Economics 230a, Fall 2015
Lecture Note 7: Externalities, the Marginal Cost of Public Funds, and Imperfect Competition

We have seen that some approaches to dealing with externalities (for example, taxes vs. abatement subsidies, selling permits vs. giving them away) differ only in the amount of revenue raised. If revenue from sources induces excess burden, how does this influence the optimal policy toward externalities? It seems clear that it becomes more costly to use policies for controlling externalities that do not raise revenue, given the excess burden of raising revenues in other ways, but can we say more? To address this question, we need to integrate externalities into our previous treatment of the optimal tax problem. It will also be useful to consider how the provision of public goods is affected by the use of distortionary taxation.

Provision of Public Goods and Externalities using Distortionary Taxation

Public Goods

Following Auerbach and Hines (pp. 1384-5), let us consider the optimal provision of a public good, G, using distortionary taxation. Assume that there are H identical individuals (heterogeneity won't add much of interest here) and that society's CRS production function is $f(\boldsymbol{X}, G) \leq 0$, where $\boldsymbol{X}$ is the vector of private consumption. The representative individual's utility function is $U(\boldsymbol{x}^h, G)$, where $\boldsymbol{X} = \sum_h \boldsymbol{x}^h$. The individual's corresponding indirect utility function may be written $V(\boldsymbol{p}; G)$, where the presence of G indicates that this is not a choice variable for individuals, but simply something that influences utility, with the property that $U_G = V_G$. Attaching the Lagrange multiplier μ to the production constraint and maximizing social welfare $H\,V(\boldsymbol{p}; G)$ with respect to the choice of prices and the level of public goods provision, we will get the same first-order conditions for $\boldsymbol{p}$ as before (since G is held constant in deriving these conditions). The first-order condition with respect to G may be rearranged as:

(1) $$H\frac{U_G}{U_0} = \frac{\mu}{\lambda}\left[\frac{f_G}{f_0} - \frac{dR}{dG}\right]$$

where good zero is the numeraire commodity (for which the tax is set equal to zero and price equal to 1), λ is the private marginal utility of income, $= U_0$, and dR/dG is the change in revenue resulting from an increase in public goods spending. Expression (1) includes the basic elements of the Samuelson rule (ΣMRS = MRT), but there are two modifications, the ratio μ/λ and the revenue effect dR/dG. To interpret these modifications, it is helpful to rewrite (1), using our previous definition of the *social* marginal utility of income $= \lambda + \mu\sum_j t_j\frac{dX_j}{dy} = \lambda + \mu\frac{dR}{dy}$, as

(1′) $$H\frac{U_G}{U_0} = \frac{\mu(f_G/f_0) - \mu dR/dG}{\alpha - \mu dR/dy}$$

If we ignore the revenue derivatives dR/dG and dR/dy, then expression (1′) says that we should adjust the social cost of providing public goods, f_G/f_0, by the term $\mu/\alpha > 1$, which equals the cost of raising funds in a distortionary manner rather than through lump-sum taxation. However, as public goods increase, this may provide an added benefit of causing individuals to spend more on taxed goods, raising government revenue and reducing the need for distortionary taxes – a benefit of $\mu\, dR/dG$ that reduces the social cost of providing public goods. On the other hand, increasing public goods spending requires increasing revenue, which reduces real income. If that real income loss reduces spending on taxed goods (i.e., $dR/dy > 0$), then this raises the costs of providing public goods. As emphasized in the paper by Hendren, the <u>marginal cost of public funds</u> – the amount by which we must adjust the direct revenue cost to take account of associated deadweight loss – depends on the policy experiment. In this example, the real income loss and the increase in public goods spending each may interact with preexisting distortions and have an impact on marginal deadweight loss.

It is important to keep in mind that expression (1) or (1′) indicates how the marginal condition for provision of public goods relative to a particular private good is affected. It does not tell us anything about the margins relative to other private goods, or about the *level* of public goods. Consider an example in which there are two private goods, consumption (c) and labor (L), as well as the public good; let us also assume that public good provision has no impact on revenue, i.e., $dR/dG = 0$. The individual household's budget constraint is $pc = wL$, and we can impose a consumption tax or a labor income tax, in either case letting the other good be the numeraire commodity. If we impose a consumption tax, and consumption is a normal good, then $dR/dy > 0$. Thus, $\lambda = \alpha - \mu dR/dy < \alpha < \mu$. Thus, $\mu/\lambda > 1$, so expression (1) implies that $HU_G/U_L > f_G/f_L$ – the valuation of the public good relative to labor should exceed its marginal production cost in units of labor. But suppose we impose the tax on labor, letting consumption be numeraire. If *leisure* is a normal good, then *labor* will decline with income, and so will revenue; i.e., $dR/dy < 0$. This means that $\lambda > \alpha$; in fact, as shown in Auerbach and Hines (p. 1386), $\lambda = \mu$ if preferences are Cobb-Douglas, in which case expression (1) implies that $HU_G/U_c = f_G/f_c$ – the valuation of the public good relative to consumption should equal its marginal cost in units of consumption. But, since taxing consumption and taxing labor must yield the same underlying equilibrium, these two results together imply (for Cobb-Douglas preferences) that there should be a distortion on the margin between labor and the public good, but no distortion on the margin between consumption and the public good. Put another way, there should be a distortion between goods and labor, but not between the two goods. This result may be seen as an analogy to the case with two private consumption goods and labor, where imposing a uniform tax on the two goods, or a tax on labor, distorts the labor-goods margin but not the margin between the two private goods. In both cases, the fact that there is no distortion on one margin doesn't imply that there are no distortions. In the case of public goods, we will see a reduction in the consumption of both private and public goods as we distort the labor-leisure choice.

Externalities

We follow closely the derivation for public goods, simply replacing G in the direct and indirect utility functions with X_N, the aggregate consumption of good N that we assume is the source of an externality affecting all individuals equally, and letting the production function be $f(\boldsymbol{X}+\boldsymbol{R}) \leq 0$. The Lagrangian is $HV(\boldsymbol{p}; X_N) - \mu f(\boldsymbol{X}+\boldsymbol{R})$. We set good 0 as numeraire and impose taxes on goods 1, ..., N. The first-order conditions may be written (see Auerbach and Hines, p. 1388):

$$(2) \qquad -\lambda X_i + \mu \left[X_i + \sum_j t_j^* \frac{dX_j}{dp_i}\right] = 0 \qquad \forall i$$

where $t_j = \begin{cases} t_j^* & j \neq N \\ t_j^* - HV_{N+1}/\mu & j = N \end{cases}$

That is, correcting externalities affects only the expression for the good, *N*, with which the externality is associated; other taxes should be based on the standard optimal tax formula, while the tax on good *N* consists of two components, the usual optimal tax plus a second piece to address the externality. Since $V_{N+1} = U_{N+1}$ and $\lambda = U_0$, we can express the Pigouvian piece as:

(3) $$-\frac{HU_{N+1}}{U_0} = \frac{\mu}{\lambda}\left[t_j - t_j^*\right]$$

Comparing expressions (3) and (1), we see the very close analogy between the cases of public goods and externalities. As in the public goods case, the value of μ/λ depends on which margin (i.e., in which units) the externality is evaluated, but the underlying policy will be invariant to the choice of units or normalization. See Auerbach and Hines (p. 1388-9) for further discussion.

A relevant issue here is the so-called double-dividend hypothesis relating to environmental tax reform, discussed at length in the *Handbook of Public Economics* chapter by Bovenberg and Goulder (section 3). Some proponents of environmental taxes have argued that the value of these taxes is enhanced in a setting where revenue must be raised through distortionary taxation, since the revenue from environmental taxes reduces the revenue that must be raised using other taxes – the so-called revenue-recycling effect. Thus, so the argument goes, environmental taxes have a second benefit – they improve welfare by reducing externalities *and* by reducing distortionary taxation. The problem with this logic can be seen by considering a simple example, in which there are two consumption goods and labor, with one of the consumption goods (the "dirty" good) causing a negative externality. Suppose that preferences are such that the cross-elasticities between the two consumption goods and leisure are equal, so that in the absence of the externality, we would want equal taxes on the two goods or, alternatively, just a tax on labor income. Imagine that this tax on labor income represents the initial tax system, and that we now introduce a corrective tax on the dirty good, using the revenue to reduce the tax on labor. This reform improves welfare by correcting the externality, but it doesn't help reduce other distortions, because the increase in the real wage coming from the reduction in labor income taxes is offset by the decline in the real wage coming from the increase in the cost of the dirty good. Once the externality has been corrected, any further increase in the tax on the dirty good would simply introduce an unwanted distortion between the two consumption goods, without helping to reduce the labor supply distortion. Hence, there is no double dividend – no reason to use environmental taxes more aggressively because of the revenue-recycling effect. Although this negative conclusion is important, the revenue-recycling effect is relevant when we compare policies that correct externalities by raising revenue and those that do not, such as taxes or auctions of tradable permits versus abatement subsidies or outright grants of tradable permits. With no revenue-recycling effect, the corrective measures are less attractive. Put another way, the revenue-recycling effect doesn't provide a second dividend, but its absence *offsets* the standard benefit of corrective taxation with additional deadweight loss.

Dealing with Global Externalities

An important current policy issue is how to deal with externalities that cross national borders. For local externalities – those that do not directly affect the residents of other countries – a decentralized approach is generally called for: even if country B does not adopt an appropriate policy to deal with its local externalities, there is no cause for country A to act, except perhaps out of altruistic concern for the residents of country B. However, when externalities are global, with one country's actions causing an externality in others, the situation is different. Consider, for example, greenhouse gas emissions that contribute to global warming. Returning to the simpler case in which lump-sum taxes are assumed to be available, what should each country do?

The answer to this question depends on other elements of the policy environment, as discussed in the paper by Sandmo. In particular, if we imagine a process of worldwide social welfare maximization, then the standard single-country results carry over: we should have Pigouvian taxes that offset the worldwide externality each action causes. However, such worldwide global welfare maximization implicitly would also call for cross-country transfers, from rich countries to poor ones. What if such transfers are excluded from consideration? Then it is no longer optimal for each country to exactly offset the externalities it causes. Instead, greater offsets should occur in richer countries and smaller offsets in poorer countries. This will result in global production inefficiency, because the marginal costs of abatement will be higher in rich countries than in poor ones, but this is offset at the constrained optimum by the shift in abatement costs from poor countries to rich ones. That is, it would be more efficient for rich countries to transfer resources to poor countries and then to have the poor countries participate fully in abatement activities, but if such transfers are not feasible then a second-best strategy must be followed.

Another issue that comes up in the case of global externalities is whether countries should use taxes on imports, sometimes referred to in this context as border adjustments, to deal with inefficient behavior elsewhere. In particular, suppose that country B does not offset global externalities caused by its own production activities. Should country A impose a tax on its imports from country B, to simulate the Pigouvian tax that country B should have imposed directly? The answer to this question is complicated, because it depends in part on distributional considerations like that just considered. However, in general border adjustments will be an imperfect substitute for Pigouvian taxes, because they apply only to country A's imports from country B, not to all of country B's production.

Imperfect Competition

Imperfect competition has implications for the incidence and efficiency of taxation. In terms of incidence, a tax can be overshifted – the net price received by the producer *increasing* with the introduction of the tax. In terms of efficiency, there is now a pre-existing distortion, which influences the choice of other taxes and invites consideration of corrective taxation of the competitive distortion itself. Also, tax instruments that otherwise would be equivalent – unit taxes and *ad valorem* taxes – now have different effects on efficiency and incidence.

To illustrate some of these points, consider a simple case in which there are N identical producers engaging in Cournot (quantity setting) competition, with each firm seeking to maximize profits $px_i - tx_i - C(x_i)$, where x_i is firm i's production, t is a unit tax on the commodity, and $C(\cdot)$ is a cost function with $C' > 0$ and $C'' \geq 0$. Suppose that firms take the decisions of other firms as given, so that the first order condition for profit maximization is

(4) $p + x_i \frac{dp}{dX} - t = C'$, (where $X = \sum_i x_i$)

Differentiating (4) with respect to t (using the fact that $x_i = X/N$) yields:

(5) $\frac{dp}{dt} = \frac{1}{1+\frac{1+\eta}{N}-\frac{C''}{N\frac{dp}{dX}}}$

where η is the elasticity of the inverse demand function, dp/dX, with respect to X. Consider first the case of perfect competition, where expression (4) is modified by the assumption of price-taking, i.e., $p - t = C'$. Differentiating this with respect to t yields a modified version of (5) in which the second term in the denominator of the right-hand side disappears. Since $C'' \geq 0$ and $dp/dX < 0$ (the demand curve is downward sloping), $dp/dt \leq 1$ – the producer will bear some of the tax, with this burden approaching zero as $C'' \rightarrow 0$, i.e., as the supply elasticity becomes infinite. This is our standard incidence result. For the general case, however, overshifting is possible; for example, suppose there are constant costs, i.e., $C'' = 0$. Then, overshifting will occur if and only if $\eta < -1$. For a constant demand elasticity $\varepsilon < 0$, $\eta = 1/\varepsilon - 1 < -1$ (see Fullerton and Metcalf, p. 1826), so that overshifting *always* occurs.

Now, suppose the tax is imposed as an *ad valorem* tax, τ, so that profits equal $(1-\tau)\, px_i - C(x_i)$. As shown in Auerbach and Hines (pp. 1396-7),

(6) $\frac{dp}{d\tau} = \left[p + \frac{X}{N}\frac{dp}{dX}\right]\frac{dp}{dt}$

To compare introductions of unit and *ad valorem* taxes of equal size, $pd\tau = dt$, we divide (6) by p to get:

(6′) $\frac{1}{p}\frac{dp}{d\tau} = \left[1 + \frac{X}{pN}\frac{dp}{dX}\right]\frac{dp}{dt} < \frac{dp}{dt}$

That is, an *ad valorem* tax leads to a smaller price increase than an equal size unit tax. This occurs because as firms consider a quantity reduction in response to a tax increase, the benefit is smaller because, as the price increases with the quantity reduction, some of the resulting profit is captured by the proportional tax on revenues. Note that under perfect competition (i.e., taking $\frac{dp}{dX}$ = 0 in (6′)) $\frac{1}{p}\frac{dp}{d\tau} = \frac{dp}{dt}$ and hence the incidence of the unit and ad valorem taxes is the same.

Optimal Taxation and Imperfect Competition

How should we deal with the presence of imperfect competition when designing optimal taxes? There are two relevant considerations. First, even with constant returns to scale, there will be economic profits, and this will affect the choice of optimal taxes, just as in the perfectly competitive case. Second, there is an initial distortion associated with the wedge between price and marginal cost in the affected market. As shown in Auerbach and Hines (p. 1395), the resulting optimal tax rule incorporates these two factors, the second leading to the result derived above for the case of externalities, where the wedge associated with the externality is replaced by the wedge between price and marginal cost.

Another interesting question regarding how to deal with imperfect competition arises where an industry causes externalities. In particular, consider the electricity production industry, which has seen a pattern of deregulation in recent decades in the United States. One aim of deregulation is to encourage competition, but if the competition lowers prices for energy produced using fossil fuels for which Pigouvian taxes are not set high enough, there may be a second-best argument against encouraging competition. Having firms collect the "tax" in the form of a price above marginal private cost simulates a policy of imposing a Pigouvian tax and giving the revenue to the firms. While a direct Pigouvian tax would be preferred, as it would allow the government to choose a different use for the revenue, the government might still find the policy preferable to one with marginal cost *private* pricing.