ECONOMIC SUSTAINABILITY

LESSON OBJECTIVES

01

Define Economic Sustainability

02

Explain and Analyze Economic Sustainability

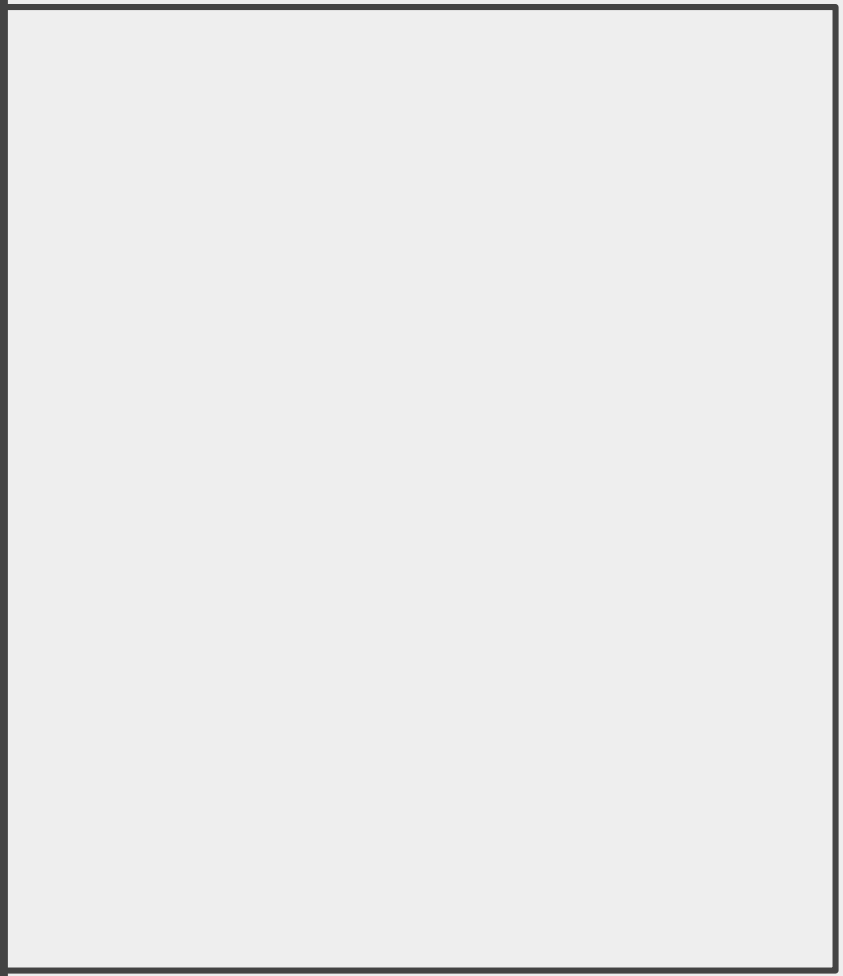
03

Explain and Analyze Green Accounting

So far have focused on micro-economic environmental problems

- With minor exceptions like labor markets

What about macro-economics and the environment?



01

DEFINING ECONOMIC SUSTAINABILITY

VISIONS OF THE FUTURE

MALTHUS

Thomas Malthus, writing in 1798, argued that humankind was destined to live at the subsistence level—the minimum level of income per person necessary to survive.

According to the **Malthusian cycle**, any increase in income per capita above the subsistence level would lead to higher fertility rates.

STANLEY JEVONS

Stanley Jevons – English Economist

- In 1865, predicted coal would be exhausted in under 100 yrs
- What happened?

Recall this was a problem with the production-to-reserve ratio measure that fueled the US Energy Crisis in the 1970s.

MIT MODEL

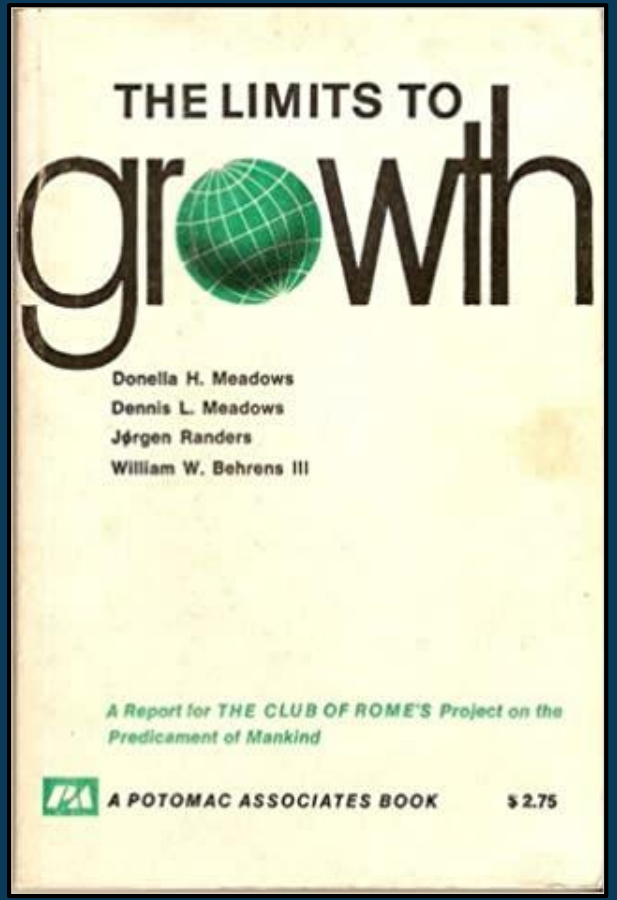
In early 1970s MIT researchers developed a model to simulate likely future outcomes for the world economy

Assumptions:

- Exponential economic growth
- Fixed resource stocks
- No substitution between non-renewables and other inputs
- No changes in world's institutions
- No technological change

Found two outcomes:

1. Severely restrict economic growth to prevent collision with Earth's natural limits
2. Global Economy would collapse within 100 years.



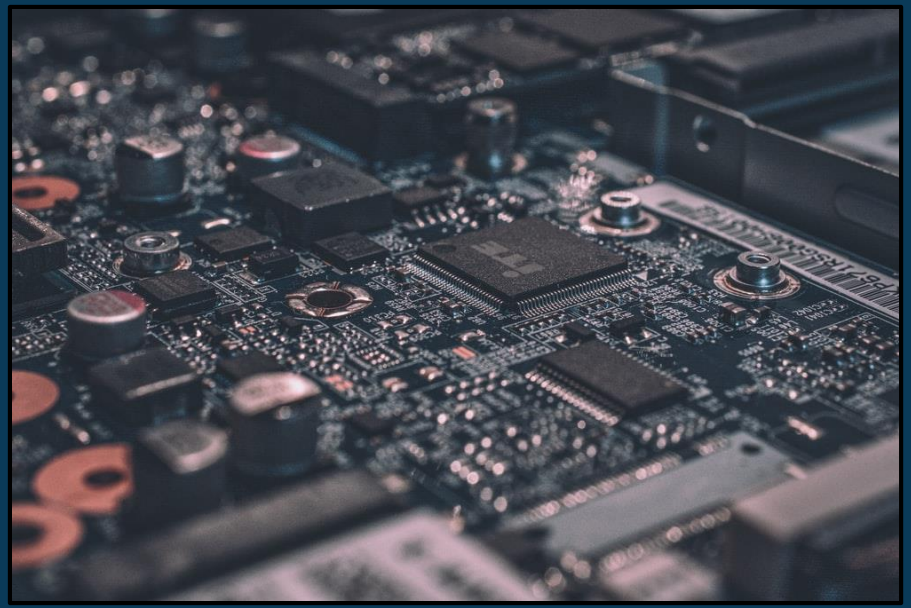
COUNTER ARGUMENT

Technology change will outpace the small drag on economic growth from resource scarcity

We know that resource prices will reflect scarcity.

- Remember definition of scarcity

As resource depletes, there is incentive to substitute or innovate



PAUL EHRLICH VS. JULIAN SIMON

There have been attempts to assess the scarcity of nonrenewable resources over time through prices

- As a resource becomes more scarce, price should increase

In 1980, Economist Julian Simon made a bet with biologist Paul Ehrlich

- Ehrlich was to pick any 5 metals worth a combined $1,000
- If the inflation-adjusted prices were higher than the initial value in 10 years, Ehrlich would receive payment for the difference
- If the prices declined, Ehrlich would pay Simon
- Simon received a check for $576.07

Why is scarcity not increasing?

- Technological change and substitution

Table 11.1
Reserves-to-Production Ratios for Petroleum, 1980–2013

Year	*Ratio (years)*
1980	28
1985	32
1990	41
1995	39
2000	36
2005	41
2010	42
2013	50

Source: Calculated by the authors from data published by the U.S. Energy Information Administration, "International Energy Statistics," available at http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm, accessed February 11, 2015.

EFFECT OF SCARCITY ON ECONOMIC GROWTH

Source of drag	*Impact on world growth rate, 1980–2050 (percent)*
Market goods	
Nonrenewable resources	
Energy fuels	–0.16
Nonfuel minerals	–0.03
Renewable resources	
Land	–0.05
Environmental goods	
Global warming	–0.03
Local pollutants	–0.04
Total	**–0.31**

Source: Adapted from William D. Nordhaus, "Lethal Model 2: The Limits to Growth Revisited," *Brookings Papers on Economic Activity* (2): 1–59 (1992), table 3, p. 31.

Theory suggests that scarcity of natural resources over time should have a dragging effect on economic growth.

There have been several attempts to capture these scarcity impacts.

Nordhaus (1992)

- Examined influence of select nonrenewable and renewable resources on economic growth.
- Estimates scarcity of resources could slow global economic growth by combined 0.31%/yr between 1980 and 2050

EFFECT OF SCARCITY ON ECONOMIC GROWTH

Weitzman (1999)

- Estimates scarcity of fourteen minerals important to economic growth causes a decrease in global consumption of about 1%/yr
- Estimates the positive impacts of technological change to be about 40x the negative impact of resource depletion.

Evidence supports optimistic view that nonrenewable resource scarcity will not be an obstical to continued economic growth

Economists have repeatedly predicted a doomsday scenario.

- Concerns over carrying capacity of Earth
- Concerns over the depletion of natural resources.

PROBLEM

Can we sustain our economy and environment?

HOW DO ECONOMISTS DEFINE SUSTAINABILITY?

PROBLEM

Can we sustain our economy and environment?

How should we treat future generations?

What is fairness?

What is the equity/efficiency trade-off?

BUT FIRST…

How do we define sustainability?

How can economists think about sustainability?

SUSTAINABILITY

UN World Commission on Environment and Development 1987

"Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

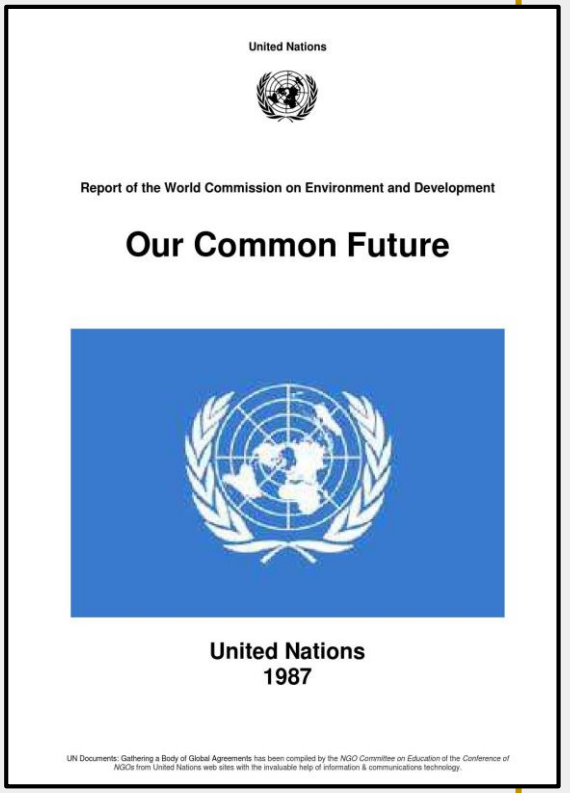
Great!...well, maybe?

In 1991, Robert Solow gave an economic definition of sustainability in a lecture at the Woods Hole Oceanographic Institute

Solow 1991

Leave to future generations "the capacity to be as well off as we are today"

Must avoid "enriching ourselves by impoverishing our successors"



SUSTAINABLE ECONOMY

What does this all mean?

Solow is saying that we don't need to preserve specific resources!
Treating a resource as natural capital, if it is extracted, we must use the gains to create enough capital of other forms to replace the lost value.

- Allows for substitutability of different forms of capital
- If we deplete one, we must increase another at a **greater** rate

A **sustainable economy** is one that allows people's well-being to increase over time.
Sustainable development is based on the notion that current generations should be free to pursue their own well-being as long as they do not harm future generations in the process.

- This may remind you of our Pareto Efficiency Criterion!
- More on this later.

SUSTAINABILITY, SUBSTITUTION, AND TECHNOLOGICAL CHANGE

So this definition of sustainability meshes with our stories of avoided doomsday scenarios.

We saw that while resources were extracted, there was substitution and technological progress that allowed future generations to be at least as well off.

Economic definition of sustainability depends on substitution and technological progress

- If a good has no substitutes and is highly valued, then its depletion is not consistent with Solow's definition of economic sustainability

Most resources have a substitute, though the degree of substitutability varies

- Fresh water has a substitute in saltwater, but it may require desalination
- Not a perfect substitute, but still a substitute

02

ANALYZING ECONOMIC SUSTAINABILITY DEFINITION

PROBLEMS WITH DEFINITION OF ECONOMIC SUSTAINABILITY

PROBLEMS

Solow gives us an economic definition of sustainability?

<u>But, it comes with its own problems:</u>

Need significant information about the future

- Tastes and preferences of future generations
- Future technologies that will be available

Often sustainability problems must project far into the future where there is significant uncertainty

- Think of what people in 1900 predicted for life in 2000!
- Things change rapidly and it is difficult to forecast.

Solow gives us an economic definition of sustainability?

<u>But, it comes with its own problems:</u>
Often sustainability problems must project far into the future where there is significant uncertainty

What discount rate should we use?

- Market rate?
- Intergenerational social discount rate?

Makes Solow's definition still not particularly usable.
But if we act in expectation perhaps we will get close.

PROBLEMS

	Present value of $1,000			
	T years from now			
Discount rate	*T* = 10	*T* = 50	*T* = 100	*T* = 200
1%	$905	$608	$370	$137
2%	$820	$372	$138	$19
3%	$744	$228	$52	$2.7
5%	$614	$87	$7.6	$0.06
7%	$508	$34	$1.2	$0.001
10%	$386	$8.5	$0.07	$0.00001

INSIGHTS FROM ECONOMIC DEFINITION OF SUSTAINABILITY

GETTING PRICES RIGHT

The first insight we can draw from our economic definition of sustainability is that dynamic efficiency is a necessary condition.

Prices act as a signal for the economic value of a good, service, or natural resource amenity

- Its value in use
- Opportunity cost of consumption (including relative scarcity)

If firms and consumers do not internalize and bear the true costs and benefits from production and consumption, on aggregate, there will be a reduction in welfare.

- Dynamic efficiency is a necessary condition
- Again must invest rents rather than consume

TWO-PERIOD EXAMPLE (REVISITED)

Setup:
Two periods: Today and tomorrow
Demand for oil: P = 10 – 0.5Q
MC of oil extraction: MC= $3
Discount rate = 10%

Solution:
$q_1^* = 10.19$ barrels
$q_2^* = 9.81$ barrels

$$PV(MB_1 - MC_1) = PV(MB_2 - MC_2)$$

$$10 - 0.5q_1 - 3 = \frac{1}{1+r}(10 - 0.5q_2 - 3)$$

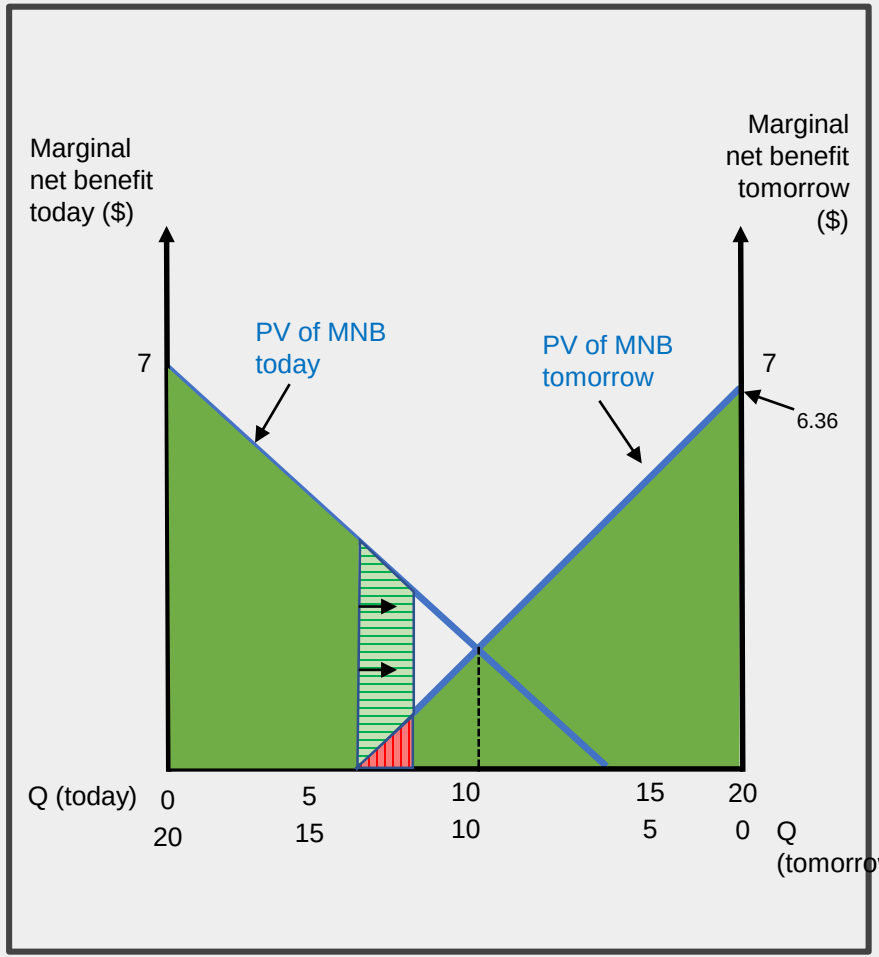
$$10 - 0.5q_1 - 3 = \frac{(10 - 0.5(20 - q_1) - 3)}{1+r}$$

$$7 - 0.5q_1 = \frac{0.5q_1 - 3}{1 + 0.1}$$

Why don’t we just split it 10 barrels today/10 barrels tomorrow?

We know there is a time value of money.

So how do we know 10.19 barrels today/9.81 barrels tomorrow is the efficient extraction path?



When resources are limited, consumption today comes at a cost of forgone consumption tomorrow

The present value of those costs give us the marginal user cost (MUC), or scarcity rents

The difference between P and MC measures the scarcity rents
In period 1 the MUC = $1.905
In period 2 the MUC = $2.095

Scarcity rent rises over time as resource becomes scarcer

WHY DOES P≠MC?

$q_1^* = 10.19$ barrels, $q_2^* = 9.81$ barrels

What about price? P = 10 – 0.5Q
$p_1^* = \$4.905$, $p_2^* = \$5.095$

But MC=$3? What happened?

We must get prices right to be *economically* sustainable.

As we have seen, in many environmental problems, there are externalities and other sources of market failure.

Thus, it is unlikely economic growth will be sustainable without policies to correct sources of market failure.

IMPLICATIONS FOR ENVIRONMENTAL POLICY

SUSTAINABILITY AND INTERGENERATIONAL EQUITY

INTERTEMPORAL EQUITY

How much should we leave for future generations?
What is the appropriate rate of discount?
How do we make decisions for a group of people who are not around to negotiate for themselves?
Sustainability criterion: future generations should be left no worse off than current generations and should perhaps be left better off.

ARE EFFICIENT ALLOCATIONS FAIR?

A dynamic efficient allocation will not automatically satisfy the sustainability criterion, but is not necessarily inconsistent with sustainability.

- With a discount rate greater than zero, an economically efficient allocation will allocate more of a resource to the first period than the second. Net benefits will be greater in the first period than the second.
- The sustainability criterion can still be met if the first period sets aside sufficient net benefits for the second period.

SUSTAINABILITY AS PARETO EFFICIENCY

Recall our definition of Pareto efficiency

- Make at least one better-off without making anyone else worse-off

Sustainability is Pareto efficiency across generations!

- If a resource is depleted, it will result in a a net gain or loss to future generations
- If it is a loss they must be compensated

Generally, evidence suggests we are better off than those who came before us.

- Suggests previous generations were “too generous”
- Intergenerational vs. intragenerational equity

INTERGENERATIONAL VS. INTRAGENERATIONAL EQUITY PARADOX

We consider the expenditure of large sums today to "purchase" a climate less impacted by greenhouse gas emissions **tomorrow**.

Could we use that money instead to raise the living standards of the poor **today**?

Future beneficiaries of climate change action will be residents of developing countries **tomorrow**.

But those residents are likely to be wealthier than residents of those countries **today**.

Due to this tradeoff, we could think of these policies billing poor residents **today** to improve welfare of wealthier residents **tomorrow**.

There is a trade-off!

EVALUATING SUSTAINABILITY

SUSTAINABILITY CRITERION

Weak sustainability: requires that the value of the stock of *total* capital is maintained.

Weak sustainability suggests that resource use by previous generations should not exceed a level that prevents future generations from achieving at least the same level of well-being.

Strong sustainability: requires that the value of the stock of *natural* capital is maintained.

- Assumes that there is little or no substitution between physical and natural capital.

Environmental sustainability: Requires that certain physical flows of certain individual resources (such as a fishery or a mineral) be maintained.

Thus, maintaining the value of an aggregate such as natural capital or physical capital is not sufficient.

PROBLEM

How do we apply the sustainability criterion?

APPLYING THE SUSTAINABILITY CRITERION

As we discussed, the sustainability criterion is going to be difficult to implement

- It requires knowing something about the preferences of the future generation.
- What discount rate should we use?

So, is there a different criterion we could use?
Yes!
A more operational criterion is called "Hartwick's Rule."

HARTWICK'S RULE

Hartwick's Rule suggests that if all scarcity rent is invested in capital, then a constant level of consumption could be maintained in perpetuity.

- If all scarcity rent is invested in capital, the value of the total capital stock will not decline.
- If the principal or the value of total capital is declining, the allocation is not sustainable.

Total capital is defined as physical capital plus natural capital. These are assumed to be substitutable under Hartwick's Rule.

- Physical capital consists of buildings, equipment and infrastructure.
- Natural capital refers to environmental and natural resources.

The usefulness of Hartwick's Rule depends on how substitutable physical capital and natural capital are.

HARTWICK'S RULE IN THE WILD

1960s: oil deposits discovered in the North Sea.
1980s: oil prices made extraction of the oil economically feasible.

<u>UK and Norway began extraction</u>

UK:

- Rapidly extracted and levied a substantial tax
- Revenues were used to support consumption levels and lift the country out of a long economic recession

Norway:

- Tax revenues from oil companies extracting and royalties for licenses to explore went into the fund
- Goes into a Petroleum Fund setup in 1990
- .Fund is owned by citizens of Norway and administered by the Norwegian Central Bank
- By February 2015, the value of the fund was more than $6.5 trillion.
- Uses the fund to offset taxes and pay for public projects

HARTWICK'S RULE IN THE WILD

Others have followed in this approach.

Alaska Permanent Fund (1976)
- Funded by oil revenues in Alaska
- Pays a dividend to residents (reached $2,000 in 2015)

Botswana
- Diamond extraction
- Has helped grow from one of the poorest countries in 1966 to a "middle income" country

RESOURCE CURSE

Other resource rich areas have fallen victim to the "curse of natural resources"

- "Countries with greater natural resource wealth grow more slowly than resource-poor countries" (Sachs and Warner, EER 2001)

<u>What causes this?</u>

Underinvestment in developing human capital

Rent-seeking behavior

Corruption

Dutch disease

- Inflow of foreign funds, which appreciates the national currency and makes other exports less competitive

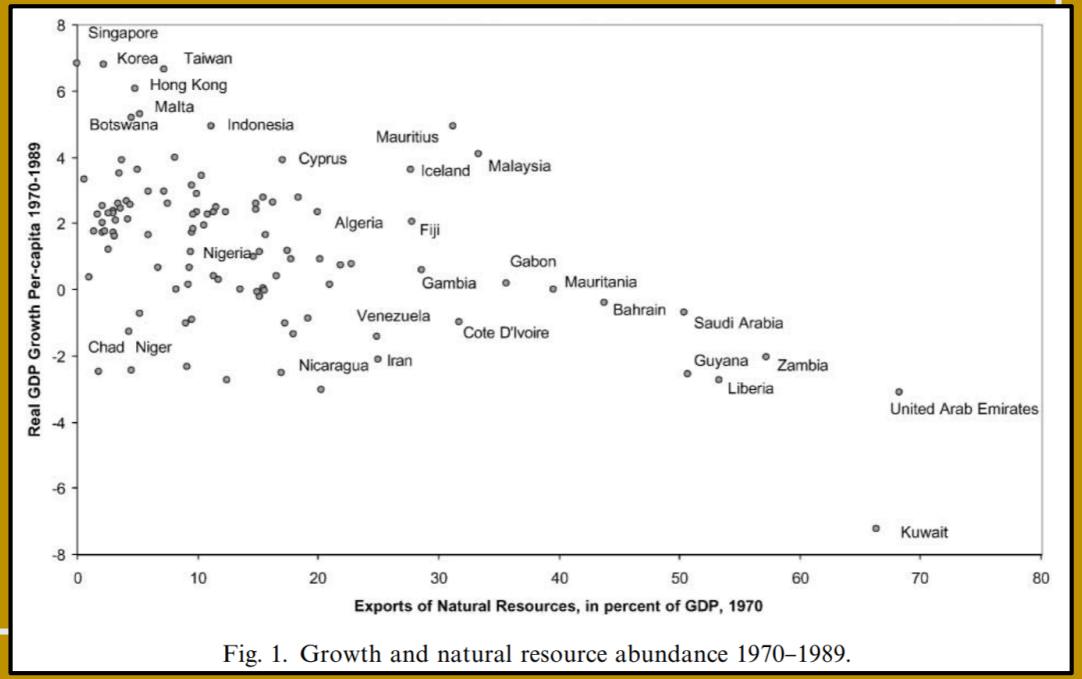


Fig. 1. Growth and natural resource abundance 1970–1989.

03

GREEN ACCOUNTING

TRADITIONAL MEASURES OF ECONOMIC GROWTH

How does the environment and sustainability fit in with our typical measures of economic growth?

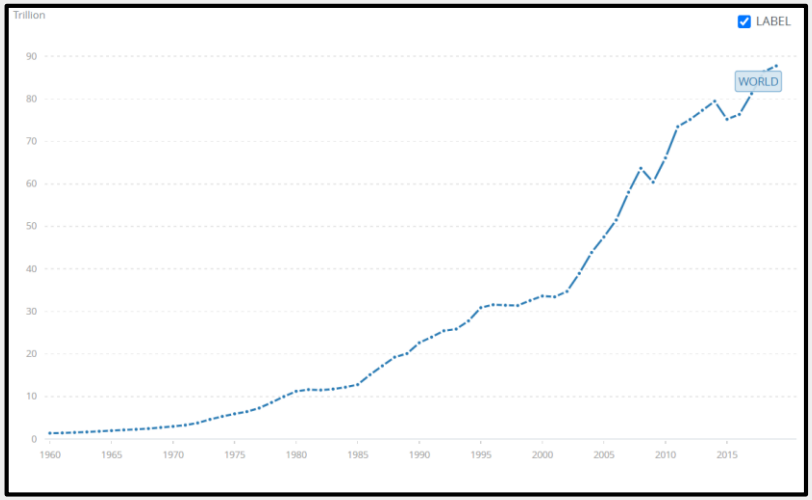
Gross Domestic Product (GDP):
- Goods and services produced within a county

GNP
- Goods and services produced by a country's nationals

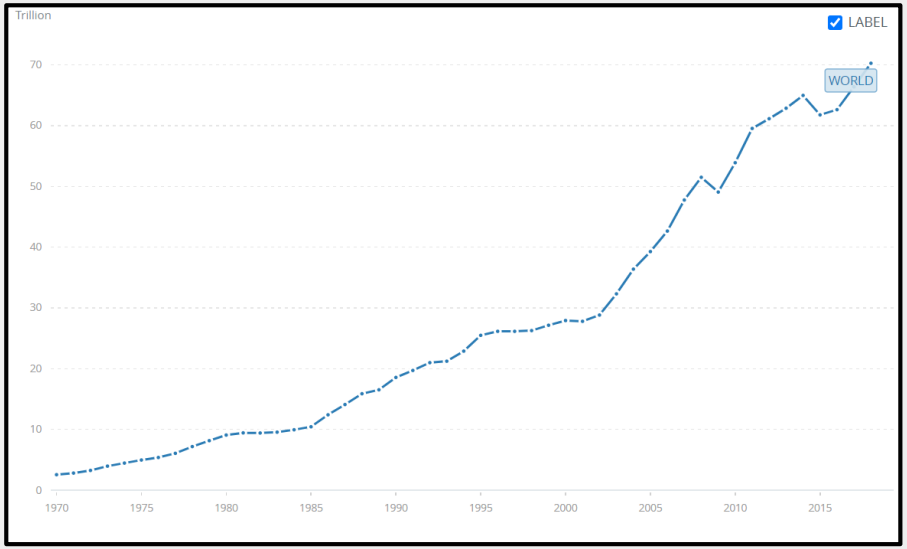
NDP
- GDP minus capital depreciation

NNP
- GNP minus capital depreciation

World GDP



World NNP



PROBLEMS WITH MEASURES OF ECONOMIC GROWTH

Do any of those sound like they would be a good way to measure if the world's (or a country's) total capital stock?

Well NNP sounds good!

- Measures gains net of costs

But there's a problem…
Traditional measures of economic growth exclude nonmarket activities

- Household production (cooking, cleaning, child care, etc.)

What about the value of environmental stocks?
Often these are nonmarket!

PROBLEMS WITH MEASURES OF ECONOMIC GROWTH

This problem was recognized when Simon Kuznets developed the measures.

- Never intended the measure to be used as a measure of social welfare

Pigou noted: “If a man marries his housekeeper or his cook, the national income is diminished”.

Say an oil owner pumps and sells the remaining oil in a well.

- Sale value added to NNP
- Capital depreciation subtracted from NNP
- What about the value of oil no longer under the ground?

PROBLEM

We've said that natural resources should be treated as a capital asset.

But often these resources are excluded from measures of economic growth!

SOLUTION?

Could we change our measures?

CAN WE CONSTRUCT A NEW "GREEN" MEASURE OF ECONOMIC GROWTH?

CAN WE CONSTRUCT A DIFFERENT MEASURE?

Green NNP

Two Yale economists tried this in the 1970s

- Incorporated traffic, crime, and some natural resource depletion
- Found growth per capita of less than half the traditional measure between 1929 and 1965

In 2012, the UN developed an accounting framework for natural capital.

- The US tried to incorporate resource depletion in 1994 but was opposed by congress

A NEW MEASURE OF ECONOMIC GROWTH

Traditional measure of economic growth do not include non-market values. Many environmental goods and services lack markets and are thus excluded. Could we construct a new measure?

Yes! But, let's discuss why we often don't…

1. Its hard – nonmarket values are hard to measure
2. Traditional measures, though not perfect, are often correlated with a comprehensive measure

IS ENVIRONMENTAL QUALITY A NORMAL GOOD?

ENVIRONMENTAL KUZNETS CURVE

How does environmental quality change with income?
This is important for understanding inter-generational equity

- If future generations are wealthier, can we expect this to change their preferences for environmental quality?
- Will future wealth repair past environmental damages?

Do we think environmental quality is a normal good?
Do we think environmental quality is a luxury good?

How will demand change with income?

ENVIRONMENTAL KUZNETS CURVE

This question gave rise to the measurement of the Environmental Kuznets Curve (EKC)

- Measures environmental quality against income across countries.

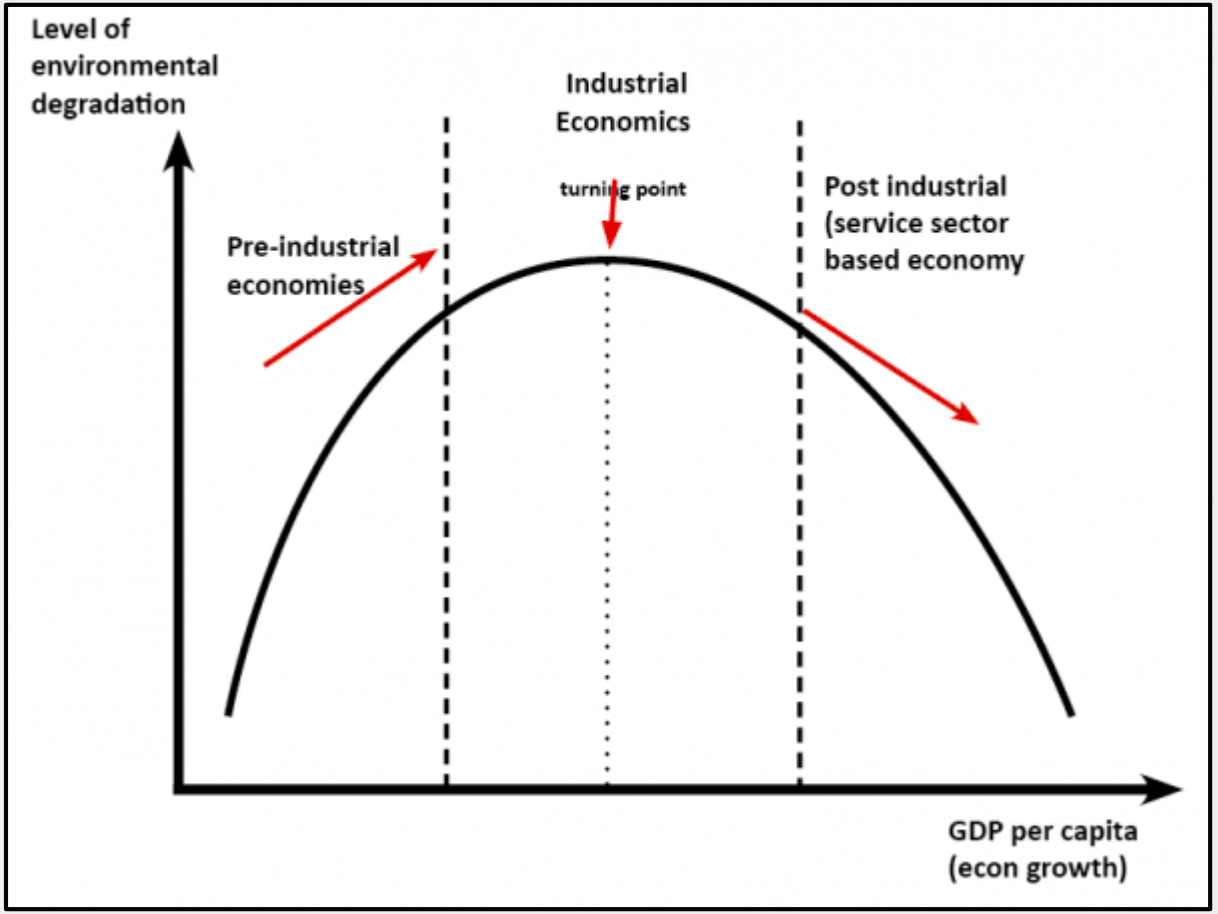
Typically observed to be an inverted U-shape across countries

- Pollution increases during early development until reaching a maximum
- Beyond peak, pollution decreases.

However, beyond initial evidence, further scrutiny has struggled to uphold the initial findings

- EKC is still debated by economists

EKC


Level of environmental degradation
Industrial Economics
turning point
Pre-industrial economies
Post industrial (service sector based economy
GDP per capita (econ growth)

ATTENDANCE ACTIVITY

Take a minute to reflect on the lesson.

Take a few minutes to write down your reflection.

- What did you understand?
- What is still unclear?

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