under what condition does opening the closed economy lead to a reduction in the tax?

(b) Show that if the economy is open, damages are caused by consumption, the regulator uses a consumption tax or quota and returns revenue to consumers, the optimal tax is

$$t = \gamma.$$

How does opening the closed economy affect the equilibrium tax?