Lecture # 24 – Growth and the Environment

I. The Macroeconomy and Green Growth

- Up to now, the analysis in class has focuses on microeconomic issues.
  - That is, how do individual actors behave, and what incentives affect this behavior?
  - This analysis allows us to find the optimal level of various activities.
- However, all of these activities affect the economy as a whole.
  - Consider, for example, the effect of higher energy prices on the economy.
- Also, we need to know how economic growth affects the environment.
  - Is economic growth good or bad for the environment?
- To begin, we must distinguish between economic growth and economic development.
  - Growth refers to increases in aggregate level of output.
  - Development refers to increases in per-capita output.
    - Thus, population is important.
- We begin with some macroeconomic basics.
  - The traditional measure of macroeconomic performance is Gross Domestic Product (GDP).
  - GDP is the sum of the money values of all final goods and services produced in the domestic economy during a year.
    - Does not include sales of intermediate goods and services.
    - Only includes work done in the United States.
    - Only market activity is included.
      - Since there isn't a market for most environmental goods, they are not included!!!
      - In contrast, defensive expenditures (e.g. repairs after an auto accident) are included.

        - Problems that result:
            - The value of environmental amenities is not included in GDP.
                - A recent paper by Mueller (2020) provides an example
                - To incorporate environmental benefits, he simply accounts for the health benefits of reducing particulate emissions
                - Simply by doing that, growth of GDP before 1970 falls, and after 1970 rises
                    - 1970 is the passage of the US Clean Air Act
            - Depleting a stock of natural resources (e.g. oil, minerals, and forests) increases GDP, since it results in new sales.
                - GDP is a flow, not a stock
                    - It measures income, not wealth
                - Using natural capital increases GDP, preserving it does not
            - Defensive expenditures are included.
                - Defensive expenditures are expenditures made to eliminate, mitigate, or avoid damages caused by other economic activity.
                - For example, after a car accident, the costs to repair the car, provide medical treatment to the victims, pay for lawyers, etc. all add to GDP. But, has the car accident really increased welfare?
                    - A study of Germany found that 10% of the country's GDP consisted of defensive expenditures.

- Policy makers currently talk about "green growth." What is "green growth"?
    - Economic growth that is environmentally sustainable
    - "(a)ims to operationalize sustainable development by enabling developing countries to achieve robust growth without locking themselves into unsustainable patterns." (World Bank, 2012, p. 30)
    - "World Bank's environmental strategy defines green growth as growth that is efficient, clean, and resilient—efficient in its use of natural resources, clean in that it minimizes pollution and environmental impacts, and resilient in that it accounts for natural hazards and the role of environmental management and natural capital in preventing physical disasters." (World Bank, 2012, p. 30)
    - Chapter argues impacts will be greater if efforts are made to make green growth policies inclusive of the poor.
- To see how the environment can affect the economy, we need:
    - Aa more detailed model of the economy
    - A definition of what is "sustainable"

II. An Analytic Framework for Green Growth

- Our goal is to consider two questions:
  - How does environmental policy affect economic growth?
  - How does the environment benefit economic growth?
- Analytic framework for green growth
  - Economists usually model economic growth using a production function.
    - Traditional growth theory models growth as a function of capital and labor.
    - The model can be extended to include natural capital
    - $Y = f(A,K, L, E)$
      - A: technology
      - K: capital
      - L: labor
      - E: natural capital
    - In this model, growth occurs from increases in production factors or technology
  - To analyze effect of green growth policies, need to modify growth models to include market failures
    - Must account for suboptimal market conditions that lead to externalities
    - Replace the production function with a production frontier: maximum possible production possible with available technology and inputs
      - Actual production is then:
        - $Y = \varphi f(A, K, L, E)$
      - Where φ is between 0-1 and measures the efficiency of production
    - Introduce P_E, which is the effort dedicated to environmental policies
      - Environmental policies can create synergies with economic output by increasing productive capital (K, L, E), by improving efficiency, or by accelerating technological change:
        - $Y = \varphi(P_E)f[A(P_E), K(P_E), L(P_E), E(P_E)]$
      - Negative effects of environmental policy are also possible. Examples include:
        - Environmental regulations divert inputs from the production of output to other goals, such as reducing emissions.
        - Since environmental benefits are not measured in GDP, they are not part of Y. Thus, resources diverted to environmental protection cannot be considered in the equation. GDP falls, so economic growth, as traditionally measured, slows.
        - Environmental regulations may also prohibit certain resources, such as timber, from being used at all.

- How do environmental policies increase conventionally measured GDP?
    - Use a production frontier framework to analyze (Figure 1.4 in the World Bank chapter)
    - Input effect
        - Increasing inputs (arrow i in the figure), such as:
            - Through better management of natural capital (E in model)
                - Environmental resources are an input to production.
                    - If clean water is not available, it cannot be used. Environmental regulations that protect water thus benefit GDP.
                - Improved health of workers => fewer days of work lost to illness (L in model)
                    - Environmental quality affects the quality of other inputs.
                        - For example, reduced air pollution makes agriculture more productive and provides healthier workers.
                        - Not only are healthy workers more productive, but health care is a large portion of GDP spending. If average costs are rising, reducing the number of sick people reduces the costs of treating them.
                - Increase physical capital by better managing natural risks (K in model)
                    - Fewer losses from natural disasters
    - Efficiency effect: $\varphi(P_E)$ in the model
        - Increase productivity by correcting market failures and improving the efficiency of resource use (arrow ii in the figure)
        - Energy efficiency enhancements are an example
    - Stimulus effect:
        - Large investments in green infrastructure may increase demand and address short-term unemployment (also represented by arrow ii above)
        - Useful during a recession, when capacity utilization and employment are low ($\varphi(P_E)$ in the model)
        - Note that this is not always a policy option
            - Only works if the problems in the economy are not structural
            - If demand is low because of structural problems, a stimulus may prove costly
    - Innovation (A in the model)
        - Environmental policies can shift the production frontier by accelerating innovation and creation of knowledge spillovers (arrow iii in the figure)
        - Innovation effects can be positive or negative, depending on whether other productive investment is crowded out

- What are the costs of environmental policy?
    - Reduced productivity by causing producers to use more expensive or less productive technologies (A and K in our model)
    - Reduced productivity by crowding out other R&D (affects A)
    - Early retirement of physical capital
        - Either represents a decrease in capital (K in our model) or an increase in the rate of capital depreciation
    - Increases in the prices of some goods and services
    - Note that the assessment of costs depends on the accounting framework
        - Green accounting would consider things such as the value of ecosystem services
        - GDP will not
        - Environmental regulations divert inputs from the production of output to other goals, such as reducing emissions.
            - Since environmental benefits are not measured in GDP, they are not part of Y. Thus, resources diverted to environmental protection cannot be considered in the equation. GDP falls, so economic growth, as traditionally measured, slows.
- What about welfare?
    - The final step is what happens to utility
    - Focus on welfare, not output, using a utility function
        - Utility depends on both consumption plus environmental quality
            - $U=u(C, E, P_E)$
            - Including P_E acknowledges that environmental policy can affect utility directly, in both positive and negative ways.

III. What is Sustainable Development?

- The Brundtland Report (1987), part of a World Commission on Environment and Development, proposed the following definition of sustainable development:
    - "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
        - What exactly does this mean?
        - What are the needs of the present?
        - How well off should future generations be?
- Heal: "A lifestyle, a way of doing things, is sustainable if most of the world's population could continue it for a long time without major adverse consequences." (Heal, p. 153)
    - "Can we maintain or increase our well-being if we continue trading natural environments and endangered species for better technology and infrastructure?" (p. 154)
        - Heal thinks not

- Weak vs. strong sustainability
    - Weak sustainability: will what we are doing allow future generations to achieve our living standard or better?
        - Does not incorporate stewardship and responsibility toward the natural world
        - Note that this views sustainability as a need for dynamic efficiency.
            - Thus, a measure of welfare needs to be maximized.
    - Strong sustainability
        - Natural capital itself (at least the animate part of it) should be sustained.
        - Constancy of this natural capital should be the goal of sustainability
    - Are we seeking to conserve human living standards or all life forms?
- As we noted in our discussion, clearly defining a sustainable path is difficult.
    - Three dimensions of sustainability are important:
        - The existence of a positive sustainable level of welfare,
        - The magnitude of the ultimate sustainable level of welfare vis à vis current welfare levels, and
        - The sensitivity of the future welfare to actions by previous generations.
    - Both intergenerational and within-generation equity are also issues
- Projections for which scenario will occur depend on assumptions. Are natural and physical capital substitutes?
    - While we are leaving future generations less natural capital, we are leaving them more:
        - Built capital
        - Roads, airports, building, infrastructure
        - Intellectual capital
        - New innovations and ways of doing things
            - Consider, for example, the impact of the Internet
    - If they are substitutes, increased investment in physical or human capital or technological change can compensate for environmental damages
    - If they are substitutes, protecting the environment necessary to maintain economic production
    - Thus, if elasticity of substitution between natural and physical capital is low, weak and strong sustainability are similar concepts. If it is large, they are not.

- Examples of compensating for the loss of natural capital
    - Oil producing countries/regions
        - At oil prices of $130/barrel, Saudi Arabia was generating about $19,000 per capita per year.
            - Could provide a family of four $76,000/year
            - But, once the oil runs out, there will be no other source of income
            - Saudi Arabia has not invested money to provide other streams of income
        - Note that some countries now use sovereign wealth funds to prepare for the future (e.g. *Economist* article on Gulf states)
        - In both Norway and Alaska, investment in other forms of capital compensates for loss of natural capital
            - Norway
                - Invest resources from oil in the Norwegian State Fund
                - Government owns 80 percent share of Statoil
            - Alaska
                - Alaska Permanent Fund receives about 25% of oil and gas royalties
                - Pays an annual dividend to Alaska residents
    - Botswana
        - Botswana is rich in minerals. Generates income by depleting these minerals (particularly diamonds)
            - Botswana offsets this by building up other forms of capital
            - Wealth per person and income per person have tripled over 20 years
- "Resource nationalism" in Latin America
    - Over half of the world's lithium is in Latin America, as well as large sources of copper and nickel
    - As these metals will be important for the energy transition, countries are deciding how to manage these natural resources
    - Many countries are taking greater control of these resources
        - In April 2023, Chile announced plans to create a state-owned lithium company.
            - Other companies would need to form joint ventures with this company to access lithium from Chile
            - Mining (mostly of copper) represented 15% of GDP and 62% of exports in 2021
        - Mexico reduced the length of mining concessions to private companies from 50 years to 30 years, and is considering nationalizing lithium reserves
        - Argentina, Bolivia, Brazil, and Chile are discussing forming a "lithium OPEC" to control prices
            - Outside of Latin America, Indonesia banned exports of nickel ore, so that refining takes place in Indonesia

    - What are the goals of resource nationalism?
        - Increase state revenue and economic power
        - To create more jobs and business opportunities
            - Have struggled to create high-skilled jobs due to quality of labor force and low R&D spending
            - Use natural resources as inputs to product, rather than exporting as raw materials
            - Chile's President discusses transitioning "to a sustainable and developed economy"
        - Social justice
    - QUESTION: What are the risks of resource nationalism?
        - Nationalized oil companies did not perform well
            - Incentives for government-run companies may be different – not just profits
        - Will local firms have access to technology that they need?
            - Nationalization may discourage investment from foreign companies with cutting edge technologies
            - Chile increased royalties for lithium to 40% and required companies to sell 25% of output to local companies at below market rates
- Key question: is compensation possible for the loss of other natural capital (e.g. hydrological cycle, biodiversity)?
    - "In the limit, the answer has to be no." (Heal, p. 157)
        - For example, we cannot live without oxygen, which is produced by photosynthesis
    - Key point is that, for some types of natural capital, the elasticity of substitution between natural and physical capital is less than 1.
    - Mineral resources are different, in that they are just wealth. Can compensate for depletion by building up other wealth.
    - Thus, Heal argues that sustainability requires we keep some natural capital intact, but can safely deplete others.
        - It is primarily living aspects of natural capital that must be preserved.

IV. Alternatives to GDP

- Heal discusses alternatives for measuring sustainability
    - Notes that “what gets measured, gets managed” (p. 159)
    - Heal notes that the data below can answer two questions:
        - How well off are people now? Is this changing over time? (e.g. flow measures)
            - GDP and HDI address this
        - Can current levels of well-being be sustained over time? (e.g. stock measures)
            - ANS attempts to capture this
            - So can the UN’s Inclusive Wealth measure
    - Measuring income
        - Can think of income as the “maximum you can spend this month, consistent with spending the same in all subsequent months’’ (Hicks, as quoted in Heal, p. 159)
            - Has weak sustainability built into it
            - Saudi Arabia’s revenues from oil are not income in this definition
    - Measuring wealth
        - We can use market values for some types of natural capital
            - Mineral rights
            - Use of soil for agriculture (fertile land has value)
        - Others are not valued by markets
            - Biodiversity
            - Need to calculate shadow prices for these
    - Impact of scarcity on price
        - If some forms of natural capital are truly vital, their value will increase as they become scarce
        - Thus, at some point, it will be too costly to replace with other forms of capital
            - Total wealth will then fall if we use that natural capital

- Alternatives to GDP
    - Net Domestic Product (NDP)
        - Subtracts depreciation of capital from GDP
        - How it helps the environment
            - Impact of human activity on natural capital depreciates the capital
                - E.g. oil in Saudi Arabia
                    - Depreciating Saudi Arabia's capital by the amount of oil sold makes them a poor country
        - Doesn't require new data collection, but measuring depreciation accurately can be difficult
            - Measured depreciation comes from financial reports that are influenced by tax laws, rather than true economic depreciation of value
        - But, since GDP only includes physical capital, only physical capital would be depreciated
    - The U.N. Human Development Index (HDI)
        - Tries to measure the well-being of individuals more directly
        - Combines into an index: (1) income (GDP per capita), (2) health (life expectancy at birth), (3) education (school enrollment)
        - Top countries in 2022
            - (1) Iceland, (2) Norway, (3) Switzerland, (4) Denmark, (5) Germany
            - Doesn't currently include environmental quality, but could be adapted to do so
    - Gross National Happiness
        - Used in Bhutan
        - Considers nine dimensions:
            - Psychological well-being
            - Time use
                - How much time available for nonwork activities such as recreation?
            - Community vitality
                - Attempts to measure trust, reciprocity, how safe people feel, and how closely connected they feel to others
            - Culture
            - Health
            - Education
            - Environmental diversity
            - Living standard
            - Governance
        - Environmental diversity measured by the level of afforestation or deforestation and other measures of environmental "degradation"
        - Challenge: how to measure these concepts and combine them into a single number

- Adjusted net savings
  - Begins with a conventional measure of net investment in plant and equipment
  - Adds investment in human capital through education and intellectual capital through R&D
  - Subtracts depreciation or degradation of natural capital
  - Heal argues that an economy's present value of all future welfare levels is nondecreasing at any given time t if ANS is positive at time t.
    - True for Botswana and Norway, not always for Saudi Arabia (figure 5)
  - Nonetheless, Heal concludes that while ANS is the ideal goal, we cannot yet measure this accurately
    - We don't have quantitative measures of some aspects of wealth
      - We don't have economic values for all types of wealth
- United Nations Inclusive Wealth Report
  - Includes measures of three types of capital:
    - Manufactured capital
      - E.g. physical capital such as infrastructure
    - Human capital
      - Skills, education, health
    - Natural capital
      - Here, the study focused on things that can be directly owned, bought, or sold
      - Thus, market prices exist
  - 2014 update includes health capital explicitly
    - Based on estimates of value of a life
  - 2018 update uses new methodology
    - More natural capital data
    - Updated calculations for human capital
      - Estimate shadow prices for health and education human capital
      - Note that shares of human capital in rich countries fall as a result
  - 2023 update updates and further refines the data
    - Example: now makes adjustments for coastal and marine systems impact on carbon emissions
  - Human capital is a larger share of total wealth in high-income countries (figure 5.6c).
  - Lower income countries get more wealth from natural capital (figure 5.6a).

- Over time, the share of natural capital in total wealth has fallen, whereas the share of produced capital has increased (figure 5.7).
- Over time, while GDP per capita is growing, IW per capita is not (figure 5.9).
- Compare annual growth rates of wealth per capita, GDP per capita, and HDI
    - Wealth
        - Positive growth rate for 92 of 163 countries (56%)
        - Note that growth rates generally lower than growth in GDP
        - 61 countries have negative wealth growth, but positive growth in GDP per captia
        - 71 countries have negative wealth growth but positive growth in HDI
    - HDI
        - Positive growth rate for all 163 countries
    - GDP per capita
        - Positive growth for 149 of 163 countries (91%)