The Economics of Collisions and Contagions in a Crowded World

THE SPIRIT OF GREEN

William D. Nordhaus

22

Green Planet?

Most of the facets of Green discussed up to now operated at the personal, local, or national level. However, some of the most intractable and risky externalities are global. We discussed one important global ailment, pandemics, in an earlier chapter. This and the next chapter survey global Green as represented by global warming.

Climate Change as a Global Externality

Climate change is a particularly thorny externality because it is global. Many critical issues facing humanity today—global warming and ozone depletion, COVID-19, financial crises, cyberwarfare, and nuclear proliferation—are similarly global in effect and resist the control of both markets and national governments. Such global externalities, whose impacts are indivisibly spread around the entire world, are not new, but they are becoming more important because of rapid technological change and the process of globalization.[1]

Global warming is the Goliath of all externalities because it involves so many activities. It affects the entire planet for decades and even centuries, yet none of us acting individually, or even as nations, can do much to slow the changes.

Global externalities have long challenged national governments. In earlier centuries, countries faced religious conflicts, marauding armies, and the spread of pandemics of smallpox and the plague. In the modern world, the older global challenges have not disappeared, as we see with the COVID-19 pandemic, while new ones have arisen—including not only global warming but others such as the threat of nuclear proliferation, drug trafficking, and international financial crises.

Further reflection will reveal that nations have had limited success with agreements to deal with global economic externalities. Two successful cases include handling international trade disputes (today primarily through the World Trade Organization) and the protocols to limit the use of ozone-killing chlorofluorocarbons. The study of economic aspects of environmental treaties has been pioneered by Columbia University economist Scott Barrett. He and other scholars believe these two treaties were successful because the benefits far outweighed the costs and because effective institutions were created to foster cooperation among nations.[2]

Governance is a central issue in dealing with global externalities because effective management requires the concerted action of major countries. However, under current international law, there is no legal mechanism by which disinterested majorities of countries can require other nations to share in the responsibility for managing global externalities. Moreover, extralegal methods such as armed force are hardly recommended when the point is to persuade countries to behave cooperatively.

It must be emphasized that global environmental concerns raise completely different governance issues from national environmental concerns, such as air and water pollution. For national public goods, the problems largely involve making the national political institutions responsive to the diffuse national public interest rather than concentrated national private interests. For global public goods, the problems arise because individual nations enjoy only a small fraction of the benefits of their actions. In other words, even the most democratic nations acting noncooperatively in their own interests would take minimal actions because most of the benefits spill out to other nations. It is only by designing, implementing, and enforcing *cooperative multinational policies* that nations can ensure effective policies.

This chapter discusses the scientific and economic background to climate change. The next chapter explores global mechanisms (what I call climate clubs or compacts) to deal with the lack of incentives to manage global externalities.

The Changing Science of Climate Change

If you read the newspaper, listen to the radio, or read Twitter, you are virtually certain to encounter stories about global warming. Here is a sample from a variety of sources:

> "The last decade was the warmest on record."
> "The concept of global warming was created by and for the Chinese in order to make U.S. manufacturing non-competitive."
> "Polar bears could disappear within a century."
> "The Greenland ice sheet has experienced record melting."

Clearly, global warming is getting a lot of attention today. And just as clearly, people disagree about whether it is real, whether it is important, and what it means for human societies. What should the interested citizen conclude from these conflicting stories? And if the answer is that global warming is real, how much does it matter? Where should our concerns about global warming rank among the other issues we face, such as persistent inequality, pandemics, and nuclear proliferation?

The short answer is that global warming is a major threat to humans and the natural world. It is the ultimate challenge for Green policies, threatening to turn Planet Earth into Planet Brown.

I have used the metaphor that climate change is like a vast casino. By this, I mean that economic growth is producing unintended but perilous changes in the climate and Earth systems. These changes will lead to unforeseeable and probably dangerous consequences. We are rolling the climatic dice, and the outcome will produce surprises, some of which are likely to be perilous. The message in these chapters is that we can put down the climatic dice and walk out of the casino.

Global warming is one of the defining issues of our time. It ranks along with pandemics and economic depressions as a force that will shape the human and natural landscapes for the indefinite future. Global warming is also a complex subject. It spans disciplines from basic climate science to ecology and economics, and even includes politics and international relations.

Climate Basics

A few chapters in this book cannot hope to cover the vast scope of climate change. Rather, this discussion will highlight the major issues involved, explain why climate change threatens the planet, and show how these relate to the overall Green philosophy in this book.[3]

The beginning of our understanding lies in earth sciences. Climate science is a dynamic field, but the essential elements have been developed by earth scientists over the last century and are well established. The ultimate source of global warming is the burning of fossil (or carbon-based) fuels such as coal, oil, and natural gas, which leads to emissions of carbon dioxide (CO_2). Gases such as CO_2 are called greenhouse gases (GHGs). They accumulate in the atmosphere and stay there for a long time.

Higher atmospheric concentrations of GHGs lead to surface warming of the land and oceans. The initial warming is amplified through feedback effects in the atmosphere, oceans, and ice sheets. The result includes changes in temperatures as well as in temperature extremes, precipitation patterns, storm location and frequency, snowpacks, river runoff, water availability, and ice sheets. Each of these will have profound impacts on biological and human activities that are sensitive to the climate.

Past climates—varying from ice-free conditions to Snowball Earth—were driven by natural sources. Current climate change is increasingly caused by human activities. The major driver of global warming is the emission of CO_2 from the burning of fossil fuels. CO_2 concentrations in the atmosphere were 280 parts per million (ppm) in 1750 and have reached over 410 ppm today. Models project that, unless forceful steps are taken to reduce fossil-fuel use, concentrations of CO_2 will reach 700–900 ppm by 2100. According to climate models, this will lead to warming averaged over the globe in the range of 3–5°C by 2100, with significant further warming after that. So, unless there are strong efforts to curb CO_2 emissions sharply, we can expect continued accumulations of CO_2 emissions in the atmosphere—and the resulting global warming with all its consequences.

Is this all a fantasy of scientists who are looking for funding for their pet projects? Such a cynical and misguided view not only insults the talented people who have labored in this field but also overlooks the powerful evidence they have provided. Figure 22-1 shows one critical piece of evidence here, the record of atmospheric CO_2 concentrations over the last 800,000 years. You can see the seesaw of concentrations associated with the ice ages. Cold periods were those in which CO_2 declined sharply (probably because it went into the deep oceans), while warm periods led to large CO_2 releases. Concentrations varied from lows around 170 ppm to highs around 280 ppm in the preindustrial period. During the most recent ice age, global temperatures were about 5°C lower than today, and atmospheric CO_2 concentrations were at their lowest point, 180 ppm.

Then, around 1750, as humans began clearing forests and burning fossil fuels, CO_2 concentrations headed up. Concentrations passed the 800,000-year record around 1950 and by 2020 were 410 ppm. Carbon-cycle models indicate that the elevated levels result from industrial emissions, with about half of all emissions from the last century remaining in the atmosphere—and likely to stay there for a century or more.

The accumulating CO_2, along with other GHGs, is leading to rising temperatures and other accompanying climatic effects. Global temperatures have risen more than 1°C over the last century. If emissions continue unabated, climate models suggest that global temperatures will rise another 2–4°C by the end of the century. Some areas, such as the Arctic, will see much sharper temperature increases. But temperature is only a small part of the impacts, many of which are imperfectly understood. Among other impacts are drying in the midcontinental regions, more intense storms, smaller glaciers and snowpacks, perhaps more widespread wildfires, and changing monsoonal patterns.

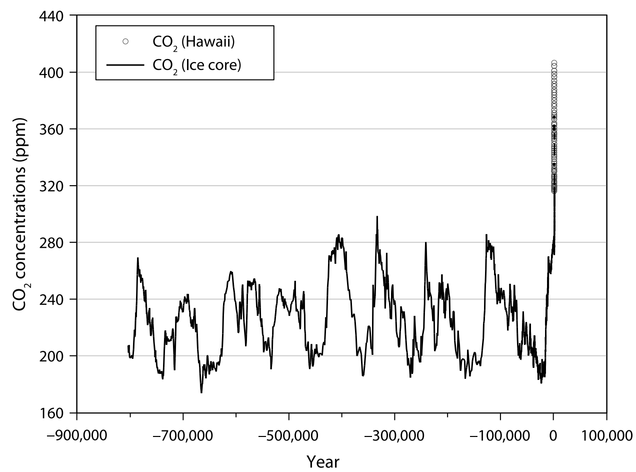

FIGURE 22-1. CO_2 concentrations from ice cores and historical record through 2020
The longer solid line comes from ice cores in large ice sheets such as Antarctica. The dots starting in 1957 are instrumental records from Hawaii.

Figure 22-2 shows a reconstruction of global temperatures using Antarctica ice-core data for the last half-million years. The temperature at present is normalized at 0°C. The line with dots shooting up at the far right shows a projection of future temperature increases if there are no policies to slow climate change. If global warming continues unchecked, future temperatures will soon surpass the historical maximum of the last half-million years.

Rising temperatures are not the major concern about the impacts of climate change. More important are the effects on human and natural systems with regard to storms, giant ice sheets, and monsoonal systems. A central concept in analyzing impacts is whether a system can be managed. The nonagricultural sectors of high-income countries are highly managed, and this feature will allow these sectors to adapt to climate change at a relatively low cost for at least a few decades.

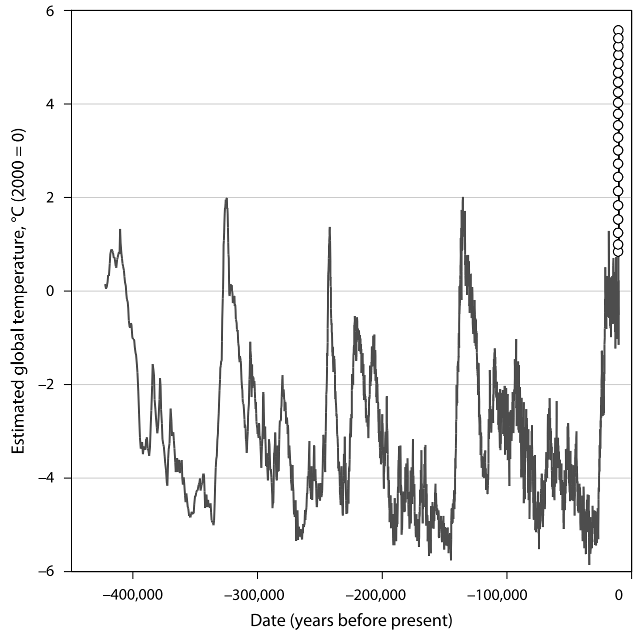

FIGURE 22-2. Estimated global temperature variations for the last four hundred thousand years (*solid line*) along with model projections for the next two centuries (*circles*)

However, many human and natural systems are unmanaged or unmanageable and are highly vulnerable to future climate change. While some sectors or countries may benefit from climate change, most countries are likely to be significantly disrupted in sectors closely tied to climate-sensitive physical systems. The potential damages will probably be most heavily concentrated in low-income and tropical regions, such as tropical Africa, Latin America, coastal communities, and the Indian subcontinent. Vulnerable systems include rain-fed agriculture, seasonal snowpacks, coastal communities impacted by sea-level rise, river runoffs, and natural ecosystems. There is potential for serious impacts in these areas.

Scientists are particularly concerned about *tipping points* in the earth's systems. These involve processes in which sudden or irreversible changes occur as systems cross thresholds. Many of these systems operate at such a large scale that they are effectively unmanageable by humans with existing technologies. Four important global tipping points are the rapid melting of large ice sheets (such as Greenland and Antarctica); large-scale changes in ocean circulation, such as the Gulf Stream; melting of the permafrost; and major changes in monsoonal patterns. These tipping points are particularly dangerous because they are not easily reversed once they are triggered.

The best evidence indicates that the impacts of climate change will be nonlinear and cumulative. For example, the first 1°C or 2°C of warming is unlikely to have massive disruptive effects on agriculture, particularly if warming is gradual and farmers can adapt their technologies. However, as global warming passes the 3°C or 4°C mark, the combination of changes in temperature, precipitation, and water availability is likely to highly disrupt most agricultural systems.

The Climate Deniers

The science and economics of major environmental issues is vigorously debated and sometimes denied by those who cause the problems and whose interests would be adversely affected by mitigating policies. We saw that when Rachel Carson warned the world about the dangers of DDT and other pesticides, she was targeted as enemy number one by Big Chemicals. Similarly, energy companies, particularly those producing or selling fossil fuels, see their profits threatened if strong climate policies are established. The most damaging participants are politicians who argue against Green policies because of ideology or campaign contributions. Companies have the money, but politicians have the votes and the power.

I have studied climate science for decades and find it solid and convincing. But there are skeptics. Many people misunderstand the issues. A few influential politicians sow doubts about the validity of mainstream climate science. Affected industries undermine the science and exaggerate the costs of policies to slow warming. Here are some examples of the contentious dialogue:

FROM PRESIDENT DONALD TRUMP: "The concept of global warming was created by and for the Chinese in order to make U.S. manufacturing non-competitive."

THE TITLE OF A BOOK BY U.S. SENATOR JAMES INHOFE: *The Greatest Hoax: How the Global Warming Conspiracy Threatens Your Future*

DR. WILLIAM HAPPER (SEE BELOW): "I believe that more CO_2 is good for the world, that the world has been in a CO_2 famine for many tens of millions of years."

FROM A KEY ADVISER TO RUSSIAN PRESIDENT VLADIMIR PUTIN: "No link has been established between carbon dioxide emissions and climate change."

The list could go on and on. While these debates seem amusing distractions, they pose serious challenges because of their impact on public opinion. It is worth looking into these claims to test their validity.

The media desires "fairness," so often an established theory will be "balanced" by some far-out idea. This has been the case for climate change. We find today a small and vocal group of contrarian scientists who argue that the consensus on climate change is poorly grounded and that policies to slow warming are not warranted.

To explain how such contrarian views are propagated, I will take the case of a 2012 article by "sixteen scientists" in the *Wall Street Journal* titled "No Need to Panic about Global Warming." Dissenting scientists here are not typically active researchers in the field but are influential because they carry the mantle of science and often have made important contributions in other areas. It is useful to look at this statement because it contains many of the standard criticisms.

The basic message of the article asserts that the globe is not warming and that CO_2 is not harmful. I will analyze two of their claims as typical of the contrarian viewpoint.

1. The first claim for contrarians is that the planet is not warming. The 16 scientists wrote, "Perhaps the most inconvenient fact is the lack of global warming for well over 10 years now."

It is easy to get lost in the tiniest details here. Just because the stock market went down today does not mean that it does not generally rise. It will be useful to look at the record of actual temperature measurements. Our best measures show that global mean temperature has risen 1.3°C since 1900, with an accelerating trend since 1980.

Moreover, climate scientists have moved way beyond global mean temperature in looking for evidence of human-caused climate change. Scientists have found several indicators that point to a warming world with humans as the major cause. These include melting of glaciers and ice sheets; changes in ocean heat content, rainfall patterns, atmospheric moisture, and river runoff; stratospheric cooling; and the shrinking of Arctic sea ice. Those who look only at global temperature trends are like investigators using only eyewitness reports and ignoring fingerprints and DNA-based evidence. Yet the contrarians continue to repeat their claims using outmoded techniques and data.

2. One of the strangest claims of contrarians is the second argument: "The fact is that CO_2 is not a pollutant." What might this mean? Presumably, it means that CO_2 is not by itself toxic to humans or other organisms within the range of concentrations that we are likely to encounter, and indeed higher CO_2 concentrations may be beneficial.

However, this is not the meaning of pollution under U.S. law or in standard economics. The U.S. Clean Air Act defined an air pollutant as "any air pollution agent or combination of such agents, including any physical, chemical, biological, radioactive … substance or matter which is emitted into or otherwise enters the ambient air." In a 2007 decision, the Supreme Court ruled on the question:

> Carbon dioxide, methane, nitrous oxide, and hydrofluorocarbons are without a doubt "physical [and] chemical … substance[s] which [are] emitted into … the ambient air." … Greenhouse gases fit well within the Clean Air Act's capacious definition of "air pollutant."[4]

In economics, a pollutant is a form of negative externality—that is, a by-product of economic activity that causes damages to innocent bystanders. The question here is whether emissions of CO_2 and other GHGs will cause damages, large or small, now and in the future. Virtually all studies of the impacts of rising concentrations of CO_2 and the accompanying earth-system changes have concluded that there are net damages, that the damages are large, and that the damages rise sharply for warming greater than 1°C. In short, CO_2 is indeed a pollutant in the sense that it is a damaging side effect of economic activity.

Other claims of contrarians range from the absurd (it is a hoax created by the Chinese in order to make U.S. manufacturing noncompetitive) to the abstruse (clouds will save the globe from catastrophic warming).

Economics of Climate Change

We move now from science to economics. Economists have focused on strategies to slow climate change. The most promising is *mitigation*, or reducing emissions of CO_2 and other GHGs. Unfortunately, this approach is expensive. Studies indicate that it will cost in the range of 2 to 6% of world income (roughly, $2 trillion to $6 trillion annually at today's level of income) to attain international climate targets, even if mitigation is undertaken in an efficient manner. While some miraculous technological breakthroughs might conceivably be discovered that can reduce the costs dramatically, experts do not see them arriving in the near future. New technologies—particularly for energy systems that have massive investments in capital such as power plants, structures, roads, airports, and factories—take many decades to develop and deploy.[5]

The economics of climate change is straightforward. When we burn fossil fuels, we inadvertently emit CO_2 into the atmosphere, and this leads to the harmful impacts just discussed. As explained elsewhere in this book, such a process is an externality, which occurs because those who generate the emissions do not pay, and those who are harmed are not compensated. One major lesson from economics is that unregulated markets cannot efficiently deal with extensive harmful externalities. Unregulated markets will produce too much CO_2 because there is a zero price on the external damages of CO_2 emissions.

Economics points to one central and all-important truth about climate-change policy. This truth is so central that it must be stated and restated. For any policy to be effective, it must raise the market price of CO_2 and other GHG emissions. Putting a price on emissions corrects for the underpricing of the externality in the marketplace. Prices can be raised by putting a regulatory tradable limit on the amount of allowable emissions (cap-and-trade) or by levying a tax on carbon emissions (carbon tax).

A central lesson of economic history is the power of incentives. Take the example of land values. Where land is scarce and land prices are high, such as on the island of Manhattan, people build smaller dwellings and go high into the sky. Where land prices are low, such as in southern New Mexico, people worry little about the cost of the land and spread out their houses and barns.

Applying that to our subject, we can ask how to use incentives to slow climate change. Here, the incentive must be for everyone to replace their current fossil-fuel-driven consumption with low-carbon activities. Making this change requires the actions of millions of firms and billions of people spending trillions of dollars.

The most effective incentive to induce the transition is a high price for carbon. Raising the price of carbon will achieve four goals. First, it will signal to *consumers* which goods and services are carbon-intensive and should therefore be used sparingly. Second, it will provide data to *producers* about which inputs are carbon-intensive (such as coal and oil) and which are low carbon (such as natural gas or wind power), thereby inducing firms to move to low-carbon technologies. Third, it will give market incentives for *inventors, innovators, and investment bankers* to invent, fund, develop, and commercialize new low-carbon products and processes. Finally, a carbon price will economize on the *information* required to undertake all these tasks.

Economists have extensively studied the major questions of climate-change policy: How sharply should countries reduce CO_2 and other GHG emissions? What should be the time profile of emissions reductions? How should the reductions be distributed across industries and countries? What policy tools are most effective—taxes, market-based emissions caps, regulations, or subsidies? Here are some of the findings.

It is tempting to set climate objectives as hard targets based on climate history or ecological principles. A common target is to limit global temperature increase to 2°C; more recently, scientists point to a limit of 1.5°C as the upper bound if we are to protect many biological processes and avoid dangerous tipping points. However, these aspirational goals may be infeasible given the current trajectory of emissions, as well as the slow pace of actions in taking strong policies.

Economists often advocate an approach known as cost-benefit analysis, in which targets are chosen by balancing costs and benefits. Because the mechanisms involved in climate change and its impacts are so complex, economists and scientists have developed computerized *integrated assessment models* to project trends, assess policies, and calculate costs and benefits. Here are some of the major findings:[6]

- Policies to slow emissions should be introduced *as soon as possible*.
- A second and surprising finding is the importance of harmonizing climate policies. This requires equalizing the marginal costs of reducing emissions everywhere. Equivalently, in a market context that means the carbon price should be equal in every sector and every country.
- Effective policies should have the highest possible *participation*; that is, the maximum number of countries and sectors should be on board as soon as possible. Free riding should be discouraged.
- Finally, an effective policy is one that *ramps up gradually*—to give people time to adapt to a high-carbon-price world, to give firms a signal about the economic environment for future investments, and to tighten the screws increasingly on carbon emissions.

Most experts agree on these central principles—universal participation, equalizing marginal costs or carbon prices in all uses in a given year, full participation, and increasing stringency over time. However, experts disagree on the stringency of policies. I have worked on models that suggest a current carbon price in the range of $40 per ton of CO_2, rising over time. This policy would lead to eventual warming of around 3°C above preindustrial levels.

However, the most ambitious policies of limiting temperature change to 2°C would require much higher carbon prices, near $200 per ton of CO_2 in the near term. Yet other prices would be consistent with other temperature trajectories, participation rates, and discounting. A lower price is appropriate if costs are low, participation rates are high, and the discount rate on future economic impacts is high. A higher price would apply for high costs, low participation rates, and low discounting.

However, whether the goal is policies that keep temperatures near 2°C or 3°C or 4°C, we must be realistic and realize that the world is not close to attaining those goals. Effective policies have not been introduced, either in any major country or for the world as a whole. Compared to a target for current carbon prices of $40 per ton of CO_2, the actual global carbon price is close to $2 per ton in 2020. Carbon prices in the United States and most other countries are virtually zero, so there is a huge gap between reality and global aspirations.

Why have *global* policies on climate change been so ineffective compared to *many national environmental* policies (for pollution, public health, and water quality as examples)? Why have landmark agreements such as the Kyoto Protocol and the Paris Accord failed to make a dent on emissions trends? The difficulties that arise for global public goods are discussed next, along with potential solutions.