The regulation of free access (Based on DH (1979).)

We wish to further analyze the problem of free access to a fishery with n identical fishers. We consider still the symmetrical Nash equilibrium which was characterized as

$$pf'(X^e) = w + \frac{n-1}{n} pX^e \frac{\partial}{\partial X}\left(\frac{f(X^e)}{X^e}\right), \tag{1}$$

where X^e denotes the equilibrium total number of boats operating on the fishery, i.e. $X^e = nx^e$. Answer the following questions analytically and provide an intuitive explanation for each.

1) **Taxes**
   a) Find the tax rate per unit of effort that would re-establish optimality. What does it represent exactly?
   b) How does the unit tax value vary with the number of firms?
   c) Do fishing firms prefer the free-access regime with the tax or without? Discuss.
   d) Assume now that the number of fishing firms is large, i.e. $n \to \infty$. Compare the optimal tax rate obtained in 4) to the price of an entry ticket per boat (q^*) charged by a *single* rights holder as found in our analysis of the *anti-commons* in class, i.e. with $m = 1$ and $n \to \infty$. Comment on what it really means to impose a tax as a regulation measure.

2) **Licenses**
   a) Instead of taxes, assume now that the government chooses to distribute fishing licenses. Each license confers a right to add one boat to the fishery. A firm may own more than one license. We assume that initially, the government *arbitrarily* distributes a total number X^l of licenses between firms that can thereafter be traded. A market for licenses thus develops.
   What will be the equilibrium price of each license? To simplify, assume that firms are price-takers in the market for licenses and denote the price as q (as proposed in DH 67).
   b) If the government distributes an efficient number of license, how does the price of a license compare to the efficient tax rate found above?

3) Do firms prefer regulation through licenses or taxes? Discuss.

ANSWERS

1) **Taxes**
   a) The objective is to find a tax rate that can re-establish the efficient number of boats on the fishery. In other words, with the tax, the total number of boats X^* must respect

the following condition

$$pf'(X^*) = w \text{ where } X^* = nx^*. \tag{2}$$

Let t be the tax per boat. The new NE is now characterized by

$$pf'(X^t) = (w+t) + \frac{n-1}{n} pX^t \frac{\partial}{\partial X}\left(\frac{f(X^t)}{x^t}\right). \tag{3}$$

If we set t at the following value:

$$\begin{aligned} t^* &= -\frac{n-1}{n} pX^* \frac{\partial}{\partial X}\left(\frac{f(X^*)}{X^*}\right), && (4) \\ &= -(n-1)px^* \frac{\partial}{\partial X}\left(\frac{f(X^*)}{X^*}\right), && (5) \end{aligned}$$

then the tax equilibrium becomes the one sought for in equation (2).
Note that X^* here is a *fixed* value defined in equation (2). Hence, the optimal tax t^* is actually equal to the value of the *externalities* evaluated at X^* that one firm imposes on the others when it decides to send another boat on the fishery. Such a tax is referred to as a *Pigovian* tax in the literature, which is defined as the marginal external damage imposed on others *at the efficient level*. It is related to the *Polluter-Pay-Principle* and supposes that the regulator has the capacity to determine what the efficient input level must be.

b) **Tax and number of firms**
According to expression (4), the tax increases with the number of firms. (Remember that X^* is fixed.) This is not surprising, as we have seen that the larger the number of firms, the larger the value of the externalities that each firm imposes on the others. When $n = 1$, this value is nil; when $n \to \infty$, this value is maximized.

c) **Firm profits with and without the tax** (Based on DH 3.4)
We wish to compare total firm profits with the tax and without. The answer is not *a priori* obvious because even though firms must pay taxes, higher efficiency with taxes means that there are more total rents. Its is thus a question of comparing the effect of a larger pie versus a lower share of the pie.

Let R be the total *net* rents perceived by the firms. In the **no-tax NE**, we have:

$$\begin{aligned} R^e &= pf(X^e) - wX^e, && (6) \\ &= \left(p\frac{f(X^e)}{X^e} - w\right) X^e, && (7) \\ &= \frac{p}{n}\left(f(X^e) - X^e f'(X^e)\right). && (8) \end{aligned}$$

The last equation is obtained by making use of the symmetrical NE condition.

In a **NE with tax**, we have:

$$R^t = pf(X^*) - (w+t^*)X^*, \tag{9}$$

$$= \left(p\frac{f(X^*)}{X^*} - (w+t^*)\right)X^*, \tag{10}$$

$$= \frac{p}{n}\left(f(X^*) - X^*f'(X^*)\right). \tag{11}$$

Now it must be the case that $R^t < R^e$ because $X^e > X^*$ and

$$\frac{\partial}{\partial X}\left(f(X) - Xf'(X)\right) = -Xf''(X) > 0. \tag{12}$$

Hence, in the absence of a redistribution of tax receipts, firms prefer the no-tax NE equilibrium.

d) The optimal tax rate is the same as the entry ticket price charged by a single exclusion-rights holder in the anti-commons case. This is not surprising as both tax collector and and the exclusion-rights holder seek to maximize rents under the same constraint of fishing firms accessing the fishery in a "free access fashion".
This means that introducing a tax is equivalent to removing free access on the fishery, as with the holder of exclusion rights. Hence, the government's role as a tax collector that seeks to reestablish efficiency on the fishery is really one of an excluder, not a tax collector. Indeed, the ability to tax implies that those who do not pay the tax are excluded from the fishery. The state could alternatively have decided to freely grant a group of people the privilege to send X^* boats on the fishery, or auction off licenses. The actual payments made to access the fishery will determine how rents are to be distributed, but *exclusion is the bottom line.*

2) **Licenses**

a) If a license can be bought and sold at price q, then the *opportunity cost* of a boat is now $w+q$ instead of just w in the free-access NE. In a market equilibrium for licenses, it must be the case that given the license price q, each firm is satisfied with the number of licenses that it has, i.e. it cannot increase its profits by selling or acquiring more licenses. More formally, the marginal profit from a license must be nil. The profit for one firm is:

$$\pi_i = x_i p\frac{f(X)}{X} - (w+q)x_i, \text{ where } X = x_{-i} + x_i. \tag{13}$$

Hence, the zero marginal profit condition is

$$\frac{\partial \pi_i}{\partial x_i} = p\frac{f(X)}{X} + x_i p\frac{\partial}{\partial X}\left(\frac{f(X)}{X}\right) - (w+q) = 0. \tag{14}$$

The price q must be such that this condition is satisfied for all firms. Assuming identical firms, we have:

$$p\frac{f(X)}{X} + xp\frac{\partial}{\partial X}\left(\frac{f(X)}{X}\right) - (w+q) = 0. \tag{15}$$

This implies

$$pf'(X) - w - q + \left(\frac{n-1}{n}\right)\left(p\frac{f(X)}{X} - pf'(X)\right) = 0. \tag{16}$$

Now if we assume that the authorities will distribute the efficient number X^* of licenses, we have $pf'(X^*) - w = 0$, such that:

$$q^* = p\left(\frac{n-1}{n}\right)\left(\frac{f(X^*)}{X^*} - f'(X^*)\right), \tag{17}$$

$$= -p\left(\frac{n-1}{n}\right)\frac{\partial}{\partial X}\left(\frac{f(X^*)}{X^*}\right). \tag{18}$$

b) The equilibrium price q is equal to the optimal tax rate found in (4).

3) **Licenses v. taxes**

If firms must buy their licenses form the government, then there is obviously no difference between the tax and the license equilibrium as far as their profits are concerned. If the licenses are distributed freely to the firms, then they prefer the license scheme.