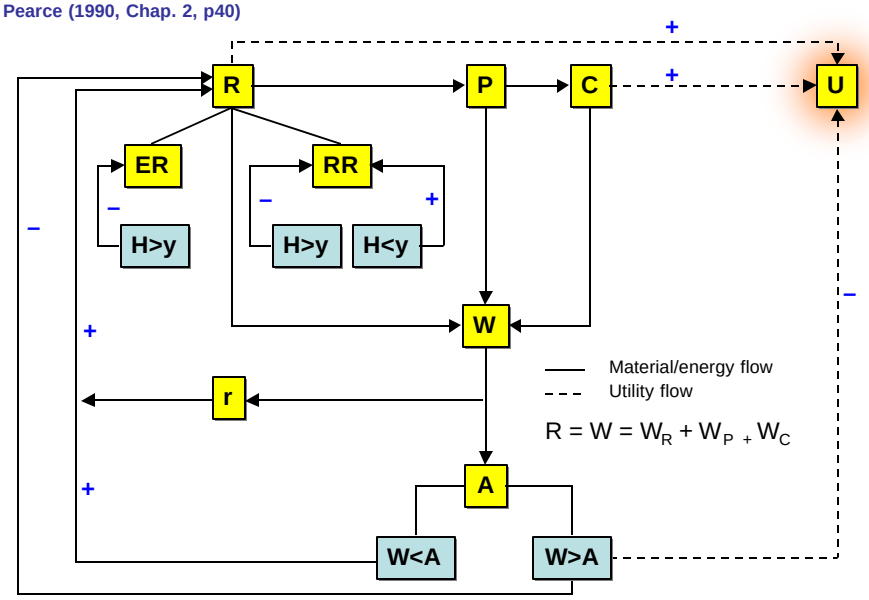
Natural Resource and Environmental Economics

1st Lecture: An Introduction

The Circular Flow Economy

Pearce (1990, Chap. 2, p40)



Are we running out natural resource?

How rich are we (Indonesia)?

World Bank's (1998) study reveals ….
The 10 richest countries in the world
(Wealth estimates in US$ Billion)

1	United States	83,220
2	China	33,707
3	Japan	31,143
4	Germany	18,652
5	France	13,809
6	India	13,658
7	United Kingdom	12,488
8	Italy	12,016
9	Brazil	10,801
10	Indonesia	8,635

The 10 richest countries in natural resource (US$ Billion)

1	United States	3,126
2	India	2,544
3	China	2,316
4	**Indonesia**	**1,015**
5	Saudi Arabia	857
6	Brazil	784
7	Canada	780
8	Australia	441
9	Mexico	418
10	France	329

Components of Indonesian Natural Resource (US$ Billion)

Agricultural Land	788	77.7%
Cropland	780	76.9%
Pasture Land	8	0.8%
Forest & Protected Areas	123	12.1%
Timber	91	9.0%
Non-Timber Benefit	20	1.9%
Protected Areas	12	1.2%
Subsoil Assets	104	10.2%
Metal and Mineral	9	0.9%
Oil	46	4.5%
Hard Coal	3	0.3%
Natural Gas	47	4.6%

Natural Resource Scarcity

How is it measured?

Is it really scarce?

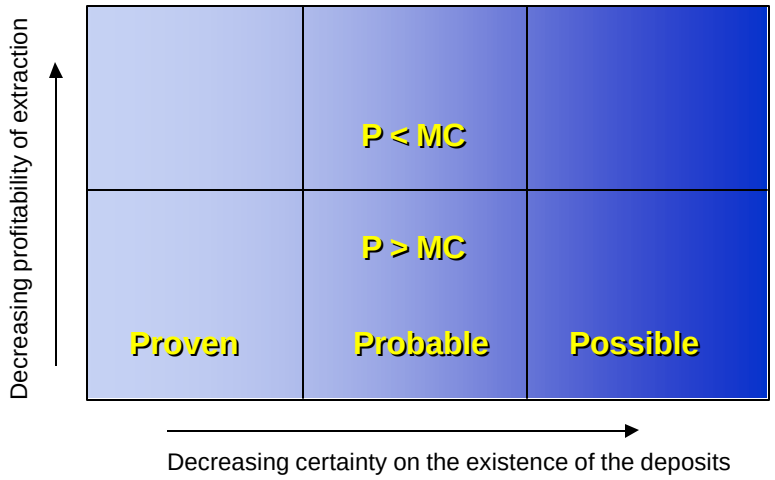
Malthusian and Ricardian

(Pearce, 1990, ch. 19)

- Malthusian: scarcity in terms of absolute physical limits (Neo-malthusian: Limit to Growth, Club of Rome, 1972)
- Ricardian: depletion effect, rising cost and price. More optimistic.

Reserves of Natural Resource:

Some problems in definition (Hanley, et al, 1997)



Indicators of Scarcity

(Hanley, et al, 1997)

- Physical indicator (a bad measure)
- Unit cost measures
- Real price
- Economic rent

Physical measure: why bad?

- Simple physical measure
- Life time of the resource
- Reserves to consumption ratio

- Lets take a look some data …..

Table 1 **Changing values of 'resource life' 1970 to 1994**

Resource	T_{1970} years	T_{1994} years	Rate of change in T % p.a.
Aluminium	31	104	5.2
Copper	21	25	0.7
Iron	93	115	0.8
Lead	21	11	- 2.3
Mercury	13	20*	1.8
Silver	13	na	na
Coal	111	139	0.9
Gas	22	42	2.7
Oil	20	35	2.3

Source (Pearce's lecture notes, supplied)

Are we running out oil?

Not really

(Bjorn Lomborg, 2001, "The Skeptical Environmentalist)

Figure 66 Years-of-consumption: world oil reserves compared to the annual production, 1920–2000. Source: Simon *et al.* 1994, EIA 1997b:Table 11.3, 11.5, 1999c:271, 2000d:277, 2000a:109, 2000c:156, 2001a:137, 2001b:115. Total reserves until 1944 are only American, since 1944 for the entire world.

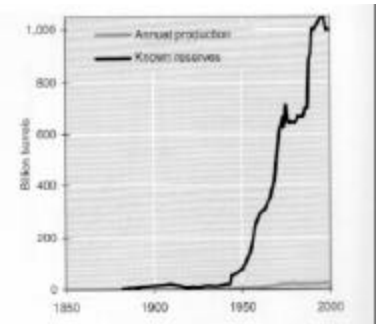


Figure 67 The world's known oil reserves and world oil production, 1920–2000. Source: As Figure 66.

How about coal?

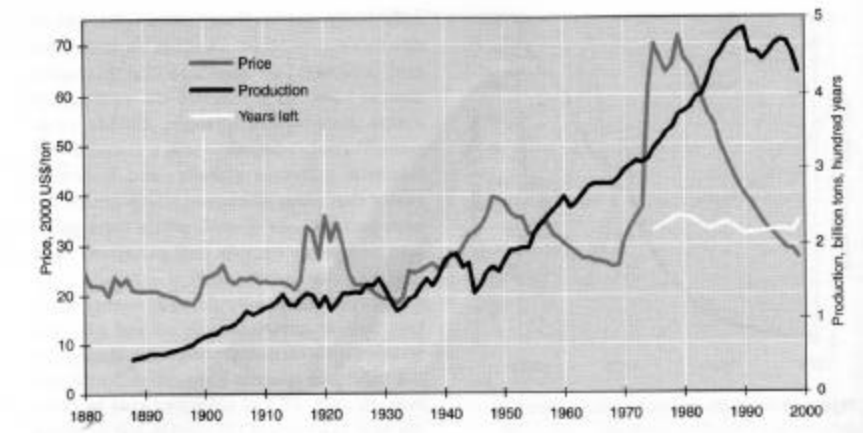


Figure 70 World coal production, price and years of consumption. Production in billion tons, 1888–1999, price in 2000 US$ per ton, 1880–1999, and years of consumption, 1975–1999 in hundreds of years (right axis). Source: Simon *et al.* 1994, EIA 1997b:Table 3.2, 11.15, EIA 1999c:63, 2000a:23, 2000d:205, 2001b:25, 295, Freme and Hong 2000:5, CPI 2001, BP 1998, 1999.[913]

Natural Gas?

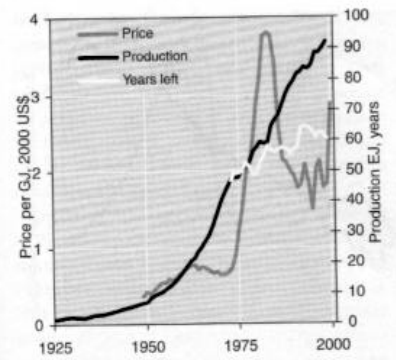


Figure 69 World gas production, price and years of consumption. Production in exajoule, 1925–1999, price in 2000 US$ per gigajoule, 1949–2000, and years of consumption, 1975–1999. Source: WI 1999c, EIA 1999c:63, 269, 2000a:109, 131, 2001b:42, CPI 2001, BP 1998, 1999.[905]

Other minerals?

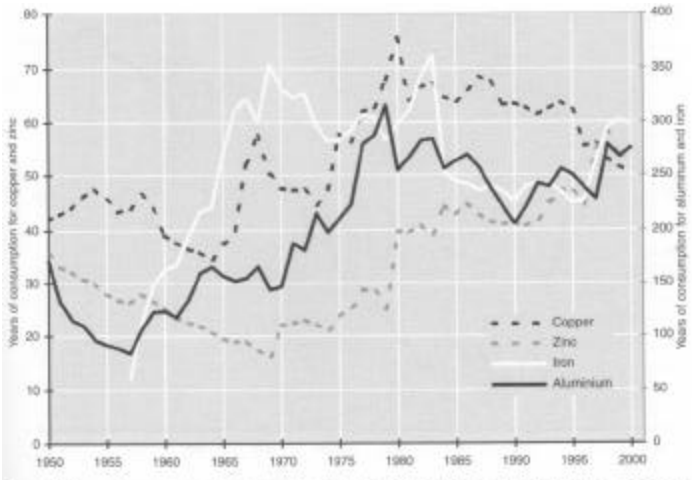


Figure 77 Years of consumption of the four most used metals, 1950–2000 (iron 1957–2000). Source: Simon et al. 1994, USGS 2001a.

Simple physical measure ..

- Tells us that we are not running out (some) natural resource
- Is it generally true?
- Is there any explanation from economic perspective? Yes: human nature, incentives, innovation: carnucopian.

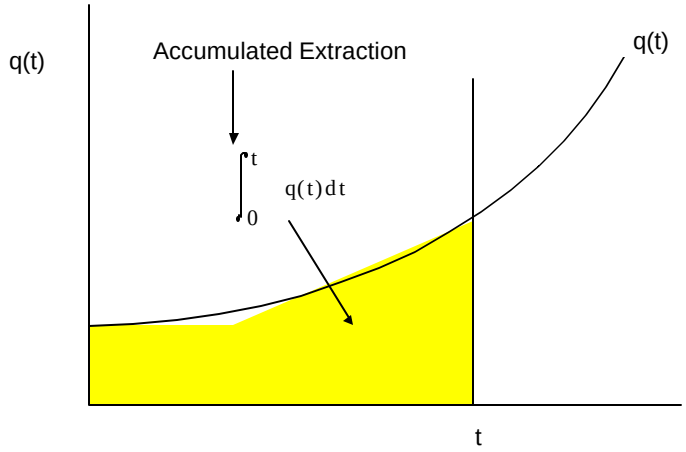
Lets see ..

- Adjusted (more realistic) physical measure of **time to exhaustion** indicator

Source (Pearce's lecture notes, supplied)

A Little Review of Integral Calculus

(On White Board)



Reserves left in the ground at time t: $S(t) := S - \int_0^t q(t)\,dt$

$$Q_t = Q_0 - q_0 \int e^{gt}$$

$$Q_T = Q_0 - q_0 \left[e^{gt}/g\right]^T_0 = 0$$

$$Q_0/q_0 = [(e^{gT} - 1)/g]$$

$Q_0/q_0 = s$, is the *static reserve lifetime*

$$s = [(e^{gT} - 1)/g]$$

$$sg = e^{gT} - 1 \qquad \ln.(sg + 1) = gT$$

$$T = \ln.(sg + 1)/g$$

$$T^*_\delta = \ln.[s(g-\delta) + 1]/(g-\delta)$$

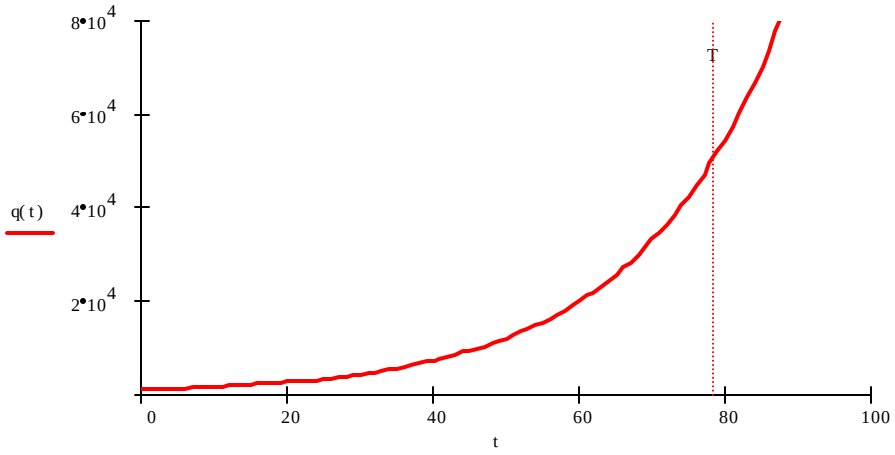
- Based on this:

$$T = \ln.(sg + 1)/g$$

$$T^*_\delta = \ln.[s(g-\delta) + 1]/(g-\delta)$$

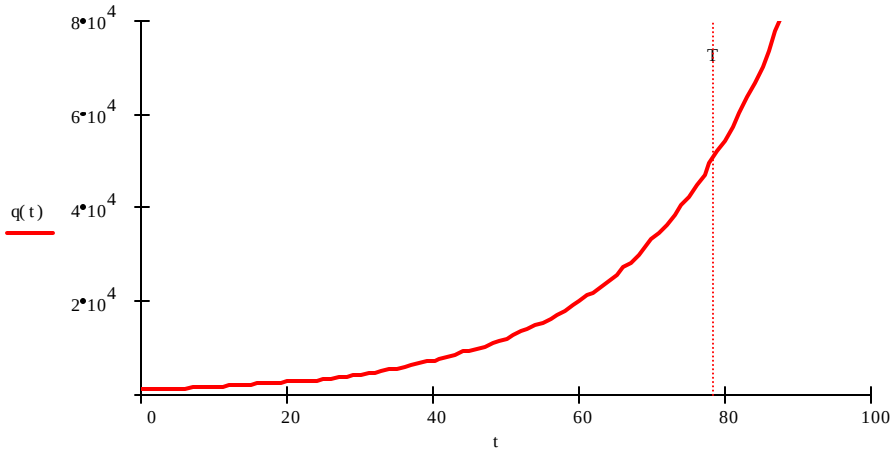
- What happen if Q_0 increase?
- What happen if q_0 increase?
- What happen if g increase?
- What happen if δ increase?

$q(t) := q_0 \cdot e^{g \cdot t}$ Path of extraction/consumption



$\int_0^T q(t)\,dt = 1000000$

What happen if growth rate of extraction increase?



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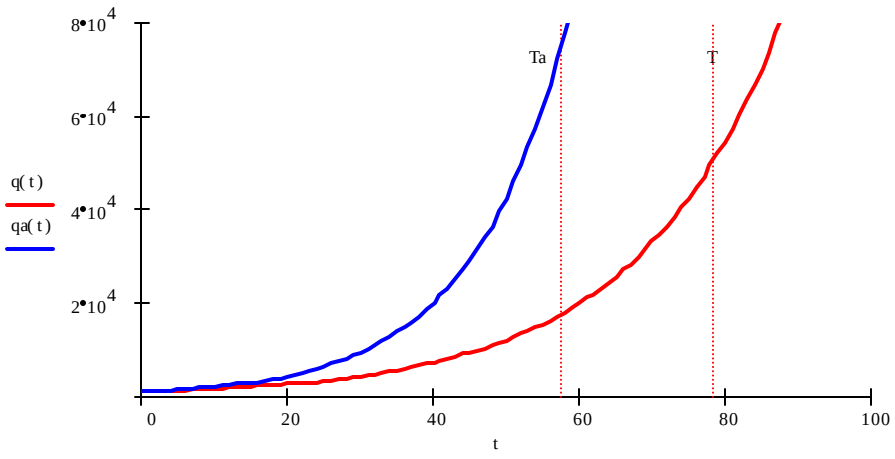
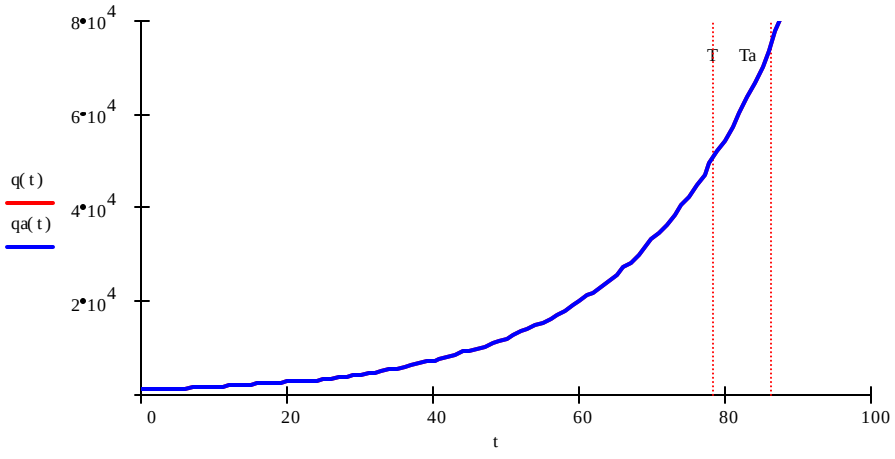


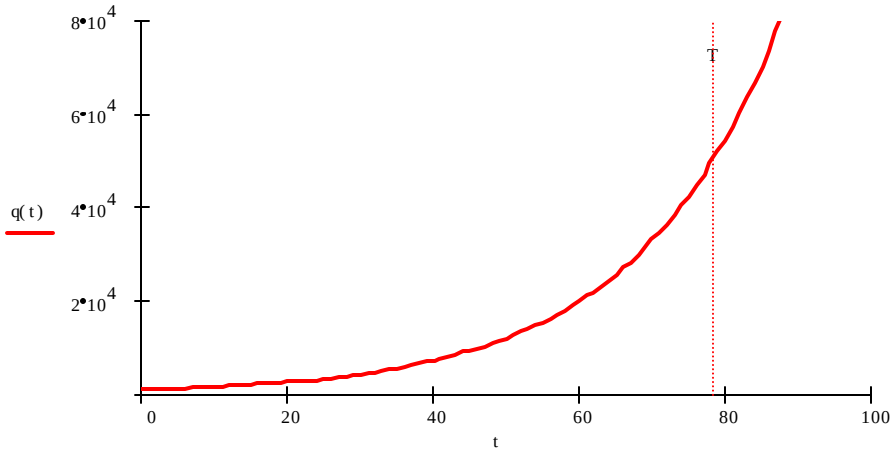
$$\int_0^T q(t)\,dt = 1000000$$

What happen if Initial Stock Increase?



$$\int_0^T q(t)\,dt = 1000000 \qquad \int_0^{Ta} q(t)\,dt = 1500000$$

What happen if initial extraction increase?



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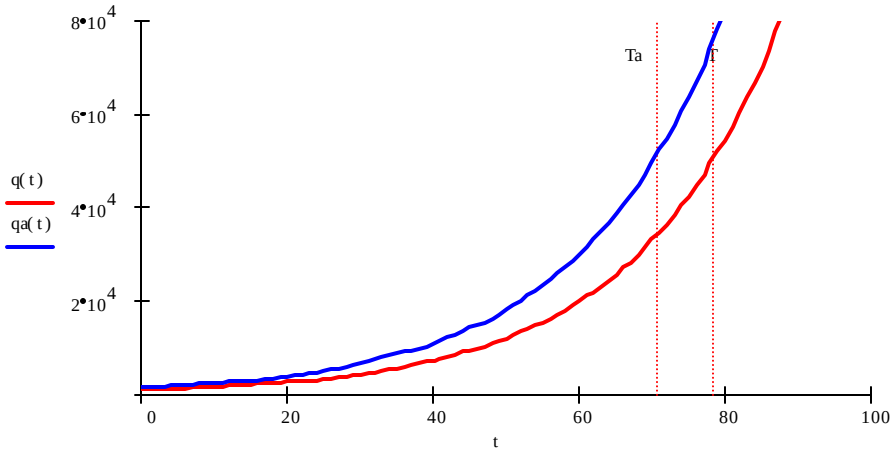
What happen if initial extraction increase?



$\int_0^T q(t)\,dt = 1000000$

Therefore, Time to Exhaustion depend on …

- Initial Stock/Reserves we have
- Initial Extraction
- Growth of extraction/stock consumption
- Rate of Discovery

Unit Cost as Indicator of Scarcity

- Barnet & Morse (1963) found: over 1870 – 1957 unit cost of a many primary product had declined,
- Johnson et al (1980) found similar observation for the period 1958 – 70
- Empirical studies support declining scarcity (based on unit cost measure)

Problem with unit cost

- Declining unit cost could be caused by technological progress
- Assumption that firm will deplete the lowest cost deposit first (perfect knowledge assumption)
- Declining cost may be caused by substitution of K and L by other input (energy)
- Only based on past experience (not forward looking)

Real price as indicator of scarcity

- Barnet & Morse (1963) also found declining prices. Slade (1982) suggest U-shaped.
- Hall and Hall (1984): real prices increased in 70s, decline in 60s, although in many cases relationship between price and time is insignificant
- Anderson & Moazzami (1989): increasing price for coal, copper, decreasing for alumunium and iron.

Problem with real price

- Imperfect competition (Cartel e.g. OPEC)
- Government intervention change price
- Price do not measure social opportunity cost
- It depend on appropriate deflator

Economic rent as indicator of scarcity

- Rent = price – marginal extraction cost
- Will be discussed further in the later lecture
- Problem with economic rent:
  - Scarce empirical data
  - Assumption that firms follow optimal plan