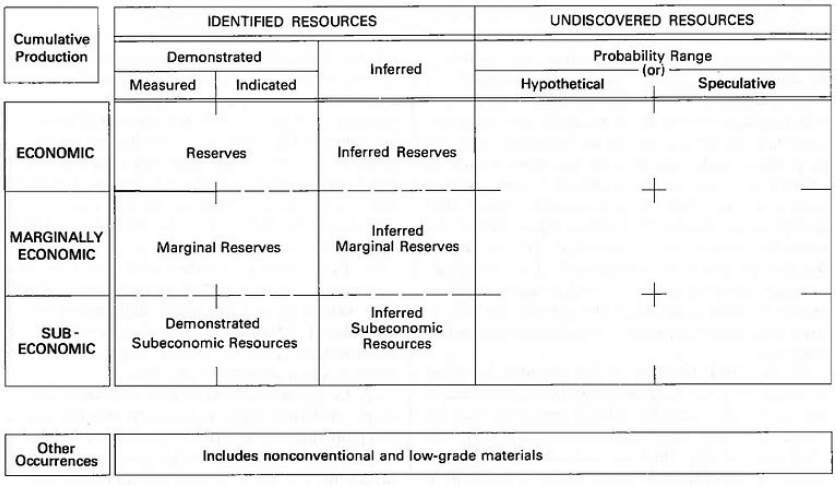
Economics of Nonrenewable Resources

Lecture 4

1. Nonrenewable Resources

- Minerals
  - Coal, Oil, Tungsten, Nickel etc.
  - Fixed stock
  - Not renewable (fish, trees, etc.)
- Efficient use over time
  - Rate of extraction

- Scarcity
  - Geologic and Economic dimensions of scarcity
    - Geologic is physical side
    - Economics recognizes that “availability” depends on extraction cost and willingness to pay (technology change and resource prices)
      - Tar sands in Canada for oil
  - McKelvey diagram



- Be wary of Physical indicator of scarcity
  - Reserves-to-Use Ratio
  - Historically have been wrong
    - Ignore technology, prices, substitutes
- Many Armageddons
  - Jevons "The Coal Question"
  - Reverend Malthus
  - Simon vs. Ehrlich (read Tierney NYT 1990)

- Efficient Extraction in 2 Periods
  - Assume: fixed quantity (20 barrels)
  - Assume: 2 periods → today and tomorrow
  - Assume: stable preferences and cost functions
  - Ask: What is the efficient rate of extraction?
  - Show: Market should account for future use of resource and does through concept of "User Cost" or "Scarcity Rent"

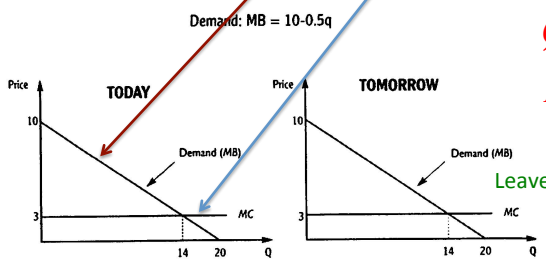
- Consider myopic result (ignoring next period)

$MB = MC$

$10 - .5Q = \$3$

Demand Function

Constant Marginal Cost



$Q^* = 14$

$P^* = \$3$

Leaves 6 for next period!

Figure 6.2 The problem with (myopic) static efficiency in the case of a scarce resource. Static efficiency would imply extracting fourteen barrels in each period—more than the total stock of twenty barrels.

Static efficiency ignores effect of loss economic value in next period!

- Consider dynamic result
  - Account for impact of current use on future lost
  - Using today implies loss use tomorrow
  - There is a second real piece to marginal cost → user cost or scarcity rent
  - Dynamic result maximizes value over the sum of two periods → today and tomorrow

- Efficient dynamic conditions
  - Set net values equal over the two time periods
  - Why is this?

$$PV(MB_1 - MC_1) = PV(MB_1 - MC_2)$$

$$10 - .5Q_1 - 3 = \frac{10 - .5Q_2 - 3}{1 + .10}$$

$$Q_1^* = 10.19$$

$$Q_2^* = 20 - Q_1^* = 9.81$$

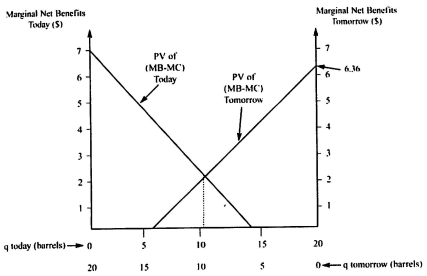


Figure 6.3 Nonrenewable resource extraction: the two-period model.

- Rearranging equation ….

Discount rate

$$MB_1 - MC_1 - \delta(MB_2 - MC_2) = 0$$

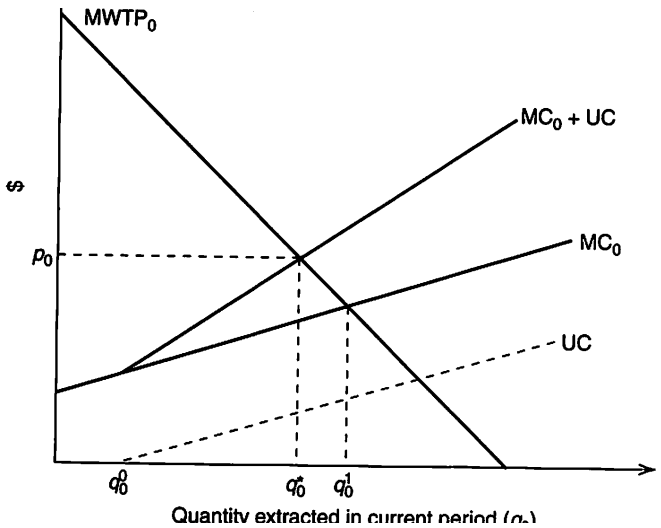
Marginal Benefit Of Current Use

Marginal Cost Of Current Use

Marginal Value of Of Future Use
- Oil left in the ground for tomorrow

Marginal user cost is a great indicator or scarcity.

-Scarcity Rent
-User Cost
Almost like an external cost on current consumption



- General Model

$$\left\{ Max \sum_{t=0}^{T} \rho^t U(q_t) \mid st \;\; R_0 - \sum_{t=0}^{T} q_t = 0 \right\}$$

$$L = Max \sum_{t=0}^{T} \rho^t U(q_t) + \mu \left\{ R_0 - \sum_{t=0}^{T} q_t \right\}$$

$$U'(q_0) = \rho U'(q_1) = \rho^2 U'(q_2) = \ldots = \rho^T U'(q_T)$$

→ Marginal Utility of extraction must grow at the rate of discount …. And Hotelling Rule applies.

- The Hotelling Rule
  - Nonrenewable resource stocks should increase in value at a rate equal to that of other types of assets in the market (i.e., something like the market rate of interest)
  - Leaving oil (or whatever mineral) in the ground is an investment with some return (rent)
    - If they grow at a slower rate → extract
    - If they grow at a faster rate → wait

- Hotelling Rule and Profit Maximizing Firm

$$\frac{MUC_2 - MUC_1}{MUC_1} = \frac{(P_2 - MC_2) - (P_1 - MC_1)}{P_1 - MC_1}$$

$$= \frac{(5.095 - 3) - (4.905 - 3)}{4.905 - 3}$$

$$= .10$$

- Comments
  - Price and Quantity paths
  - Making the model more sophisticated:
    - Technological Change (future cost curves shift in)
    - Increasing cost over time due to depletion (future cost curves shift out)
    - Increasing population and demand
    - Uncertainty
    - Backstop technologies
  - Read Livernois

- Market Failure
  - Externalities in mining and other down stream operations
  - Resource will incomplete assignment of property rights (open access resources)→ expect race to pump
    - Groundwater Aquifer
    - Some Oil Wells