

Chapter 3 – Economics

This chapter explores notions of wellbeing and the effect of affluence on environmental and social sustainability.

Review of basic economics

Microeconomics

Among the relevant tenets of basic microeconomics is the idea that wellbeing (“value function”) of (rational) consumers is always increased by more consumption. Our **wants are limitless**. What the IPAT equation calls affluence, wellbeing, happiness, and value function are all basically the same idea. Consumers are always better off with more.

“Consumption” may mean literal consumption, as in the case with food, or it could be consuming a service, such as education or getting a haircut. In many cases, what is “consumed” is ancillary to what the consumer actually desires. An example is travel. The consumer wants to travel from point A to point B. Exactly *how* they do it doesn’t really matter to them. The fact that they drive a car that burns gasoline isn’t – for the consumer – the important part. In economic terms, travel uses an *energy service*. The energy consumed is just a means to the end. (In this case, that end is travel.)

The value functions of different individuals may be different and so free trade allows each party to maximize their own value function. The opportunity cost is the value (to them) of what they give up, be it money or a good or service. If I’m a barber and I would prefer to have \$15 rather than 20 minutes of free time and you would rather have a haircut than \$15, then we can arrange a trade. I’ll trade you \$15 for a haircut. You’re happier with the \$15 and I’m happier with the haircut.

Macroeconomics

Discussing sustainability also requires some ideas from macroeconomic theory. Gross domestic product (GDP) is the *idea* of the amount of wealth created by an economy (usually national) in a year. There are various ways to *measure* or estimate GDP, usually denominated in units of money (see, for example, bea.gov).

$$GDP = C + G + I + NX$$

C is consumption and represents purchases made by individuals. Consumption makes up about two thirds of GDP for developed economies and is generally divided into three categories: durable goods, nondurable goods, and services. Services represent nontangible things. Examples include the aforementioned haircut, legal advice, education, and concert tickets. Durable goods defined as things that last longer than 3 years. Examples include appliances, automobiles, but don’t include fabrics (like clothes or carpet) even if those things happen to last more than three years. Nondurable goods are things that are consumed immediately, like food, paper, or fuel. Durable goods spending is more sensitive to economic conditions than nondurable good spending because consumers can choose to postpone spending on durable goods until their circumstances are better.

G is government spending, divided between government consumption (e.g., wages to government workers and equipment) and net investment (e.g., infrastructure improvements).

I is investment and represents savings.

NX is *net* exports; here “net” the difference between value of imports and exports. Thus, NX could be a negative number.

GDP, because it represents consumption, is only a partial indication of wealth. For instance, owning an asset, like land or a valuable painting, doesn’t factor into GDP calculations. Thus, GDP may be less useful than other measures of wealth for discussions of social sustainability. However, GDP does more accurately capture the impact on the environment because it directly correlated with resources that are used up (sources) and emissions (sinks).

Economic History

Comparing the present to the past is often difficult. We have limited economic data from the past and, generally speaking, the data is poorer the farther back you go. There are several reasons for this. Most basically, ancient societies didn’t have economic theories compatible with modern notions. Next, their ability to collect data was more limited. Finally, much of the data that was collected has either been lost or destroyed. Nevertheless, just because we don’t have *exact* data doesn’t mean we can’t make meaningful comparisons. Our *estimates* are often *good enough*.

Somewhere in the range of 1500 AD to 1850 AD is when we might begin to think of humanity as “modern” and make economic comparisons to the present. Particularly as we get into the 1800s there is some data to make meaningful comparisons. However, the data that is available needs some corrections or adjustments.

“A large proportion of our high standard of living today derives not just from our ability to more cheaply and productively manufacture the commodities of 1800, but from our ability to manufacture whole new types of commodities, some of which do a better job of meeting needs that we knew we had back in 1800, and some of which meet needs that were unimagined back in 1800. How much has this change—the fact that we make not just the same goods, but new goods and new types of goods—enhanced our material prosperity? Nordhaus (1997) provides perhaps the most eloquent and sophisticated argument that standard measures—like those of Maddison—that do not take explicit account of these factors grossly understate the rate of economic growth over the past two centuries.

I know that I at least would be extremely unhappy if I were handed my current income, told that I could spend it on goods at current prices, but that I was prohibited from buying anything that was not made before 1800. Yet Maddison’s procedures would implicitly take such a reduction in the range of goods I could purchase as having no effect on my real income or real material standard of living.

But by how much has our power to make new things—not just the same things more efficiently—amplified our material prosperity?

In at least some models of growth in which the set of goods that can be produced expands, the correct measure of real output is proportional to the product of purchasing power

(income divided by the average price of a good) and the number of goods that can be produced. As best as I can determine, about three-quarters of world expenditure today is spent on commodities that simply did not exist back in 1800. So I—somewhat arbitrarily—use this to assign an additional fourfold multiplication to output per capita since 1800 in addition to the increases in output per capita calculated by Maddison.

But since this—large—extra adjustment is not to everyone's taste, I also report the “ex-Nordhaus” series without the “new kinds of goods” adjustment.” [<https://www.bradford-delong.com/2014/05/estimates-of-world-gdp-one-million-bc-present-1998-my-view-as-of-1998-the-honest-broker-for-the-week-of-may-24-2014.html>]

Figure 1 presents Bradford's historical estimates of average, World, per-capita, GDP. Note that this notion of “average, World, per-capita, GDP” is directly compatible with the IPAT equation's notion of “affluence.”

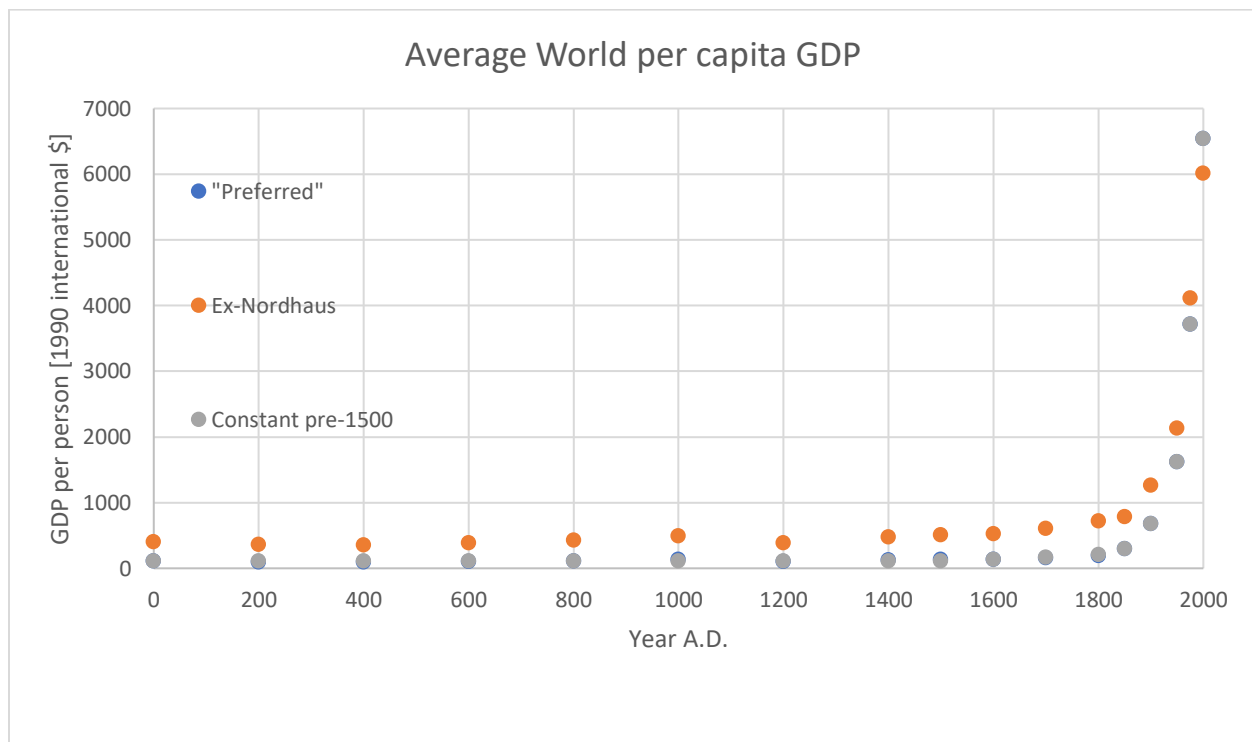


Figure 1. Various estimates of historical GDP. Note that “Preferred” and constant pre-1500 are nearly indistinguishable.

Embeddedness, Secondary Emissions, and Economic Activity

Online carbon calculators (for instance, <https://www.carbonfootprint.com/calculator.aspx>) estimate the direct impact of your activities as well as the *indirect* impact of your activities. For instance, owning and using a telephone contributes relatively little to atmospheric CO₂ – at least directly. Here direct emissions are understood as the emissions directly the result of using the product. In the case of a telephone, the emissions would be those resulting from the electricity consumed by your phone. However, the indirect emissions are greater than this. They are the emissions resulting from operating the electronic communications network(s) you're using when you use your phone.

The main idea here is that *all* of your economic activity contributes the effects your economy has on the environment, to the extent that you participate in the economy.

IPAT Revisited

We've seen that both Population (chapter 2) and Affluence (this chapter) are increasing exponentially. Technological improvements can offset this (to some degree) but we have already seen indications in the previous chapters (and will see more in the coming chapters) that human impacts on the environment are reaching critical levels.

How high can impact go and still be “sustainable?”

Technology in the IPAT equation has units of impact per consumption, which in this chapter we could think of as impact per GDP. (GDP is actually the demand (what we've been calling consumption) side of the supply-equals-demand equation. However, since supply equals demand IPAT captures impacts that arise from either/both production and consumption.) Technology is a measure of efficiency – how efficiently can resources be converted to goods and services – that is, how can we convert resources to goods and services with as little impact as possible. In the 1970s, automobiles could provide transportation service with an efficiency in the range of 10-15 miles per gallon of gasoline. Modern vehicles are able to provide the same transportation service (that is, a mile traveled) far more efficiently. (Also note that in addition to burning less gasoline per mile, modern vehicles also emit other emissions (such as unburned hydrocarbons, SoX, NoX, carbon monoxide, and soot) at far lower rates than older vehicles.

Technology and the “law” of diminishing returns

The law of diminishing returns is a general observation that successively continuing improvements become harder and harder to make. When I ran high school track, my time for the mile dropped from 6:36 to 5:00 my freshman year. It would have been very difficult to get my time down to 3:24 my sophomore year.

On the other hand, Moore's Law has continued to hold – the *rate* of technological improvement has been constant for a long time, which is part of what makes Moore's Law so remarkable. We generally would expect the rate of increase to slow because of diminishing returns.

Because of the law of diminishing returns, we would expect technological reductions in impact would not keep pace with increasing population and affluence.

Planetary Boundaries

One important notion of sustainability is how high can “impacts” go? What is a safe limit? For instance, we can put *some* CO₂ into the atmosphere because CO₂ is removed by plants and ocean coral. Thus if humans put less CO₂ into the atmosphere than natural systems remove, the levels of CO₂ in the atmosphere won't increase. On the other hand, if we put more CO₂ into the atmosphere than can be removed CO₂ will increase without limit – by definition unsustainable. We call *ecosystem services* those benefits to humans provided by the ecosystem, for example, removal of CO₂ from the atmosphere.

In 2009 scientists suggested nine possible boundaries (see table 1), at least three of which have been exceeded.

Table 1. Planetary Boundaries (https://en.wikipedia.org/wiki/Planetary_boundaries) Red indicates the limit has been exceeded.

Earth-system process	Control variable	Planetary boundary	Current value
Climate change	Atmospheric CO ₂ [ppm]	350	412
Biodiversity loss	Extinction rate [species per million per year]	10	>100
Biogeochemical	anthropogenic nitrogen removed from the atmosphere [millions of tonnes per year]	35	121
	anthropogenic phosphorus going into the oceans [millions of tonnes per year]	11	8.5-9.5
Ocean acidification	Global mean saturation state of calcium carbonate in surface seawater [omega units]	>2.75	2.9
Land use	Land surface converted to cropland	15%	11.7%
Freshwater	Global human consumption of water [km ³ /yr]	4000	2600
Ozone depletion	Stratospheric ozone concentration [Dobson units]	276	283
Atmospheric aerosols	Overall particulate concentration in the atmosphere, on a regional basis	Not yet quantified	
Chemical pollution	Concentration of toxic substances, plastics, endocrine disruptors, heavy metals, and radioactive contamination into the environment	Not yet quantified	

Planetary boundaries are not, in most cases, constant. They are functions of multiple variables and many involve feedback loops. For instance, the ability of coral to remove CO₂ from the atmosphere is degraded by higher concentrations of CO₂ in the atmosphere because of increasing ocean acidification. The recovery of boundaries after limits have been exceeded is an important area of ongoing research.

There may be multiple solutions to exceeding planetary boundaries. Ecosystem services could be enhanced so allow increased impacts. Impacts could be reduced, either through increasing technology or reducing affluence. Or humanity could move to space so that planet Earth is not a limiting factor.