LECTURE 6

ECONOMIC AND POPULATION GROWTH:

THE ENVIRONMENTAL CONSEQUENCES

A. Consequences of growth of world income and population:

Depletion Non-renewable Natural Resources?

*Degrading of Renewable Natural Resources***?**

Global Warming?

B. Are Non-Renewable Resources Underpriced?

Evidence of Resource Scarcity? Prices, Reserves,

C Pollution: Market or Policy Failures

"Optimal Pollution"

D. Global Warming

Literature referred to: see last slide

[6.2] Consequences of growth of world income and population

1) Depletion of Non-renewable Natural Resources?

2) Degradation of Renewable Natural Resources?

3) Global warming?

Issues:

a) Has past growth induced scarcity of resources and degraded the environment? (growth 1960-2000 in [6.3, bottom]).

b) If so, why?

- **-market failures**
- **-government failures**
- **-ignorance**
- **-rational choice**

c) Are there solutions other than hindering growth of income and population?

Start with the issue of depletion of non-renewable resources, but first look at a possible scenario for economic and population growth in a medium term perspective.

[6.3]Table 6.1. **Rough Projections** of World Income (WI) by Year 2035

Normalised income in year 2000: $\mathbf{WI_{2000} = 100; RCI_{2000} = 60; PCI_{2000} = 40}$

Projected annual growth rates 2000-2035	Rich countries (RC)		Poor countries (PC)	
	Scenario 1	**Scenario 2**	**Scenario 1**	**Scenario 2**
Growth of per capita income	0.02	0.015	0.04	0.02
Growth of population[a)]	0.01	0.005	0.015	0.01
Growth of total income	0.03	0.02	0.055	0.03

a) Based on the high and low recent (2001) UN projections (see [5.4])

Scenario 1: $\mathbf{WI_{2035} = 60(1 + 0.03)^{35} + 40(1 + 0.055)^{35} \approx 430}$

Scenario 2: $\mathbf{WI_{2035} = 60(1 + 0.02)^{35} + 40(1 + 0.03)^{35} \approx 230}$

In these two projections, world income in year 2035 will hence be about 4.3 respective 2.3 times higher than world income in 2000. **China? India?**

Rough Estimation of World Income in 1960

World population: 3 billion (1960); 6 billion (2000) $\Rightarrow$ 1.75% per year

Growth of GDP per capita 1960-2000: ca 2% per year

$$\Rightarrow \quad \mathbf{WI_{1960} = 100/(1.0375)^{40} = 100/4.38 \approx 23}$$

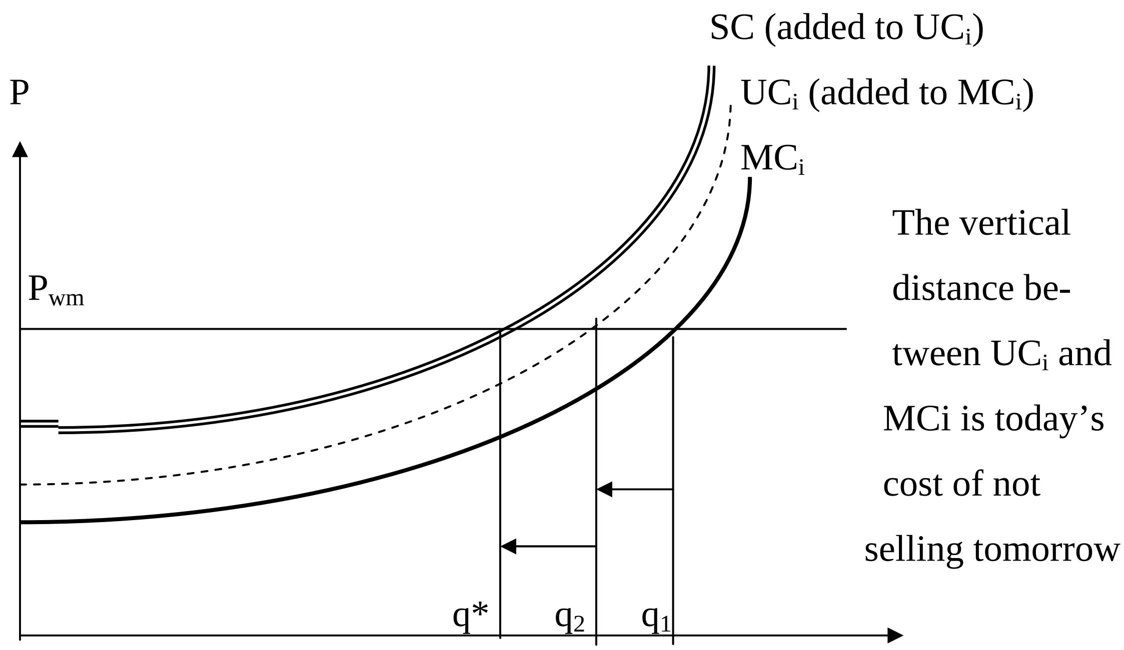
That is, world income in 1960 was about 23 per cent of that in 2000, implying a four-fold increase.

[6.4] Are non-renewable natural resources underpriced?

In a market economy with perfect competition, **private agents** will exploit a natural resource that they own by producing the output level where their private **marginal costs** (MC_i) equals the going (world)-market price (P_{wm}). That is, if they expect that price to remains **unaltered** over time.

However, if they expect prices to be higher in the future, because the resource is in finite supply, there is an **opportunity cost** of selling today. They will hence hold back production "today" at the margin so as to sell this marginal quantity "tomorrow" at the higher expected price. The discounted value of that lost profit tomorrow—if they sell today— is the so called **user cost**, UC_i). They will hence only produce up the point where the marginal production cost *plus* the user cost equal the going price today. Even in a market economy, there is thus a "mechanism" that ensure that private agents take "**future" profits** into consideration in their production decisions.

Figure 6.1. Private firm's production decision



[6.5] Pricing of natural non-renewable resources (cont'd)

Hotelling's (cupboard theory): scarcity and increasing prices

It was **Hotelling** (1931) who first demonstrated that private agents to (some extent) internalise increased scarcity (higher future prices) by considering user costs in their production decisions. In terms of Figure 6.1, instead of producing at q_1, they will produce at q_2, saving the difference for the "future".

His model has later on been used to argue that **long-term resource prices** will inevitably go up. (The model was based on highly restrictive assumptions however: fixed homogenous deposits that are all known, and no technological progress in any stage; see below.)

Three possible market failures:

1) Private producers systematically underestimate the user cost (future price increases)

2) Use a too high discount rate for user cost

3) Producers do not internalise the **social environmental costs** connected with the exploitation of a natural resource there will be overproduction (cf Figure 6.1),

Government failure also takes place. In many countries, the major natural resources are owned and exploited by the state (companies). A frequently noticed example is the former **Soviet Union**

[6.6] Other factors influencing price

Scarcity in the sense of using up resources in physically finite supply is not the only factor determining long-term price developments; also other forces at play:

<u>Supply side</u>: the long-term aggregated supply curve tends to shift downwards because of:

1) **Exploration costs** falling with new techniques

2) **New high concentration deposits** discovered concurrently

3) New more efficient **extraction techniques** lower costs and makes earlier non-profitable deposits economically viable.

4) **Transportation costs** falling (tankers, etc).

5) **Recycling**

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<u>Demand side:</u>

1) **Low income elasticity** for some resources (e.g. metals)

2) More efficient **production techniques** in general lower the use of raw materials and hence **derived demand** for these.

3) **Substitution** to less expensive materials (e.g. optic fibre glass).

Private agents may hence expect future prices to **decline** rather than increase. In terms of Figure 6.1, this would mean that they produce more than q_1 “today” as to avoid losses from lower prices “tomorrow”.

[6.7] <u>Two types of tests</u> of increasing scarcity

1) Reserve/consumption ratio

2) Long-term real price trends for raw materials

(also the question of developments on the demand side, considered later)

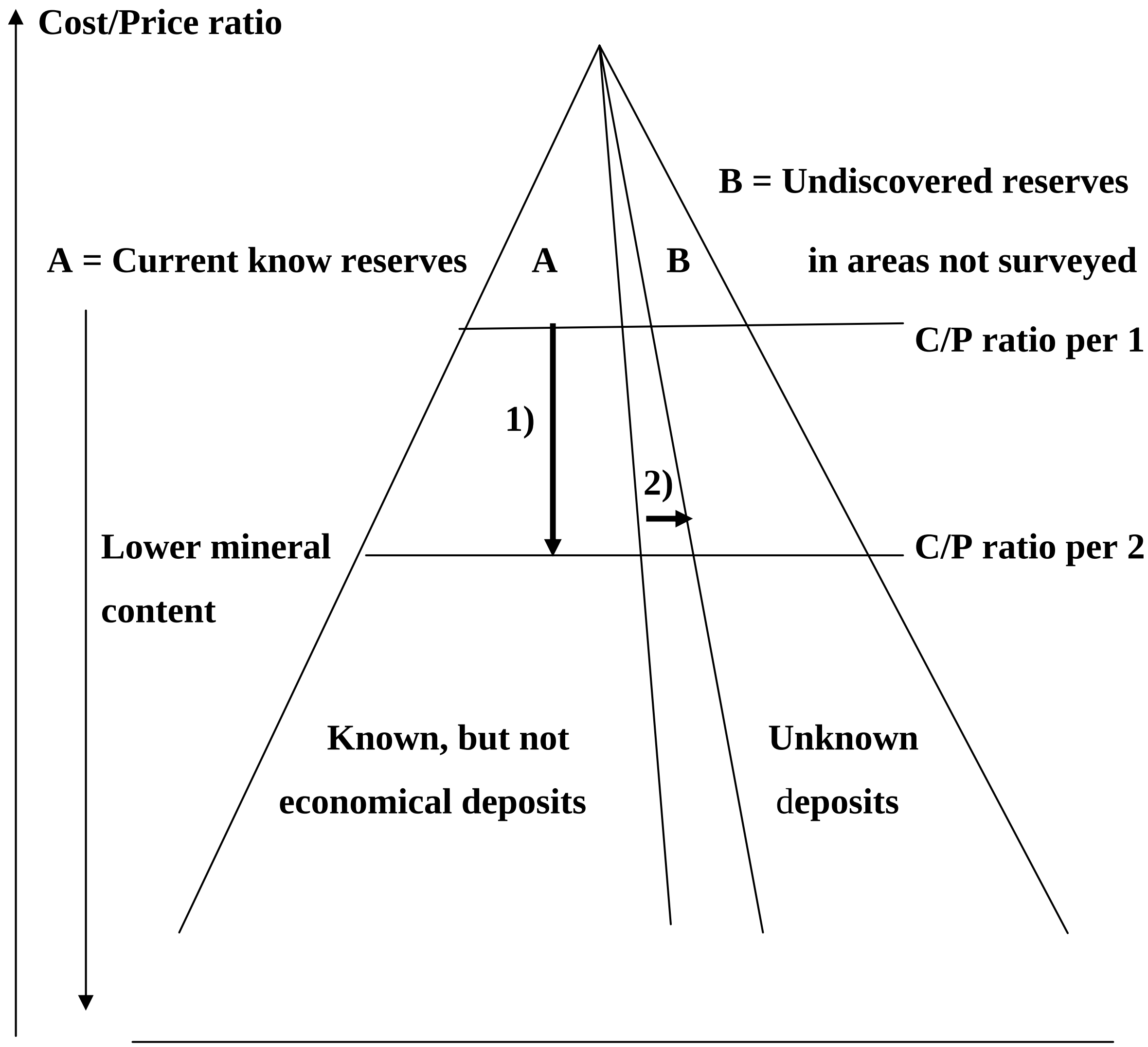
<u>Test 1</u>: Reserve to consumption ratios (Temple 1999). By reserves are meant **known deposits that are economically exploitable at the current price** of the commodity.

Table 6.2. Indicators of resource availability

Reserve to consumption ratios for main minerals			Petroleum reserves as a ratio to annual consumption	
Mineral	Reserve ratio		Year	Ratio (years)
Aluminium	252		1950	22
Copper	62		1960	37
Iron ore	233		1970	35
Lead	47		1980	27
Nickel	137		1990	45
Tin	59		2000	48
Zinc	49		2008	42

Sources: World Resource Institute, The Economist

[OH 6.7.b] Figure 6.2. Model of reserve and supply responses to real price increases in minerals and oil



Two responses to real price increase (drop in C/P):

1) Previously uneconomical known reserves become profitable (e.g. tar sands and deep off-shore oil wells)

2) Increased incentives for exploration of new reserves

[OH 6.7.c]

Q1: Have known economically viable oil deposits actually increased?

* Steady decline in **new discoveries** of oil since the 1960s.

* Since the mid 1980s, annual **production/consumption** of oil has been consistently **higher than new discoveries**.

* **Projections** for the period up to 2050 bleak, but are these based on an oil price **> US$100** and included **tar sands**?

[OH 6.7.d; to be shown in class]

Q2: Has "Peak Oil" already occurred?

Several national and international energy agencies, oil companies, and independent energy researchers have estimated that **oil production reached an all time peak already in 2005** or will do so in a few years time.

[OH 6.7.e; to be shown in class]

Mandatory reading: Peak oil premier and links, Energy Bulletin (can be downloaded from Google: enter "peak oil" and this paper is the 11th entry).

Figure 6.7.d

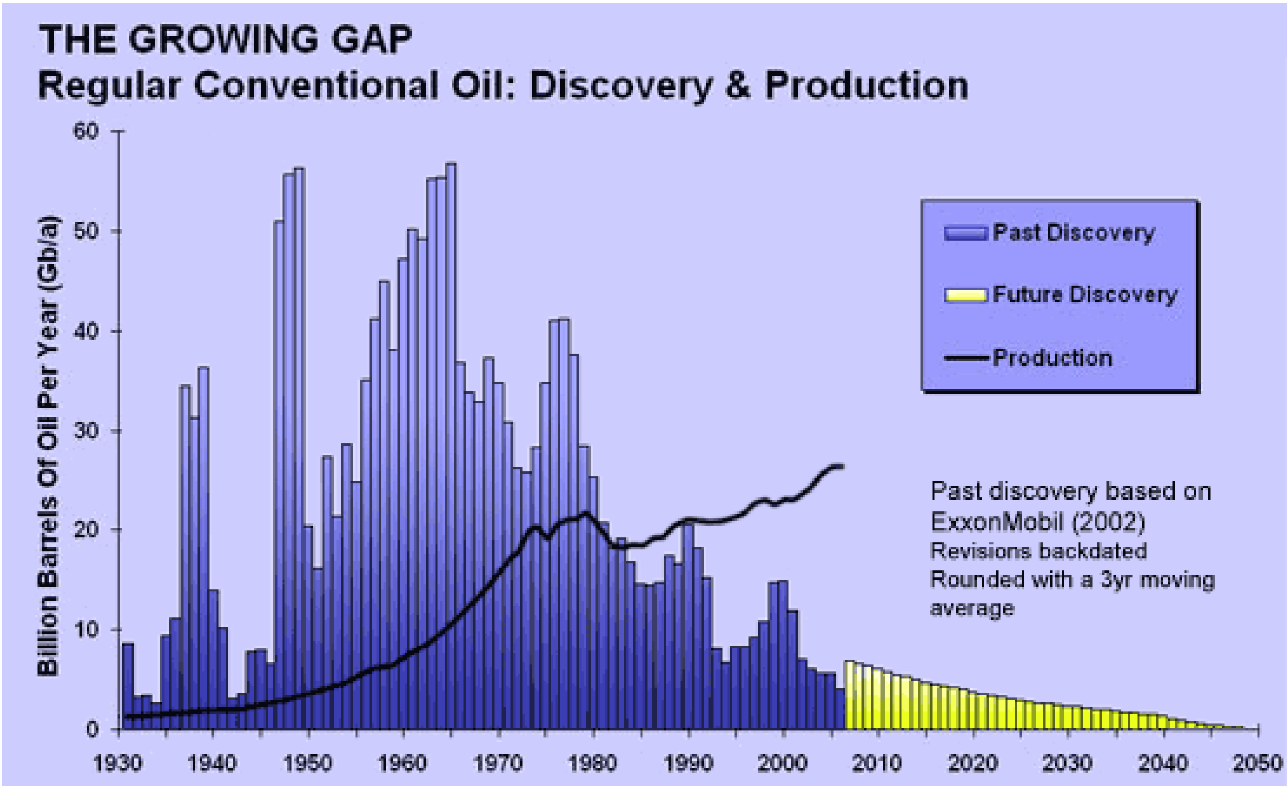
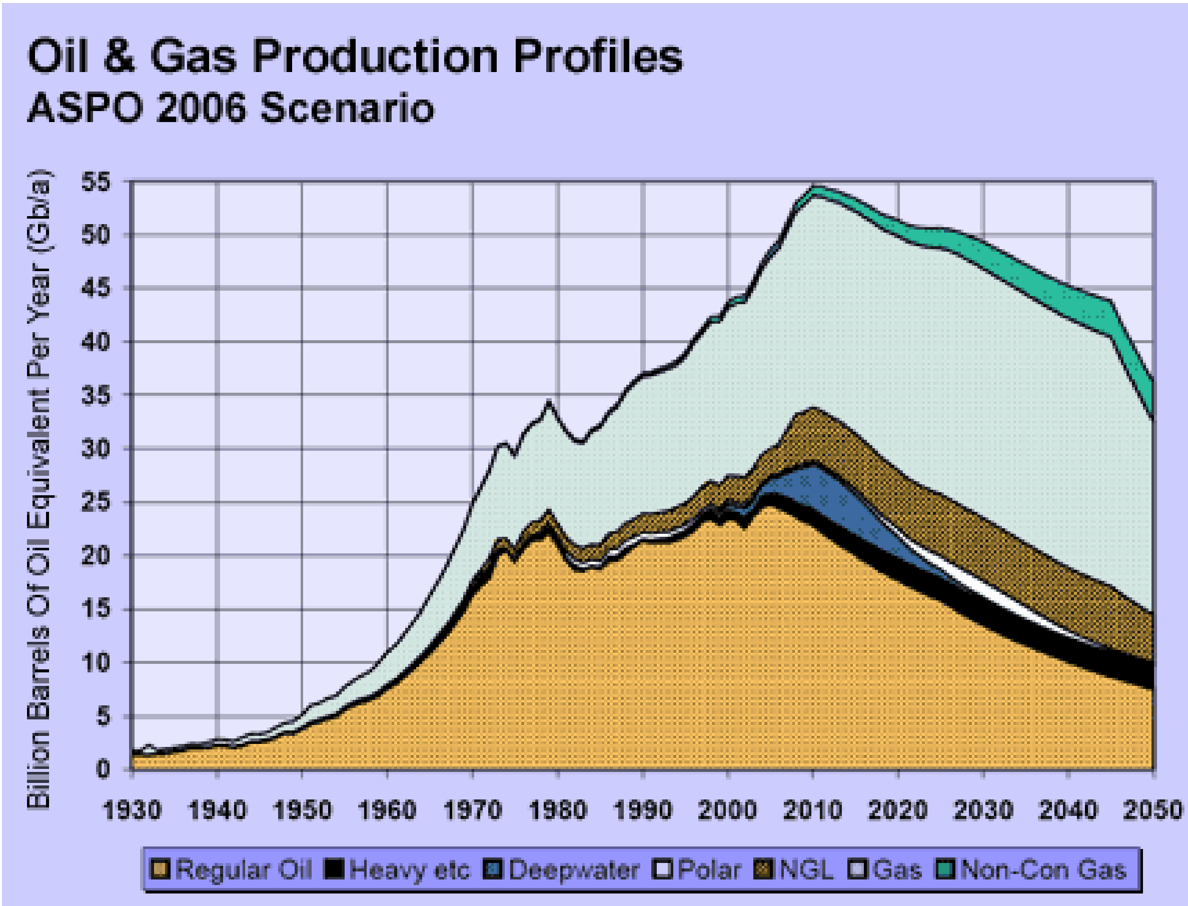

THE GROWING GAP
Regular Conventional Oil: Discovery & Production
Billion Barrels Of Oil Per Year (Gb/a)
0
10
20
30
40
50
60
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Past Discovery
Future Discovery
Production
Past discovery based on
ExxonMobil (2002)
Revisions backdated
Rounded with a 3yr moving
average

Figure 6.7.e


Oil & Gas Production Profiles
ASPO 2006 Scenario
Billion Barrels Of Oil Equivalent Per Year (Gb/a)
0
5
10
15
20
25
30
35
40
45
50
55
1930
1940
1950
1960
1970
1980
1990
2000
2010
2020
2030
2040
2050
Regular Oil
Heavy etc
Deepwater
Polar
NGL
Gas
Non-Con Gas

[6.8] **<u>Test 2</u>**: Long-term real price increases for commodities?

The *Real*, Real Price of Non-renewable Resources

The real price of a commodity (P_{real}) is traditionally derived as the nominal price (P_{nom}), deflated by the price (index) of all goods, as measured by the PPI or CPI. In recent years, it has become widely agreed that official US (and other) PPI and CPI have historically overestimated "inflation"— although it is still debated by how much.

Three main **reasons** for the overestimation:

a) **Substitution bias** in the Laspeyres index used

b) **New goods bias**: Late introduction of new goods in price indexes

c) **Quality bias**: improved quality of goods is neglected in indexes

New **findings**:

1) **Boskin** et al 1997: CPI overstates inflation by 1.1% point per annum.

2) A dozen more rent studies: 0.5-2.2% points overestimation.

Widely **accepted** by now and some revisions have been undertaken in the US since the mid 1990s — but the **historical** price series have not been revised. Going back to the end of the 19th century, the accumulated **inflation has hence been systematically overestimated.**

[6.9] <u>Test 2</u>: Time Trends in the *Real* Real Prices of non-renewable commodities: Copper (Svedberg and Tilton, *World Development*, 2006, pp. 501-19); available on my homepage).

In this paper, we have used these recent findings by Boskin and others and applied them for estimating what we call the ***Real*****, Real Price of Non-renewable Commodities**. So far we have only examined copper in detail

Figure 6.2. The real price of copper 1870-2000 under four different presumption of the inflation bias in the deflator (US CPI)

[to be added in class]

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Main results:

1) **No adjustment**: long-term linear price is **trend stationary**, and negative and **statistically significant** at the 0.05 level. A similar finding has been reported in several earlier studies of copper and many other non-renewable commodities, hence "refuting" the scarcity hypothesis.

2) **Benchmark case with adjustment**: The long-term price of copper deflated by US Consumer Price Index (CPI) adjusted downward by 1 percentage point per year. The trend now becomes **positive**, is **trend stationary**, but statistically significant only at the 0.15 level.

[6.10] The *Real* Real Prices of non-renewable commodities (cont'd)

The following **robustness tests** were conducted

1) Two **alternative adjustments** were made: 0.5 and 1.5 percentage points annually. With the 0.5 adjustment, the trend is downward, but no longer statistically significant. With the 1.5 percentage point adjustment, the trend is positive, trend stationary and significant at the 0.01 level.

2) In addition to the liner model in the benchmark case: two **alternative trend models** were tested (inverse and quadratic). The linear trend turned out to have the best fit overall, but no major change with other trends.

3) **London Metal Exchange** nominal copper prices instead of US prices did nothing to change the main results.

4) As the nominal deflator, we alternatively used the US **Producer Price Index** (PPI); same results by and large.

5) Different checks for **trend stationarity** were tried out

Overall conclusion: The conventional view that the long-term price trend for most minerals and other non-renewable resources is negative and, hence, that resource scarcity in not a problem, may no longer hold when deflated by corrected CPI or PPI price series.

Next: Do the same thing for most other non-renewable resources and investigate the implications for terms of trade.

[6.11] The Demand Side: More Efficient use of Raw Materials?

Table 6.3. Growth of World Consumption of Key Metals, Crude Petroleum and World GDP, selected periods between 1950 and 2005

	Per cent growth per annum		
	1950 - 1970	1970 - 1990	1990 - 2005
Aluminium	9.5	3.3	3.4
Nickel	7.5	1.0	2.5
Copper	5.5	2.0	3.0
Petroleum	7.5	1.5	1.5
World GDP	4.9	3.5	3.5

Sources: Radetzki 2007, table 2.3 (metals and petroleum); Maddison 2003, table 7b (GDP growth, updated for 2005).

To notice:

1) Metal/oil consumption growth much higher 1950-1970 than later

2) World economic growth also higher 1950-1970

3) Consumption of all metals and petroleum grew significantly more rapidly than growth of GDP 1950-1970, while *vice versa* later

- * Technological progress?
- * Shift in production from industry to services?

[6.12] Part 2 of Lecture 6

Degradation of *Renewable* Resources (e.g. air, groundwater, rivers, oceans and land)

Reasons

1. Private Market Failures

- Missing Property Rights ("Tragedy of the Commons")
- Missing Markets for Externalities

2. Government Failure

- Voter Demand Low
- Interest Group Pressure and Political Economy
- Short-sighted Policy Priorities (high discount rate)
- Ignorance

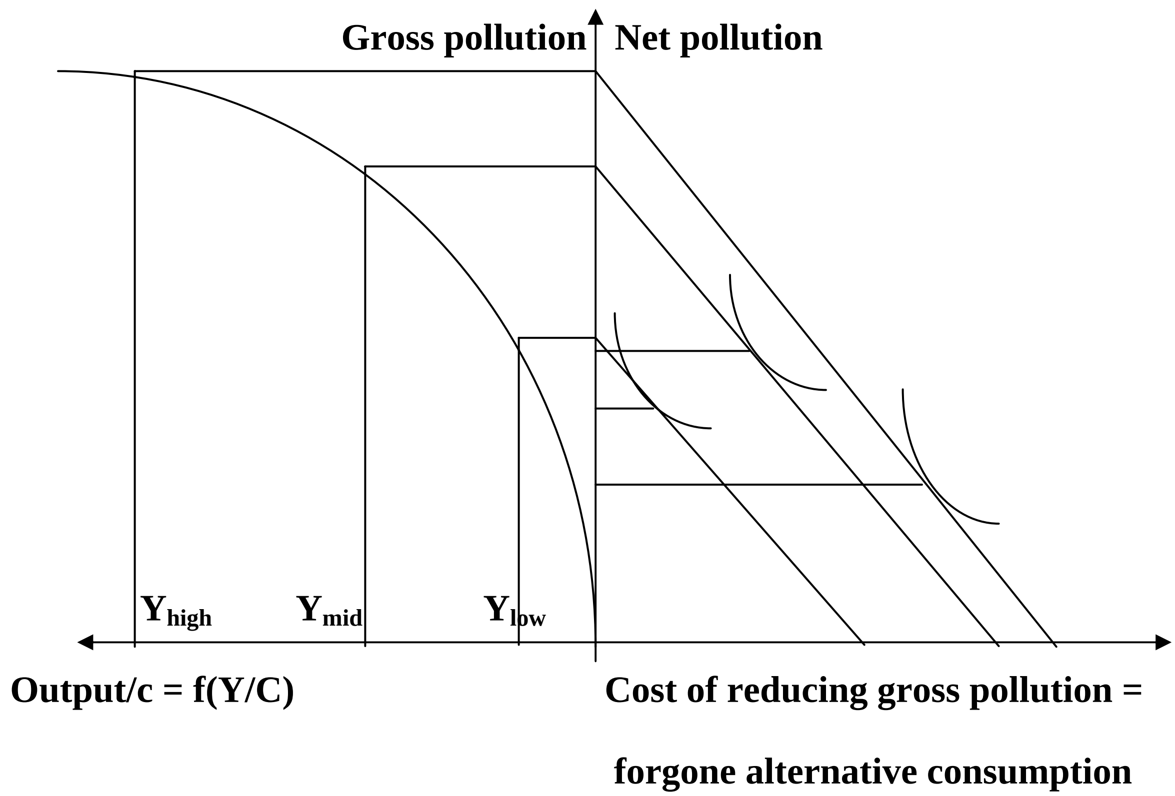
3. Deliberate and rational choice ("optimal pollution")

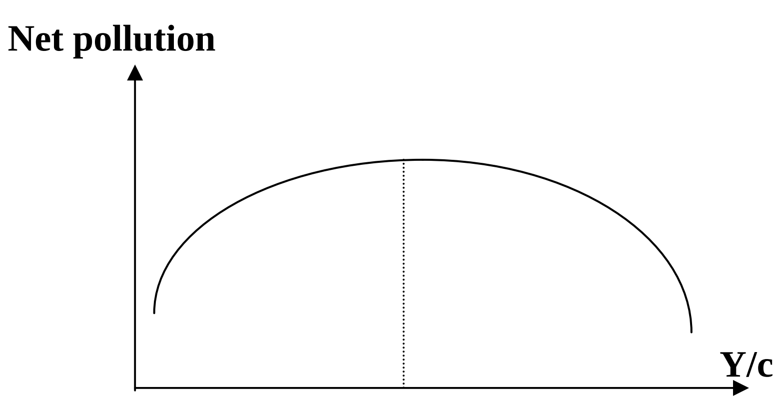
- Trade-off between costs of pollution and benefits in other forms
- Technically impossible to produce goods without some pollution

N.B. Many human activities have **improved** the environment (health)

[6.13] Environmental Degradation: First Worse, Then Better?

Figure 6.3. Model of income and gross vs net pollution and the Kuznets environment curve





Kuznets environment curve

[6.14] Empirical evidence from various sources

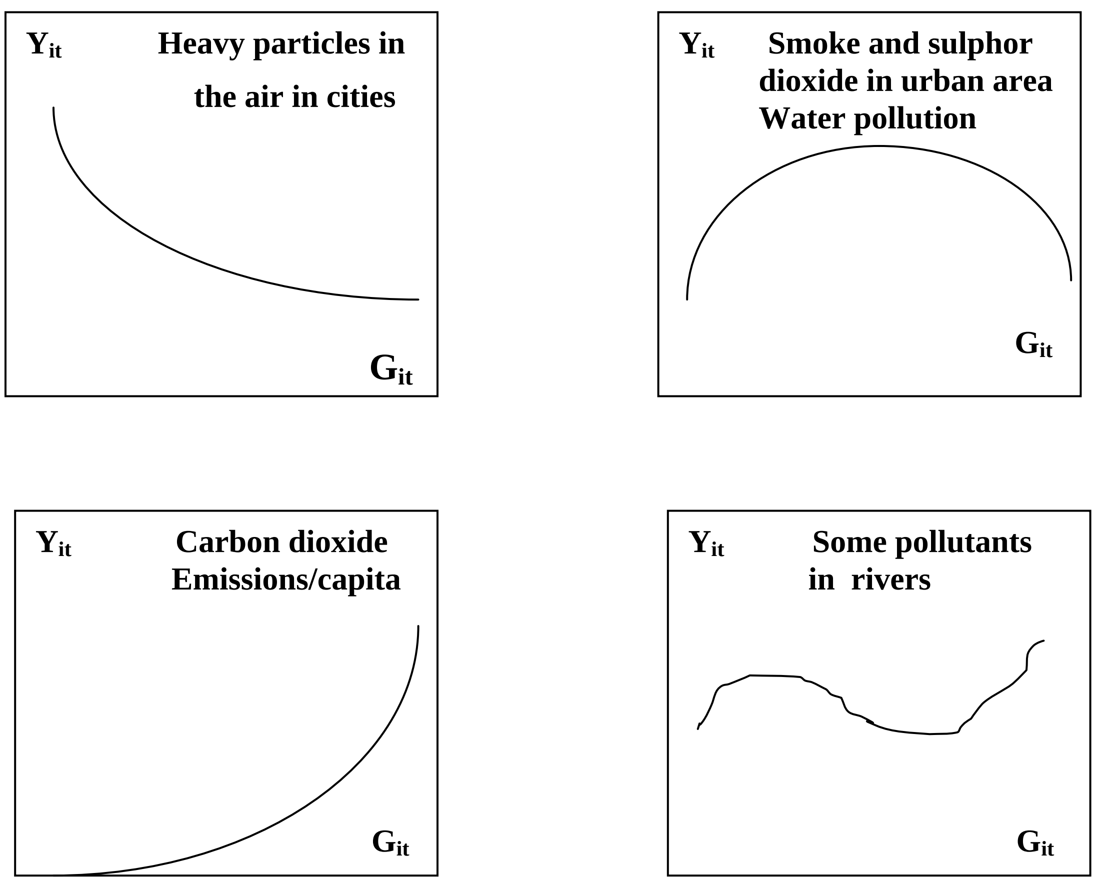
Grossman and Kruger Model:

$$Y_{it} = \beta_1 G_{it} + \beta_2 G^2_{it} + \beta_3 G^3_{it} + \beta_n X_{it} + \varepsilon_{it},$$

where Y_{it} is a measure of water or air pollution in location *i* in year *t*, G_{it} is GDP per capita in year *t* in the country in which location *i* is situated. The squared and higher order terms are included to capture non-linearities. The X_{it} is a vector of conditioning variables (se article) and ε_{it} is an error term. The *β's* are the coefficients to be estimated.

Basically a test of differences at a given point in time across countries.

Figure 6.4. Examples of varying results (also from World Bank 1992)



[6.15] Turning points and time-series observations

Results reported in [6.14] are based on cross-country observations from the 1980s. Suggest that for many types of pollutants, there is a turning point at an income of ca 8,000 dollars per capita in 1985 prices, *unadjusted* for PPP.

Equivalent to at least 12,000 dollars in today's prices and ppp-adjusted.

Table 6.4. GDP per capita in selected groups of countries year 2000. $US (PPP) and estimated year before turning

Region/ country	**Population 2000 (mill)**	**Population growth (%)**	**GDP per capita 2000**	**Year before turning?**
Low income	**2,450**	**2.0**	**1,800**	**Ca 2065?** [a)]
India	**1,000**	**1.8**	**2,200**	**Ca 2040?**
China	**1,250**	**1.1**	**3,350**	**Ca 2030?**
Mid income	**2,700**	**1.2**	**5,000**	**Ca 2030?**

Source: World Bank for base data

a) Based on the assumption that per-capita growth of income is about 3 per cent per year in the low income countries

> **The grate majority of the world's countries have a GDP per capita far below the 12,000 that made up the turning point (in todays prices in 1985), as estimated by Grossman & Kruger and World Bank. Implies that pollution will increase drastically for many decades if the "old" Kuznets curve remains unaltered.**

[6.16] Possibilities for shifting the Kuznets-environment curve downwards and to the left over time:

Supply side:

a) Improved **technology** in the production of goods

b) shifting production **from polluting to clean activities** (from manufacturing of goods to services)

c) Improved **technology in cleaning** activities

Demand side:

a) Increased **public awareness** of the benefits of clean air, water, etc (major health problems in poor countries)

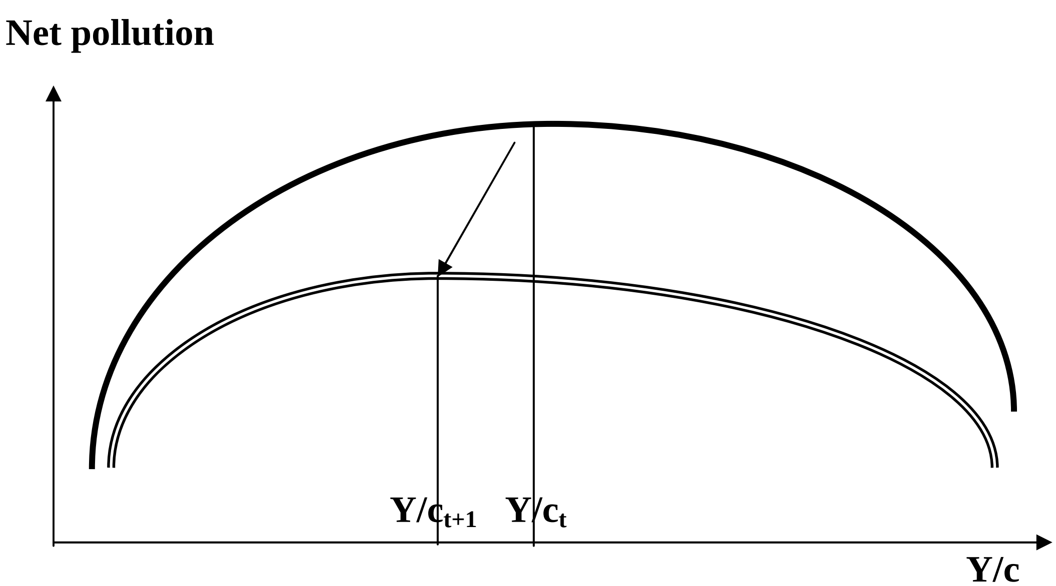
b) Reduced government **subsidies** to polluting activities and increased taxation of such activities

Much of the world's increase in gross pollution will probably take place in the most populous countries, **China and India**. Hence what will happen with environmental policy in these countries is important.

New article by Song et al (2008) provide estimate of the KEC in China, based on data for provinces and find three pollutants (waste gas, waste water, and solid waste to follow the KEC prediction!

[6.17] Changes over time

Figure 6.5. Has the environment Kuznets curve shifted with time?



1) Some evidence for selected pollutants suggest so between 1972 and 1986 (Lomborg 2001 based on World Bank).

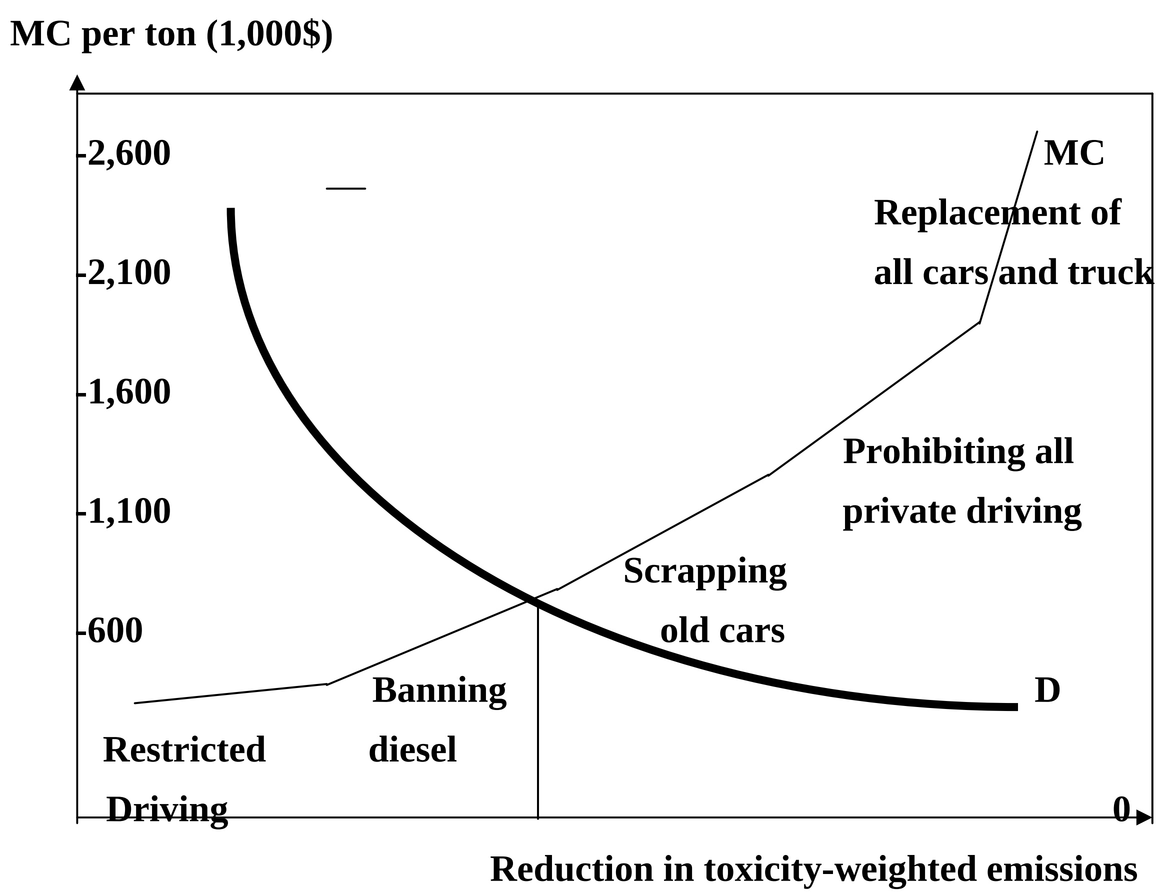
2) Many *time series* estimates of air and water pollutants show a drastic decline, especially since the mid 1970s. However, almost all these observations are from the rich developed countries (see Lomborg 2001, chapters 15 and 19).

Few such indications from the poorest countries, including India and China, with together almost one quarter of the world's population. (See Dasgupta et al., 2002; Hettige et al 2000; Stern et al 1996)

[6.18] "Optimal pollution" and deliberate choice

Almost all economic activities have some negative impact on the environment in some dimension. Does anyone want a totally "clean" environment? Take a practical example.

Figure 6.6. Marginal cost of reducing emissions: Clean air in Mexico City



The last 10% reduction may cost as much as the first 90%!

***Source*: adapted and simplified from actual World Bank assessment in the 1980s (Control of air pollution from transport in Mexico City)**

[6.19] Global Warming: Why an economic issue?

1) Increased world production based on fossil energy and emission of CO_2 are closely related – in a <u>long-term perspective</u> (and more recently)

*** World production (GDP) has increased about 17 times since 1900 (Maddison 2003)**

*** Annual emissions of CO_2 (and other greenhouse gases) over the same period have increased 13-fold (IPCC 2007)**

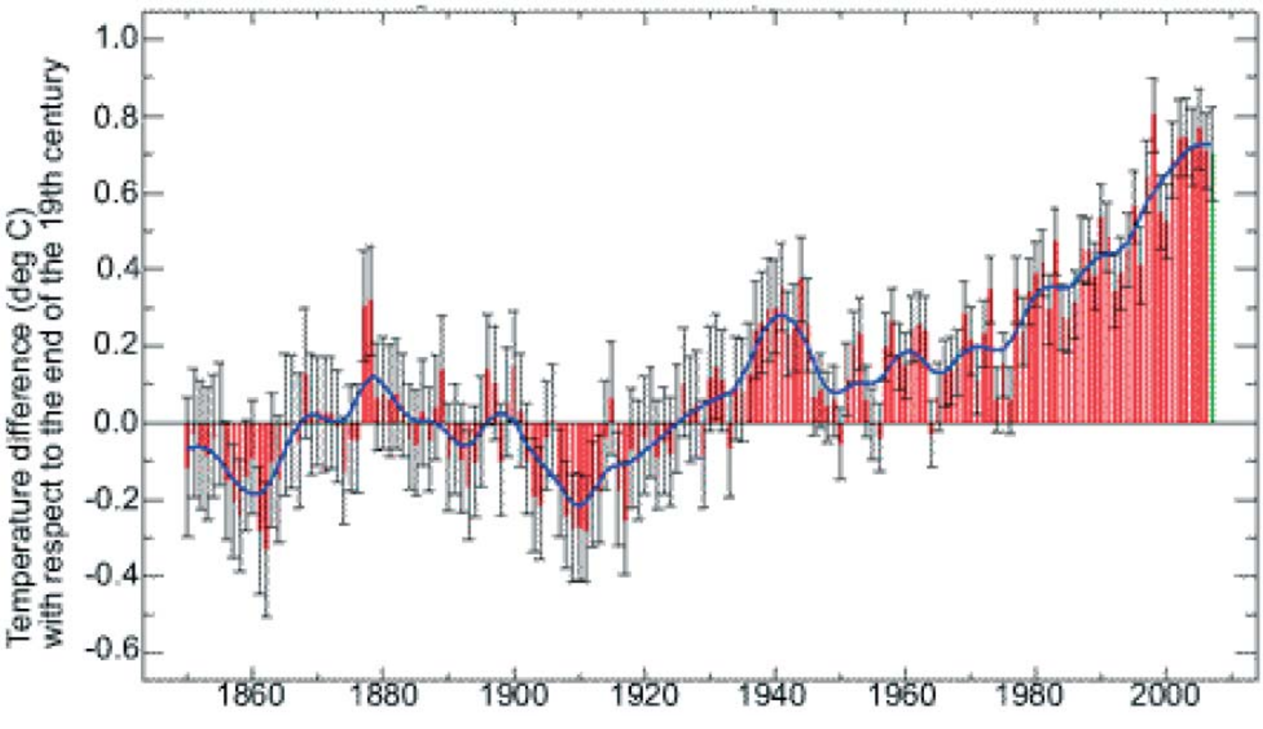
* The **carbon concentration** in the atmosphere has increased over the past 100 years, from about 290 to 385 ppm (particles per million). Ice cores from glaciers indicate that concentration is higher now than at any time during the past 600 000 years **(IPCC 2007)**

*** Global temperature** has increased by 0.6 to 0.8 degrees since the end of the nineteenth century **and is accelerating (OH 6.20)**

2) Projections of future emissions are based on projections of economic growth and sector composition of production that some have questioned

3) "*Unique challenge for economics: it is the greatest and widest ranging market failure ever seen*" (Stern review 2006). Obvious economic remedy: high taxes on carbon emissions?

[OH 6.20] Global temperature increase 1850-2007



[6.21] Global Warming: The Main Threat to Growth and Poverty Alleviation?

In 1994, it was the perceived population "explosion" that many considered the main threat to further growth and poverty alleviation; today it is the global warming that follows economic growth!

Five claims regarding more recent developments from the Inter-government Panel for Climate Change (IPCC, 2007 and the International Energy Agency (IEA 2008):

1) World **annual emission** of carbon dioxide **increased** by 79% between 1973 and 2006 and the increase shows no tendency to slow down (OH 6.22)

2) There is a strong **correlation** between **per capita income and carbon emissions** across countries (OH 6.23)

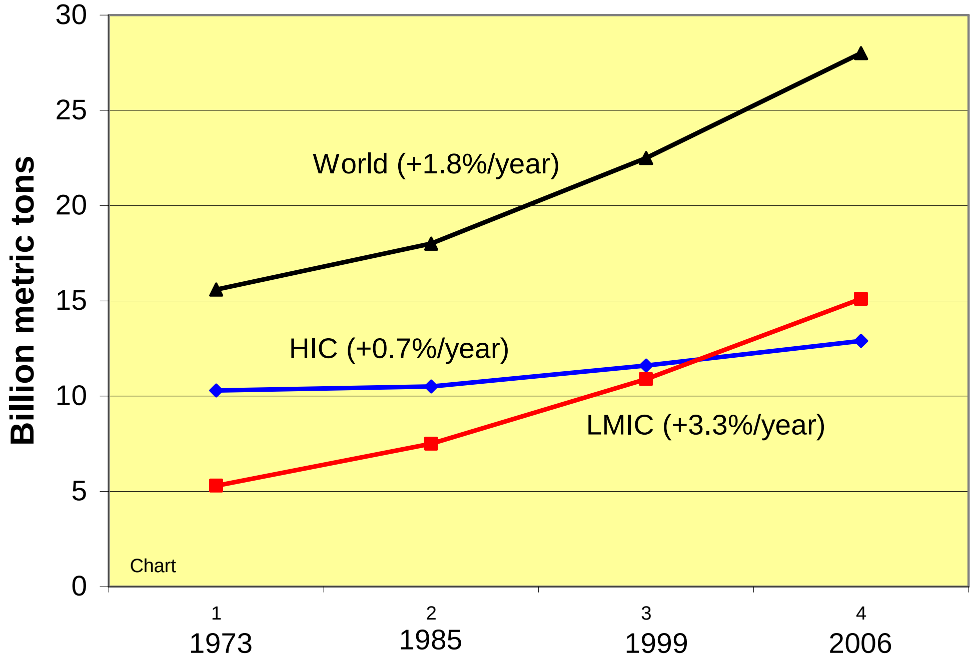
3) The relatively largest **increases** were in **low- and middle income countries**, which now account for more than **half** (54%)of total emissions

4) The share of non-renewable (fossil) in world consumption of energy has declined in the world and in HICs since the early 1970s, but increased in the LMIC) and here coal has increased the most (OH.6.24.a.b)

5) Carbon dioxide emissions **do contribute** to global warming,

but no consensus on by how much! Copenhagen December 2009

[OH.6.22] CO2 emissions, world and by high- and low-and-middle income countries 1973-2006 (billion metric tons per year)



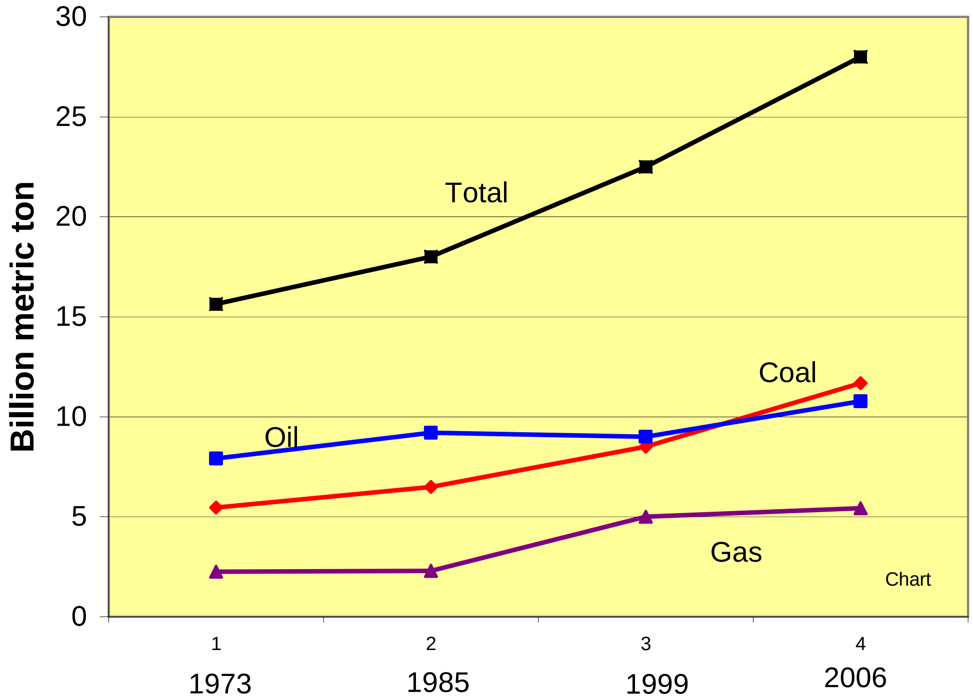
Source: IEA 2008:44

[OH 6.23] Per-capita emissions of CO_2 in world, HIC and LMIC 2006 and annual increase 1973-2006 (tons of oil equivalents per person)

	Per capita emissions 2006 (tons)	Per cent increase per year 1973-2006	Accumulated increase (%) 1973-2006
High income	4.70	0.7	25
Low- and middle income	1.16	3.3	183
World	1.80	1.8	79
Ratio HIC/LMIC	4.05	0.21	0.14

Source: IEA 2008:45 and 49

[OH 6.24] World CO_2 emissions by type of fossil fuel 1973 to 2006 (billion metric ton)



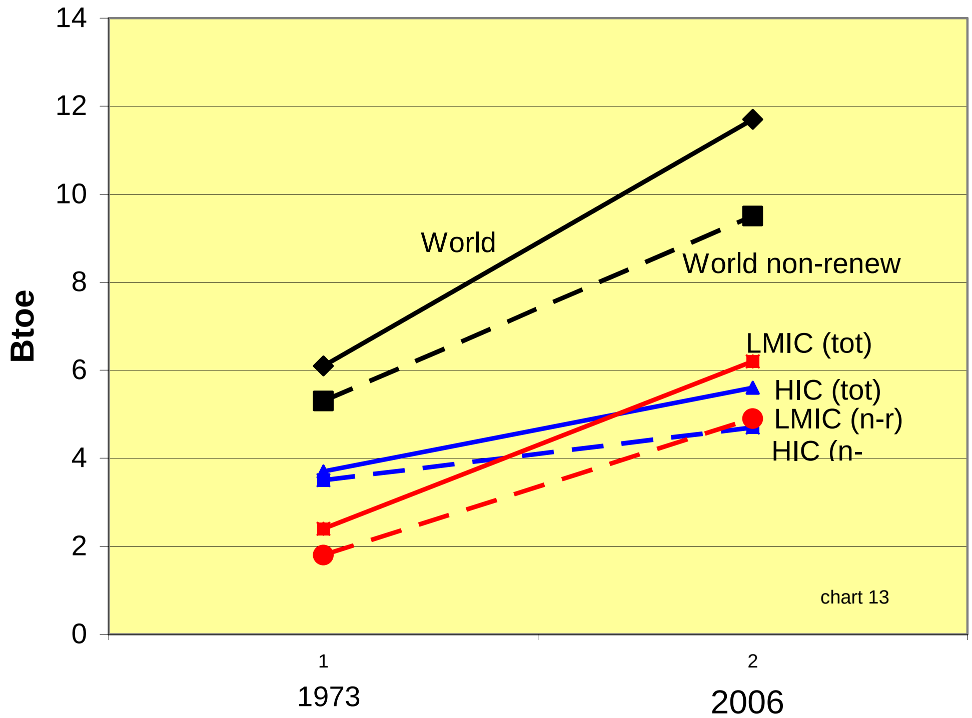
Source: IEA 2008:44

To notice:

No slowdown so far in carbon emissions

Emissions from coal, the dirtiest fuel, has increased the fastest and is now the largest source (China!)

[OH 6.24a] Total primary energy supply (TPES) and from non-renewable sources (fossil) in world and by high- and low-and-middle income countries, 1973 and 2006 (Billion metric ton of oil equivalents)



Source: IEA 2008:8-9

To notice:

1) World TPES doubled over the 33 years, but the share of non-renewable sources declined somewhat

2) TPES from high-income countries increased by 50% and non-renewables' share dropped

3) TPES from LMIC increased almost 3-fold and the share of **non-renewables increased, especially coal** (from 75% to 80%)

[6.25.a] Future global warming: controversial issues

1) Difficult to disentangle man-induced short-term variations in temperature from long-term natural cycles

2) There may be a measurement bias since increasingly more temperature observations are from urban areas which are warmer (because of heating)

3) Although continued real **income and population growth** means more economic activity, the IPCC warming projections are based on unrealistic high future economic growth rates in the now poor countries (4.5%/year).

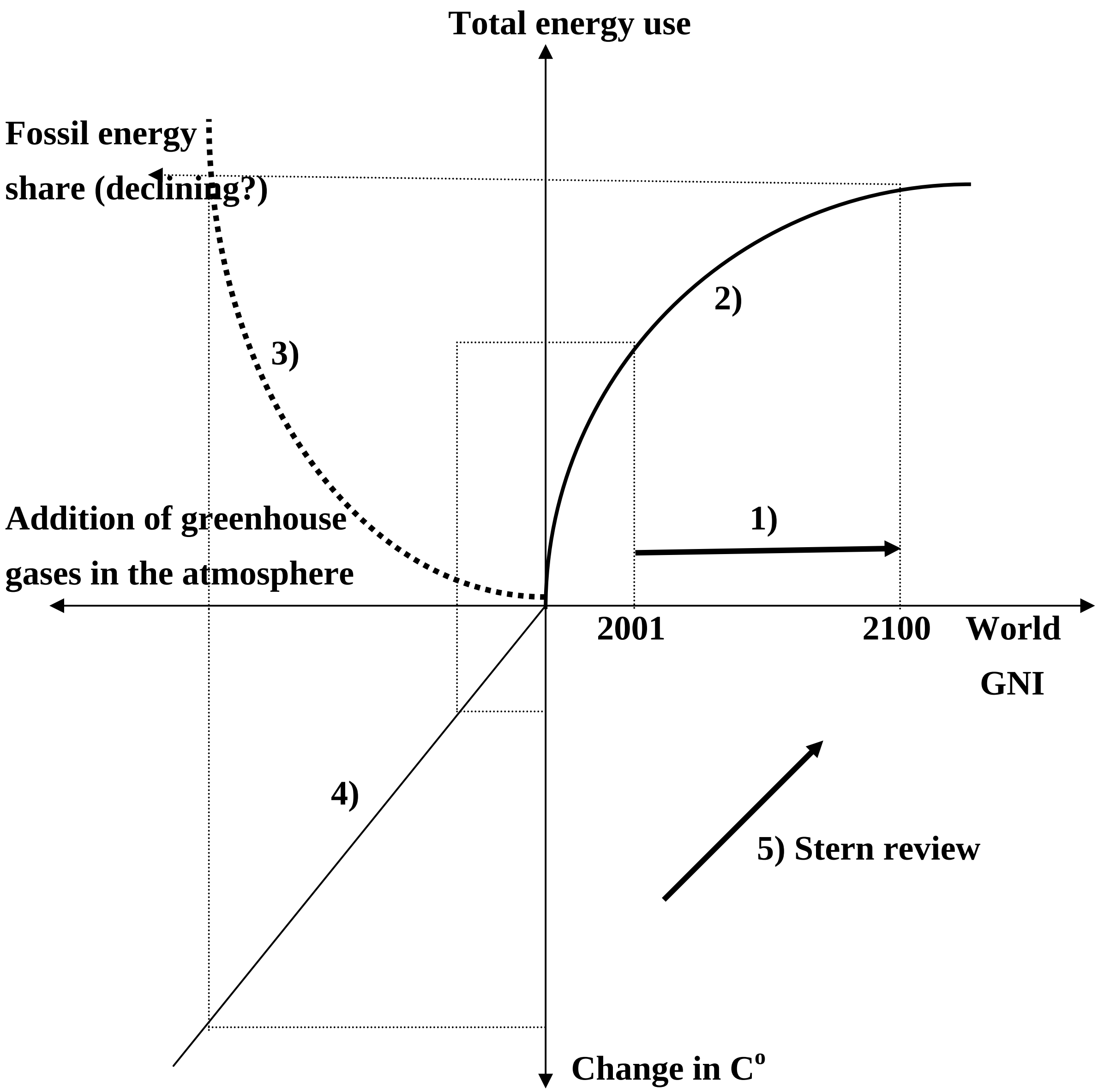
4) The IPCC has not adequately considered the change in **composition offuture growth** (from industry to low-energy intensive service sectors)

5) Regarding the methods for abating greenhouse emissions, many economists argue that the **instruments** used so far are economically inefficient and too short-sighted (mainly tradable emission permits and non-mandatory quantitative reduction commitments (Kyoto)).

6) The emission of greenhouse gases can be reduced **more efficiently** by taxes and subsidies that give incentives for (1) changes in energy **sources**, (2) sector allocation of economic **activities,** and (3) **technological advancements**

[6.25.b] Global Warming (cont'd)

The five main building blocks in the IPCC models can be illustrated with the help of a simple graph



[6.26] Global Warming (cont'd)

Relationship 1: The projected growth rates in real GDP in the "poor" countries.

The IPCC has set up a **normative objective** for growth in the poor countries which in essence is that the **income ratio (gap)** between rich (OECD) countries and the rest of the world should be reduced from a present ratio of 23 to 1.8 by 2100, signifying that by that time, per-capita income in the now poor countries should be about **55% of that in the rich countries**

Some **economists** (e.g. Castles and Hendersen, 2003) argue that this economic growth projection (at 4.3%/year) is unrealistic and way above historical growth rates, hence leading to exaggeration of global warming

Considering, however, that over the past 20 years, both China and India, as well as a large number of other countries, with about **two-thirds** of the **population** in the developing countries, have experienced growth well above 5% per capita, the sceptical economists may have to reconsider!

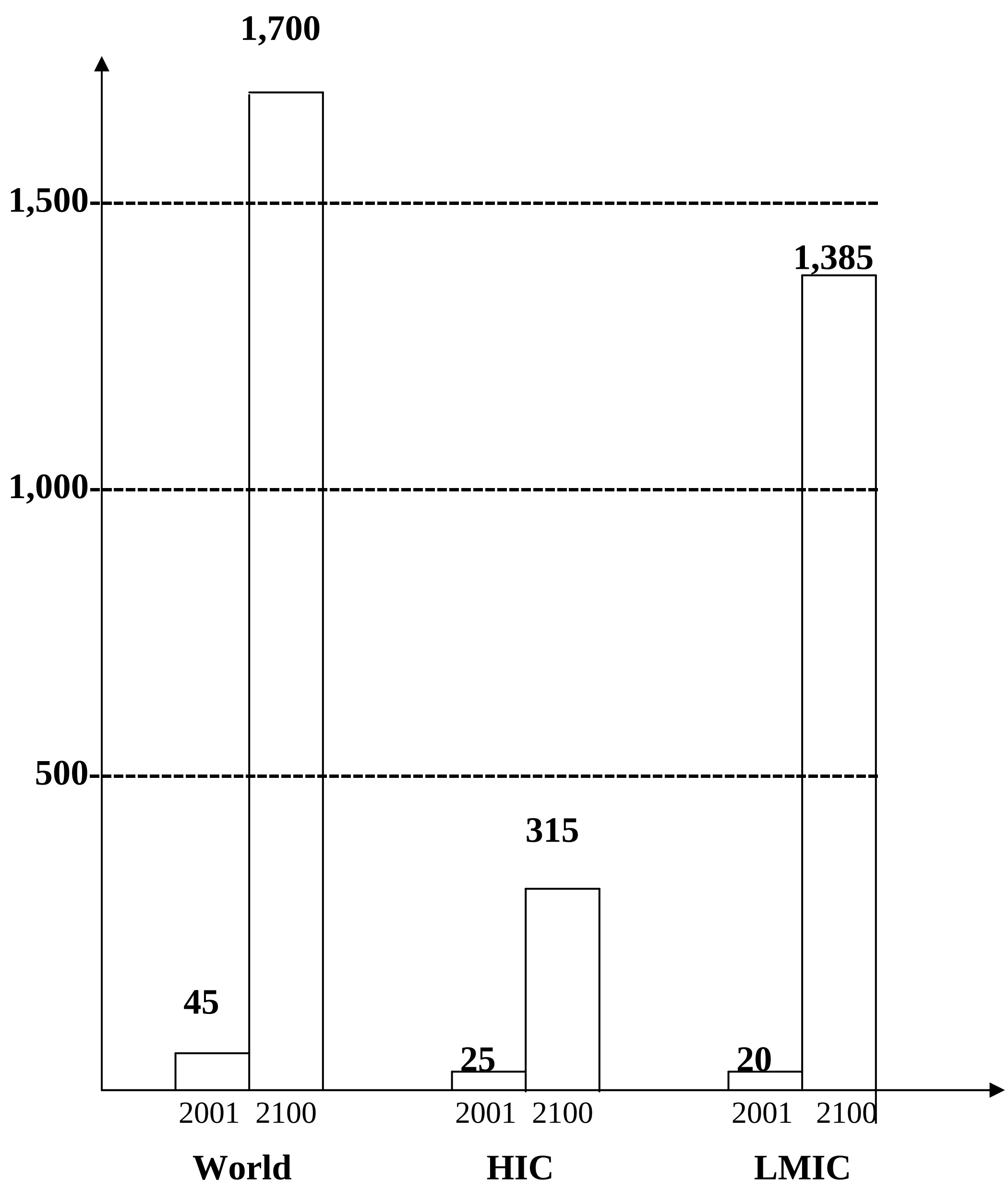
(Also see OH slide in lecture 4 on World Bank vs. population weighted recent growth rates)

The IPCC projections of growth in total world GDP is nevertheless drastic indeed (see next slide)

[6.27] Global Warming, relationship 1 (cont'd)

IPCC's projection of the World Economy in 2100

GNI (trillion $PPP in 2001 prices)



Ratio **38** **12** **69**

[6.28] Global Warming (cont'd)

Relationship 2: World GDP growth and energy use

This relationship is depicted as concave, i.e. the "total energy intensity" in production in **declines** over time as countries becomes richer, due to:

(i) **technology improvements** in energy use and

(ii) **sector re-allocation** of economic activity.

The latter mechanism is bound to be different in rich and poor countries for at least some decades.

---- In **rich** countries, an increasing share of economic activity is likely to take place in service sectors that have low energy intensity

---- In the **now** poor countries, but rapidly growing, e.g. India and China, the increase in economic activity is bound to be concentrated to industry and agricultural sectors with high energy intensity.

--- It is hence not certain that the relationship will be "very" concave.

Over the past two decades, huge improvements in reducing energy use have been made and more can most likely be done through economic incentives, taxes and subsidies, regulations, many economists argue.

[6.29] Global Warming (cont'd)

Relationship 2: Energy intensity in production 1980-2004

Table 6.8. Carbon Dioxide Emission per $PPP of GDP (kilo)

	1980	**2004**	**Change (%)**
World	**1.1**	**0.5**	**-55**
High income	**1.2**	**0.4**	**-67**
Low-and middle income	**1.0**	**0.7**	**-30**
Upper middle income	**0.7**	**0.6**	**-14**
Low middle income	**1.6**	**0.8**	**-50**
Low income	**0.6**	**0.7**	**+17**

Source*: *World Development Indicators 2003 and 2008

Main conclusions: world-wide, (fossil) energy **efficiency** in production has more than doubled in the period 1980-2004.

But the main reduction was in high-income countries; increased in the low income countries

Notable is that the overall decline has taken place during a period of relatively low oil prices ($20-40 /barrel). Recently the oil price peaked (at $147 in June 2008) and is now down to < $50

[6.30] Global Warming (cont'd)

Relationship 3: **Sources of energy use and emission of greenhouse gases**

Also this relationship is depicted as **concave** on the presumption that there will be **substitution** towards **renewable** energy sources (nuclear, hydropower, solar, wind, etc), away from fossil ones.

In many countries, taxes and subsidies have already been used to provide incentives for investments in "cleaner" energy sources, away from burning fossil energy.

It is also notable that ***if*** the huge price increases in oil and gas witnessed over the past years signal increased scarcity, there will be a market-initiated price incentive for switching to renewable energy resources

However, the switch so far away from fossil energy has been slow!

(cf. table on next slide)

The relationship between burning fossil energy and the accumulation of greenhouse gases in the atmosphere is strong, but not one-to-one. Some of the carbon dioxide is absorbed by growing vegetation (but…) and some by the oceans (with other marine environmental problems). No viable methods yet for storing or disposing of carbon dioxide!

[6.31] Global Warming; Relationship 3 (cont'd)

Along with improved energy efficiency in general, and a decline in the emission of greenhouse gases in relation to GNI, the **use of fossil energy as a share of total electricity generation** has dropped, but only **marginally**!

	High income countries		Low/middle income countries		World		
	1980	**2000**	**1980**	**2000**	**1980**	**2000**	**Change**
Hydropower	**(18)**	**12**	**24**	**24**	**21**	**17**	**-4**
Nuclear	**(18)**	**(32)**	**3**	**6**	**9**	**17**	**+8**
Fossil	**63**	**55**	**74**	**70**	**71**	**64**	**-7**
Coal	**39**	**38**	**21**	**40**	**33**	**39**	**+6**
Oil	**18**	**6**	**49**	**10**	**29**	**8**	**-21**
Gas	**6**	**11**	**4**	**20**	**9**	**17**	**+8**
Other	**1**	**1**	**-**	**-**	**-**	**1**	**+1**
Total	**100**	**100**	**100**	**100**	**100**	**100**	**-**

***Source*: *World Development Indicators, 2003,* table 3.8**

NB. Coal burning, which emits more greenhouse gases than oil (per energy equivalent), has increased in the low and middle income countries at the expense of oil.

[6.32] Global Warming (cont’d)

Relationship 4: On the fourth main link in the IPCC models, i.e. the relationship between **increased concentration** of greenhouse gases in the atmosphere and **increased ground temperature**, economists have little of substance to say.

Climatologists and other natural scientists have identified a myriad of both **“warming” and “cooling” effects** of increased greenhouse gases in the atmosphere. Some examples!

Warming:

* **Basic mechanism**: greenhouse gases reduce the solar heat that is reflected back to the atmosphere

* **Melting of the ice caps** in the Artic and Antarctic means larger darker surfaces (open water) that absorb more heat than white ones (ice)

* Huge amounts of **metan** and other gases that are now bound in the perma-frost areas (e.g. Siberia), will be released if the temperature goes up, signifying additional greenhouse gas emissions

[6.33] Global Warming, relationship 4 (cont'd)

Cooling effects

* Change the strength of **ocean currents**, e.g. slow the Gulf-stream that warms up northern Europe

* Burning fossil energy means greenhouse gas emissions, but also **emissions of sot and other small particles** into the atmosphere, which reduce the radiation of heat from the sun

* The spread of deserts and reforestation means more "light" surfaces on earth that increases the out-radiation of heat into the atmosphere

These are only a few of the **hundreds of warming and cooling mechanisms** that natural scientists have identified and integrated into their climate models. Each mechanism has to be modelled (imperfectly) and "parameterised" on the basis of **shaky data**. It is hence not surprising that the IPCC does not produce a definitive number on the projected temperature increase, but rather a range, from 2 to 4,5 degrees Celsius. Almost all seem to agree, however, that the warming effects dominate the cooling effects.

Projected effects will also vary geographically and in some parts of the world, there may be net benefits from a warmer climate (Sweden?), while in others the consequences are likely to be dire (Bangladesh).

[6.34] Global warming, Relationship 5 (cont'd)

Consequences of global warming for economic growth

The most noticed estimates of (dire) economic consequences are found in the **Stern review** (December **2006**). Main claims:

1) The overall costs and risks of climate change will be the equivalent to losing between **5 and 20% of global GDP per year**, now and forever – if no drastic reduction of greenhouse gases comes about.

2) The **poorest countries** will suffer earliest and the most due to more extreme weather, including floods, droughts and storms.

3) The **costs** of reducing global warming drastically are significant, but **much smaller** than the **benefits** incurred.

[6.35]   Economists' critique of the Stern review

1) The **future benefits** from early action to drastically reduce greenhouse emissions are hugely **overestimated** because of very **low discount rate** of future gains is used **(0.1%)**   3-6% standard!

2) **Future costs** in terms of lower food production, ill health, and weather-inflicted disasters **overestimated** because no allowance is made for **adaptation** to warmer climate is included in the calculation

3) **Underestimation** of the **immediate costs** of drastic action to reduce greenhouse gases in terms of lower present consumption, disrupted production and "transition" costs

4) The claims on the relative impact of climate change of poor vs rich countries is not based on **analysis and data**, just loose statements!

5) The handling of "fat tails" not convincing (low risk of even larger temperature increases)

6) Overall, the analysis is out of line with the **scientific literature**!

The heated debate about heat will no doubt continue!

[6.36] Further critique

7) The Stern Review (and IPCC and most other evaluations of economic consequences) take a partial approach, e.g. effects are estimated on specific sectors, agriculture, water supply, migration, etc, and then these are added up in some way.

Very recent studies (Dell et al 2008) have used a different approach. They have estimated year-to-year changes in the temperature and economic growth on a cross-country (panel) basis.

Findings:

1) In years with above normal temperature, growth tend to be lower, but only in poor countries (GDP/C < $3,800 PPP).

2) Negative effect not only in agriculture, but also in industry and on aggregate investment.

3) The estimated effects are large: A 1 grade higher temperature (C) is followed by a 1.1% point reduction in growth. Long-term consequences drastic.

A number of controls and robustness tests were conducted, signifying that the results seem to be plausible and trustworthy.

Paper available: www.iies.su.se/seminars/

[6.37] Global warming: summary

Drastic assumptions made by the IPCC?

1) Takes a **very long perspective** (100 years), which may seem unscientific considering the huge uncertainties regarding technology developments

2) Much of the critique of the IPCC has been focused on allegations that the Panel has based its projections on:

--- Very "optimistic" assumption regarding economic growth, i.e. a **70-fold increase in economic activity** in the now poor countries and a **12-fold** increase in the now rich countries

--- Very "pessimistic" assumption regarding technology advancements for reducing the use of fossil energy

3) There is little doubt something to this critique, but the Panel's task is to provide projections for scenarios of what will happen *if* nothing drastic is made to reduce burning fossil energy. The projected scenarios may thus provide incentives for policy makers to step up the use of taxes/subsidies and regulations to facilitate a more rapid switch to renewable energy and to improve energy efficiency in economic activities in general.

4) Whether global warming will be a major threat to continued development in the now poor countries depends on too many uncertainties to really be possible to have a definitive opinion on

Literature to be read:

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McKibbin, W.J. and P.J. Wilcoxen (2002), “The Role of Economics in Climate Change Policy”, *Journal of Economic Perspectives* 16(2): 107-29.

Stern report (2006) Executive summary (search on Google)

Svedberg, P. and J. Tilton (2006), “The *Real*, Real Price of Non-Renewable Resources: Copper 1870-2000”, *World Development*, 34(3):501-19.

Literature referred to in lecture:

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Maddison, A (2003), *The World Economy: Historical Statistics*, Development Centre Studies, Paris: OECD.

Met Office (2008), Clearer: make a difference with the facts about climate changes (look up on Googles).

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Song, T et al (2008), “An Empirical test of the environmental Kuznets curve in China: A panel cointegration approach”, *China Economic Review* 19: 381-92.

Stern D.I. et al (1996), "Economic Growth and Environmental Degradation: The Environmental Kuznets Curve and Sustainable Development", *World Development* 24(7): 1151-1161.

Thirlwall, *Growth and Development,* ch 11.

***Further recommended readings*:**

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Titlton, J. (2003), *On Borrowed Time: Assessing the Threat of Mineral Depletion*, RFF Press, Resources for the Future.