

## Resource Economics – Seminar 4

Thursday, October 22, 2015

Room HH201, 16:15-18:00

### Problem 1: Extraction decision under political uncertainty.

Suppose that there are two parties in a country. The one party – let’s call it “socialistic party” – argues for early expropriation with  $T$  so that maximal extraction by the firm is optimal (consider the problem set-up from last seminar). The other party – let’s call it “liberal party” – argues against expropriation in general (i.e.  $T \rightarrow \infty$ ). Assume that the current government is run by the “liberal party” but the firm knows that the “socialistic party” wins the next election with probability  $\rho$  and the “liberal party” wins with probability  $1 - \rho$ .

1. Suppose the firm has to make a binding extraction plan for all times before it knows which fraction will actually win on this issue. Solve for the optimal extraction plan of the firm and characterize the price path.
2. How does the planned extraction path depend on  $\rho$ ?
3. When the firm could influence the election probabilities by changing its extraction pattern, it would not make a difference whether it can commit to a time-path of extraction in the beginning or not. Discuss verbally why this is the case.

### Problem 2: Investment & extraction under expropriation after one period

This is a simplification of the model in Bohn and Deacon (2000). Consider the following problem. In period 0 the owner of a resource decides how much  $A$  to invest in extraction technology which lowers the extraction costs. The cost of making these investment is  $\frac{1}{2}A^2$ . In period 1 the owner decides how much to extract ( $E$ ) given world prices  $p$  (exogenous) and costs of extraction  $C = E_1^2/A$ . The stock is infinite.

1. Set up the problem of the owner in choosing  $A$  and  $E$  and solve it.

### Problem 3: Investment & extraction under expropriation after two periods

We continue with a similar problem but with two periods at which the owner can extract. In period 0 the owner decides how much  $A$  to invest in extraction technology which lowers the extraction costs. The cost of making these investment is  $\frac{1}{2}A^2$ . In period 1 the owner decides how much to  $E_1$  extract given world prices  $p$  (exogenous) and immediate costs of extraction  $C_1 = E_1^2/A$ . In period 2 the owner decides how much to extract given the same price but with extraction costs  $C_2 = cE_1 + E_2^2/A$ . There is no discounting and the stock is infinite. Parameters are as in problem 1, but in addition  $c < p$ .

1. Set up the problem of the owner in choosing  $A$  and  $E_1$  and  $E_2$
2. Solve the problem with backward induction. What is the optimal  $E_1$ ,  $E_2$  and  $A$ ?
3. How do these values of extraction and investment compare to the values from exercise 1? Why?
4. More generally, discuss what the effect is on investment and extraction when one increases the time to expropriation (see Bohn and Deacon, 2000).

5. Suppose a government wants to offer a fixed-term contract to a firm to install extraction capacity and exploit an underground reservoir. At the end of the contracted time period, the government becomes the owner of all installed production capacity and the remaining resource stock. Discuss the trade-off with respect to the contract-length and other problems that the government faces.

#### Problem 4: Exploration investment under taxation

1. Royalties: A firm is exploring for resources ( $S$ ) in a single period. Every unit of  $S$  is worth  $p$  but the firm has to pay a royalty tax  $\tau_r$  on its revenues. To find  $S$  units the firm incurs costs of exploration  $C = \frac{1}{2}S^2$ .
  - a) Solve the exploration problem of the firm, how much does it explore? What is the effect of royalties on exploration?.
  - b) The government sets the royalty rate  $\tau_r$  to maximize its total tax revenues. What is the optimal tax from the government's point of view?
2. Profit tax: Suppose the tax is based on profits instead.
  - a) Solve the problem of the exploration firm, how is exploration affected by the tax?
  - b) What is the optimal tax from the government's point of view?
3. Uncertainty: Suppose now that if the firm takes exploration effort  $e$  with per-unit cost  $c$ , then with probability  $\rho$  it finds  $S = e^{1/\theta}$  (where  $\theta > 1$ ) of the resource and with probability  $1 - \rho$  it finds nothing. What is the effect of a profit tax only on firms which make a finding? Suppose the government can, as a complement to the profit tax, subsidize firms who make a loss. Show that such a system is non-distortionary.

#### References

- Bohn, H. and Deacon, R. T. (2000). Ownership risk, investment, and the use of natural resources. *American Economic Review*, 90(3):526–549.