Chapter 2: Climate change and economic development as both destruction and resilience

Abstract: In this chapter, with the aid of research in mainstream climate science and climate economics (in the broader sense), the parallelization of climate change caused by economic growth and climate and natural disaster resilience via economic growth is explained. Specifically, it describes how economic production destroys the ecosystems but also how infrastructure development saves lives in both developed and developing countries such as the US, Japan, Bangladesh, and the Philippines. This may provide a fruitful and nuanced way of thinking about the intricate relations between climate change and economic development.

Keywords: parallelization, cost-benefit analysis, resilience, climate change, climate economics

The basic premises of climate change

Climate change is often equated with global warming (Nordhaus, 2015) and for the sake of simplicity I will use it here as synonymous with global warming. In reality, climate change is more complex and dynamic and also includes the effects of warming such as predicted future hurricane intensity, higher sea levels, and ocean acidification. According to the most prevailing theoretical and empirical explanation, climate change is predominantly driven by greenhouse gas emissions. The post-industrial period, 1900 up and until 2100, is often use to calculate the changes from a baseline level to a foreseeable future level of global warming (predominantly caused by anthropogenic effects). As greenhouse gases are released and stay in the atmosphere for a very long time, global temperatures are expected to increase over time. Only mitigation of greenhouse gases, via carbon pricing and other measures, as well as supplemental strategies (e.g., carbon capturing, adaption), could reduce warming and avoid large future problems in terms of the world's economic and ecological systems. Climate change in the pre-industrial past has typically been driven by large solar cycles and the amount of greenhouse gases in the atmosphere has differed over time and space. Nevertheless, the recent emissions, as a result from economic productivity, is regarded as an anthropogenic (i.e., human) effect (Nordhaus, 2015).

What makes the picture more complicated is, for instance, various feedback effects (which could either have cooling or warming effects) such as those that results from water vapor, clouds, surface albedo changes, and Planck feedback. Increased amounts of greenhouse gases in the atmosphere cause higher temperatures. A higher temperature then allows the atmosphere to hold more water vapor, and since water vapor is a strong greenhouse gas, the increased amount of water vapor in the atmosphere causes the temperature to rise even more. The feedback effect from water vapor is therefore said to be positive. Without clouds, the average temperature on Earth would be significantly higher than today, but not all clouds have a net cooling effect as different kinds of clouds have a different effect on the temperature. On average, clouds that are located on higher altitudes have a warming effect, while their lower counterparts typically have a cooling effect. The Earth's surface albedo explains how much solar radiation the Earth re-reflects to space. Presently, it is around 0.3, which implies that the Earth reflects approximately 30% of the inward solar radiation. The portion of the solar radiation which is reflected does not contribute to warming, however. A warm object radiates more than a cold object, or in the case of the Earth, a warm planet radiates more to space than a colder counterpart. As our planet becomes warmer, it radiates more energy to space, which in turn makes the globe colder and in parallel decreases the rate of warming. Thus, the Planck feedback constitutes a powerful negative feedback that cools the planet (Lewis, 2023).

Moreover, various tipping points make future predictions of the costs of climate change difficult to assess with vide margins of error (Cai & Lontzek, 2019; Wunderling et al., 2023). Tipping points constitute non-linear changes that may accelerate the damages of climate change (Nordhaus, 2015). Hence, climate models which account for probable costs under different assumptions may or may not include effects from tipping points.

Economic growth as a double-edged sword

The Nobel laureate in economics, William Nordhaus, is well-known for his work on the nexus between economics and climate science, in particular the Dynamic Integrated Climate-Economic Model, DICE. Nordhaus (2015) describes how climate change, specifically global warming, is a real problem which is primarily caused by economic growth via greenhouse gas emissions (e.g., carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, water vapor, as well as aerosols such as ammonia and black carbon). A large part of all economic production and infrastructure development is based on fossil fuels such as coal. First of all, if future warming is higher than expected (e.g., 4–5 degrees Celsius compared to 2–3) it could lead to a loss of biodiversity, ocean acidification, high costs to adapt (estimates typically vary 1–5% of global GDP, based on realistic assumptions), rising sea levels and many other net negative side effects. On the other hand, this is a very complex problem that requires a delicate balancing act. It is necessary to drastically reduce emissions of greenhouse gases (i.e., mitigation) but not to the extent that the economy is not growing at all. An expanding world economy is tantamount for the adaption and resilience of future climate change effects. In fact, Nordhaus is not particularly worried about many of the manageable sectors of the world economy and local markets such as healthcare and agriculture (Nordhaus, 2015). These are largely technology-based and as the economy grows in many developing countries and regions, the farmers may adapt to new circumstances. As Lomborg (2020) underscores, many of the more fatalistic scenarios of current and future climate change are based on false assumptions: that people will just sit idly and not adapt, that the world economy will not grow and so on. However, the business-as-usual (BUA) scenario is not an ideal one. In this scenario, governments and people in general will not do anything to tackle global warming. The world economy will grow substantially but at very high future costs, both market-based and non-market based such, which are associated with the effects of “unrestrained” warming. An example of economic loss are the costs associated with rising levels and more intense hurricanes and wildfires, while the extinction of many species is an example of a non-market loss. The optimal solution, according to Nordhaus (2015) and Lomborg (2020), is a combination of substantial mitigation (through carbon-based taxes), research and development, as well as adaption and a few other supplemental approaches to tackle future effects of climate change (e.g., Fakraee, M., Planavsky, & Reinhard, 2023). A larger and low-carbon intense future world economy can afford to deal with future costs relatively well, at least if global warming is limited to about 3 degrees Celsius (Nordhaus, 2015).

As Nordhaus (2015), Piontek et al. (2021) and many others underline, the quantification of economic and social climate change effects is complicated. Different research methodologies and models lead to quite disparate estimates (Cai & Lontzek, 2019; Nordhaus, 2018a, b; Nordhaus & Moffat, 2017; Piontek et al., 2021). A problem may be for example too simplified aggregates that do not distinguish between various sectors and sub-sectors of national markets. However, many of the best model teams could still implement different models with different but real assumptions. The year 2100 is typically set as a temporal goal post, which in turn introduces a higher degree of uncertainties compared to shorter timeframes, but as these processes are gradual it is also possible to consider intermediate effects in the middle of the twenty-first century. For example, currently it is interesting to see how much warming occurs until for instance 2060.

In a nutshell, Figure 1 illustrates how a researcher may account for both conventional production factors (e.g., human capital, natural capital), economic production, climate change, as well as social and ecological consequences from a warming planet. The ecological components constitute a Green-DICE model (e.g., Basten-Olvera & Moore, 2021). Figure 2, on the other hand, illustrates a tripartite interrelated parallelization flow pattern between economic growth (or production followed by output), climate change, and resilience. The double-headed arrows indicate that there is typically a bidirectional relationship between these components, as for example climate change also affects economic production. More and more companies in the world want to become "green" and "sustainable". Furthermore, economic production and output must focus more on new energy systems (e.g., solar, wind) and low-carbon emissions. In that regard one may say that climate change is "mediated" by human capital factors because it is a human discovery that causes changes in production mode rather than the climate per se on setting such changes. One may also add political and governmental decisions, both in Figure 1 and Figure 2. For the sake of simplicity, however, Figure 2 focuses on the three major elements. The resilience box is quite multifaceted once one starts to examine its underlying content and ideas. As Gallopín (2006) stresses, the meanings of central concepts such as resilience and vulnerability may differ between disciplines. In Chapter 4, which focuses on migration, vulnerability is not defined as the same phenomenon as when one pays attention to climate change (e.g., Gilodi, Albert, & Nienaber, 2022). Consequently, academic or psychological resilience are not the same as social systems or nations being resilient. To same degree the cross-disciplinary meanings may overlap, as human beings are affected psychologically by climate change (Tam, Chan, & Clayton, 2023) and war migrants and future climate migrants face adversity (Boman, 2023). Until the big economic and ecological effects emerge, discourses on climate change are sometimes more important than the effects themselves (Boman, 2021; Nordhaus, 2015). Furthermore, as they are part of colloquial language these may introduce further ambiguity and subjectivity. Nevertheless, in this regard I define resilience as a system-level capability to handle and adapt to climate change, first and foremost a higher average temperature and its current and future side effects. System-level vulnerability implies that larger units such as societies are vulnerable to climate change, regarding both its ecological, economic and social consequences. Governments in specific nations, informed by for example the IPCC reports, in conjunction with corporations and firms must handle the situation that occurs. On the micro and meso level, individuals, families and communities must also deal with various consequences such as higher energy costs or the need for installing an air condition system in the home (Masselot, et al., 2023), as well as consumption of electric vehicles, which have emerged to at least partly replace the petroleum-fueled vehicles (Nordhaus, 2015).

The emergence of resilience and adaption, akin to sound climate science, do not constitute atomistic phenomena that come out of nowhere. Indeed, these are created in a dynamic interplay between an ecological reality, a world of nations, and human activities in the economic, political, and scientific realms. Usually, governments or other actors sponsor research which may lead to the discovery of for example new energy systems that are fruitful to implement in a world which must cut carbon emissions. If these are possible to scale up (e.g., improved nuclear power, wind energy systems) they can have quite dramatic consequences for the world's future climate. Especially if that electricity can also be used for electric cars, trucks and ships (Nordhaus, 2015).

But not only scientific and engineering discoveries are funded. The basic infrastructure of our societies such as roads, bridges, houses, alarm systems, tracking devices, and communication systems – all necessary for the adaption to and resilience of likely climate change effects – are only possible to exist because of a certain degree of economic development among nations. That is also why these components, systems and mechanisms are more common and widespread in countries such as Japan and the US compared to the Philippines or Guatemala (Boman, 2021; Lomborg, 2020). As the Philippines, Guatemala and other countries with comparatively much lower GDP per capita levels experience economic growth, as well as cooperate with other states, they can more effortlessly tackle both natural disasters and probable side effects of future warming (Lomborg, 2020; Nordhaus, 2015). If, for example the economy of the Philippines grows with 4% annually, and there has been a reduction of victims from tropical storms and tsunamis at the same time, one may conclude that its level of resilience has increased. It is exactly what must happen in this and many other nations throughout the world. The local conditions matter greatly regarding the implementation of, for example, adaption to rising sea levels (Blankesport et al., 2023) and increased cyclone intensity (Wenzhong Huang et al., 2023).

But what if economic development is both necessary and hurtful? What is the optimal balance? According to Nordhaus (2015) and Lomborg (2020), it is reasonable to set the goal post to approximately 3 Celsius degrees of warming (from the baseline year 1900 until 2100).

Even that goal is complicated to accomplish as many big emitters such as China, India, and the US (Zhang, 2011; UNEP, 2022) are very different in terms of ideology and GDP per capita levels. It is easy to imagine that the average Chinese and Indian citizen are still more concerned about economic and health prospects than global warming, at least in the short term, compared to their American or Western counterparts. Still, it is important to focus on the big emitters. These are also possible to create some positive externalities such as research and development that the rest of the world can, depending on a country's developmental stage, benefit from (Lomborg, 2020; Nordhaus, 2015).

Another positive sign is that earlier resilience and adaption, which were consequences of natural disasters, shows that societies have so far been able to drastically reduce the number of victims from cataclysms by roughly 99%. Furthermore, wealthier countries are also keener on setting up national parks and nature reserves than their poorer counterparts (Lomborg, 2020). Hence, there are intricate relationships between economic growth, climate change, and resilience that must be considered.

Fig. 1: Green-DICE diagram, partly based on Basten-Olvera and Moore (2021).

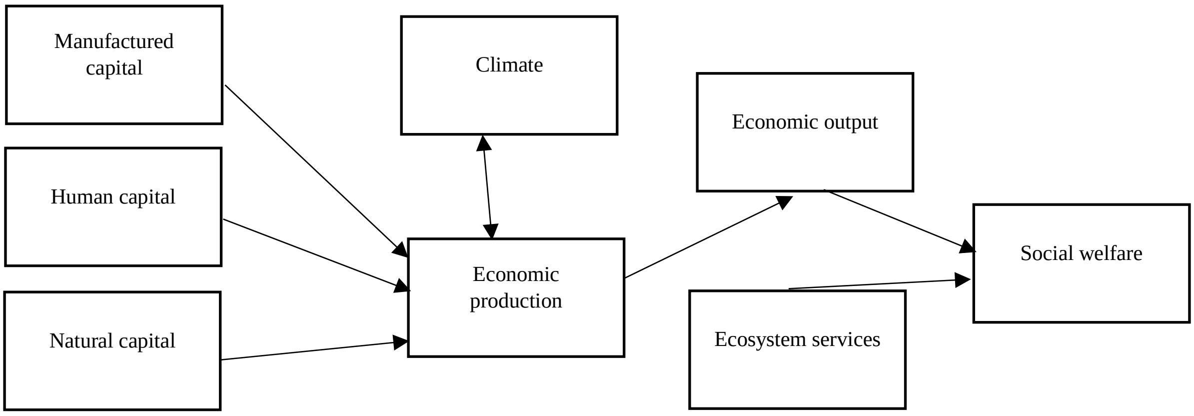
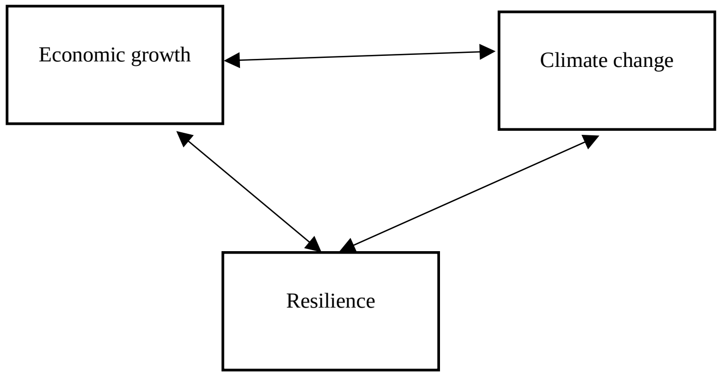


Figure 2: Parallelization framing of the climate change–economic growth nexus



Emissions data

Thus far, the overarching patterns of the parallelization of economic growth, climate change, and resilience have been established. Next, it is pertinent to examine current and future trends. The United Nations Emissions Gap report (UNEP, 2022) is an important source for credible data on recent emissions and trends in the nearby future. The document summarizes a number of key findings of which one is that countries are doing too little to tackle greenhouse gas emissions responsible for climate change (UNEP, 2022). However, based on Nordhaus's (2015) cost-benefit analysis, which aims for an optimal balance between mitigation and economic growth, the trends seem aligned with a realistic global warming trajectory at about 3 degrees Celsius (again, from the baseline year 1900 to 2100). Indeed, 2.8 degrees which UNEP (2022) points at is well above the ambitious 1.5- and 2-degrees goals but still not alarmingly high figures. Moreover, according to several scenarios posed by IPCC's APR working group there is roughly a 66% chance that temperatures will be below 1.8 degrees.

Furthermore, the report underlines that gradual implementation is no longer possible; only the implementation of broad and full-scale strategies is regarded a feasible way forward. Nordhaus (2015) accentuates the difficulties of coordinating national and local markets with regard to political decision-making, carbon tax systems and so on. However, the UNEP (2022) report still provides examples on how to more effectively and fruitfully implement changes. Politically, binding protocols such as the Kyoto protocol (implemented in 2005), the Copenhagen accord (2009), and the Paris agreement (2015) are important steps to concrete actions. Essentially, the aim is to reach the goal of less than 2 degrees of warming relative to pre-industrial levels. These accords underscore the importance of national actions and accountability under the aegis of an international framework. However, it does not stipulate how this should be done. There are a host of factors that contribute to the slow progress of ambitious plans to reduce green gas emissions. One is the geopolitical factor as the top ten emitters are the major countries in terms of population size and total GDP. Table 1 summarizes the size of emissions and major emitters.

Table 1: Total GHG emissions and major emitters

Countries	Emissions ($GtCo^2$)
China	15
USA	6
India	3.5
EU27	3.3
Indonesia	2
Russia	2.7
Brazil	1.5
International transport	1
Rest	X

Notes: Source: UNEP (2022). The numbers are rounded off.

Another reason is that per capita emissions are still the highest in the Western world, except for Russia (UNEP, 2022). National and global accountability must consider both total and average emissions in a realistic way. As Nordhaus (2015) emphasizes, any sophisticated cost-benefit analysis must account for the well-being of future generations. However, because current investments in for example constructive climate policies, technology and adaption are also to the benefit of future generations it is not wise to limit economic development too much at the benefit of costly climate policies. It hurts both current and future generations. Indeed, many countries commit to relatively vague policies such as mitigation targets being part of long-term strategies. That could lead to so-called free-riding, meaning that some parties (i.e., usually countries) benefit from the decisions of others while not contributing on their own behalf. Nordhaus (2015) suggests that a moderate carbon tax and penalties that are in accord with these in a global "climate club" could be a solution. Hence, states that do not follow their own nationally determined contributions (NDC) must face relatively severe "punishments" in an economic sense, partly similar to the sanctions against Russia in the aftermath of the Ukraine war (see Chapter 6). Of course, economic penalties and partial political isolation can only do so much. Hence, UNEP (2022) also stresses the removal of carbon subsidies, electrified transportations, implementation of zero-emissions technologies and many more investment strategies. Compared to Lomborg (2020), UNEP (2022) focuses less on adaption and resilience. Nordhaus (2015) underlines that mitigation is the most important factor in this regard. However, Lomborg (2020) argues that much of the solutions are also economic in nature. As I wrote in my article from 2021: "Economic growth is, at least at some point in history, like an armed robber who shoots a victim and then pays the hospital bill, in particular for the wealthy." (Boman, 2021). Hence, economic development constitutes both the problem and the solution.

Conclusion

Climate change is a real problem, predominantly caused by greenhouse gas emissions set off via economic production. The exact temperature and damage effects from greenhouse gas emissions is an intricate issue due to climate feedback factors such as clouds and albedo effects (Lewis, 2023). On the other hand, economic development via GDP growth is also a solution to many of the current and future problems which are associated with natural disasters and the effects of global warming. Reasonable estimates, derived from deterministic model assumptions, indicate that approximately 1–5% of the future global GDP must be allocated to tackle climate change effects such as rising sea levels, intensified hurricanes and wildfires, as well as climate refugees and related migratory processes. Some non-market effects (e.g., loss of biodiversity) cannot be assessed in purely economic terms but may be considered (Nordhaus, 2015). Other models, that focus on climate tipping points, show much higher cost estimates for future damages (Cai & Lontzek, 2019). The parallelization of climate change caused by economic growth and the resilience against climate change, likewise caused by economic growth, must be further highlighted and analyzed.

References

Bastien-Olvera, B., & Moore, F.C (2021). Use and non-use value of nature and the social cost of carbon. *Nature Sustainability, 4*.

Blankesport, B. Dasgupta, S. Wheeler, D. Jeuken, A. van Ginkel, K., Hill, K., & Hirschfeld, D. Linking sea-level research with local planning and adaption needs. (2023). Nature Climate Change, 13, 760–763.

Boman, B. (2021). Parallelization: the fourth leg of cultural globalization theory. *Integrative Psychological and Behavioral Science*, 55, 354–370.

Boman, B. (2023). Vulnerable women: Negotiations among migrant women in the aftermath of the Ukraine war. *Human Arenas*.

Cai, Y., & Lontzek, T. S. (2019). The social cost of carbon with economic and climate risks. *Journal of Political Economy*, *127*(6), 2684–2734.

Clarke, L., Edmonds, J., Krey, V., Richels, R., Rose, S., & Tavoni, M. (2009). International climate policy architectures: Overview of the EMF 22 international scenarios. *Energy Economics, 31*, 64–81.

Fakraee, M., Planavsky, N.J., Reinhard, C.T. (2023). Ocean alkalinity enhancement through restoration of blue carbon ecosystems. *Nature Sustainability*.

Gallopín, G. C. (2006). Linkages between vulnerability, resilience, and adaptive capacity. *Global Environmental Change, 16*(3), 293–303. https://doi.org/10.1016/j.gloenvcha.2006.02.004

Gilodi, A., Albert, I., & Nienaber, B. (2022). Vulnerability in the context of migration: a critical overview and a new conceptual model. *Human Arenas*.

Hausfather, Z., & Peters, G.P.. (2020). Emissions – the 'business as usual' story is misleading. *Nature*.

Kanzola, A-M. Papaioannou, K., & Petrakis, P.E. (2023). Environmental behavioral perceptions under uncertainty of alternative economic futures. *Technological Forecasting and Social Change, 190.*

Lewis, N. (2023). Objectively combining climate sensitivity evidence. *Climate Dynamics, 60*, 3139–3165.

Lomborg, B. (2020). Welfare in the 21st century: Increasing development, reducing inequality, the impact of climate change, and the cost of climate policies. *Technological Forecasting and Social Change, 156*.

Masselot, P. et al. (2023). Excess mortality attributed to heat and cold: a health impact assessment study in 854 cities in Europe. *The Lancet Planetary Health, 7*(4).

Nordhaus, W. (2015). *Climate Casino*. *Risk, uncertainty, and economics for a warming world.* Yale University Press.

Nordhaus, W. (2018a). Evolution of modeling of the economics of global warming: changes in the dice model, 1992–2017. *Climate Change, 148*(4) (2018), 623-640.

Nordhaus, W. (2018b). Projections and uncertainties about climate change in an era of minimal climate policies. *Am. Econ. J., Econ. Policy*, *10*(3), 333–360.

Nordhaus, W. (2019). Economics of the disintegration of the Greenland ice sheet. Proc. Natl. Acad. Sci., *116*(25), 12261–12269.

Nordhaus, W., & Moffat, A. (2017). A survey of global impacts of climate change: Replication, survey methods, and a statistical analysis. National Bureau of Economic Research, Cambridge, MA.

Piontek, F, et al. Integrated perspective on translating biophysical to economic impacts of climate change. *Nature Climate Change, 11*, 563–572.

UNEP. (2022). Emissions gap report. https://www.unep.org/resources/emissions-gap-report-2022?gclid=EAIaIQobChMIha7vipT__gIVW-nmCh0LRAVxEAAYASAAEgJa4fD_BwE (last accessed May 2022).

Tam, K-P., Chan, H-W., & Clayton, S. (2023). Climate change anxiety in China, India, Japan, and the United States. *Journal of Environmental Psychology, 87*.

Wenzhong Huang, MPH et al., (2023). Global short-term mortality risk and burden associated with tropical cyclones from 1980 to 2019: a multi-country time-series study. *The Lancet Planetary Health, 7*(8).

Wunderling, N., Winkelmann, R., Rockström, J., Loriani, S., Armstrong McKay, D.I., Ritchie, P.D.L., Sakchewski, B., & Donges, J.F. (2023). Global warming overshoots increase risks of climate tipping cascades in a network model. Nature Climate Change, 13, 75-82.

Zhang, Z. (2011). Assessing China's carbon intensity pledge for 2020: Stringency and credibility issues and their implications. *Environmental Economics and Policy Studies, 13*(3), 219–235.