The Challenge of Anthropocene Risks
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Abstract

The Covid-19 pandemic has been a stress test for our global society, with implications that go beyond the field of global health risks. The results give no reason for complacency. Analyzing this experience and stepwise implementing consequences will require a long-term effort involving scientists, decision-makers, and many more. The present paper offers a step in that direction. We argue that modern societies have developed risk governance systems that have achieved unprecedented successes in tackling conventional risks, ranging from many natural disasters to frequent accidents and illnesses. These successes are based on a remarkable interface between science and society. It combines scientific advances in mathematical representations of probability and utility with institutional advances in the formation of insurance markets and the development of regulatory networks. This interface informs modern risk management and governance, including the tradition of disaster risk reduction. However, Covid-19 is a paradigmatic example of disaster risks where that interface, while still necessary, becomes misleading when treated as sufficient in its present form. These are Anthropocene risks. They combine experiences of local disasters with an awareness of the global disaster they are part of. Other instances are the risks of climate change, of global financial crises, the digital arms race, biodiversity loss, and more. Anthropocene risks call for a transformation of the science-society interface. The literature on systemic risks offers important insights for this transformation. A crucial task is to integrate mathematical modeling with deliberation in ordinary language so as to create a joint learning process between scientists of different disciplines and stakeholders ranging from decision-makers to the people most at risk from future disasters. We present a method to achieve this, the Decision Theater, as one of hopefully many seeds for successful disaster risk reduction in the face of Anthropocene risks.

Keywords: Anthropocene Risks, Disaster Risk Reduction, Conventional and Systemic Risks, Decision Theater, Science and Society.
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Covid-19 and the Sendai Framework

The Covid-19 pandemic has confronted the world with a new kind of disaster (Mizutori and Hackmann, 2020; Shi and Jaeger, 2020). In China, Italy, the US, and many other countries, local disasters became parts of a single global disaster unfolding in slow motion. This was not the case with the 1918 Spanish flu. The historical Versailles peace conference, that ended World War I, took place with participants barely taking notice of the pandemic, whose death toll was of the same order of magnitude as the war itself (Spreeuwenberg et al., 2018; White, 2014). While that pandemic raged, governments that were redrawing the map of the world and designing the League of Nations didn’t see a need for large-scale countermeasures in their territories, let alone for trying to coordinate such measures internationally. With COVID-19, however, the awareness that disasters experienced locally in different places were parts of a single global disaster was established and intensified by three factors: the real-time media reporting, including images, videos and more; the global economic crisis triggered by the combination of the pandemic itself and the measures taken by governments to fend it off; and the worldwide scientific exchange about the pathogen, contagion dynamics, and the development of vaccines. For these reasons, the Covid-19 pandemic has already become part of the collective memory of humankind.

This experience is a wake-up call with far-reaching implications for the four priorities for action set in the Sendai Framework for Disaster Risk Reduction (UNDRR, 2015):

1) Understanding disaster risk
2) Strengthening disaster risk governance to manage disaster risk
3) Investing in disaster risk reduction for resilience;
4) Enhancing disaster preparedness for effective response, and to "Build Back Better" in recovery, rehabilitation and reconstruction.

To understand the implications of Covid-19 for the Sendai framework it is essential to acknowledge the precursors of the global disaster of Covid-19. With regards to pandemics, they range from HIV to swine flu to SARS to Ebola. But there are more, including the 2004 Indian Ocean earthquake and tsunami, witnessed in horror all over the world. Even people living far away from the Indian Ocean had friends or relatives spending Christmas holidays in the disaster zone with its huge death toll. Another instance of a disaster experience shared globally via media was the 2017 Tohoku earthquake, with consequences including another tsunami as well as the Fukushima nuclear disaster. The latter then led to the accelerated shutdown of nuclear power plants in far-away Germany, with major implications for European energy and climate policies.

Milanovic’s (2020) claim that the Covid-19 pandemic is the first global event in the history of humankind deserves careful reflection: “we shall all have the same stories to share: fear, tedium, isolation, lost jobs and wages, lockdowns, government restrictions and face masks. No other event comes close”. Precursors from HIV to the Tohoku earthquake already moved in that direction. Disasters have ceased to be local experiences shared directly by people living in the same region of the world, with people elsewhere becoming aware of them indirectly later on, or not at all. In the face of this shift in disaster experiences, the Sendai priority of “understanding disaster risk” becomes “understanding the fundamental change in disaster risks that is unfolding in the 21st century.”

The change is related to the fact that we humans are developing a shared awareness of the far-reaching impact our species is having on our local and global environments. These
environments include biophysical systems, but also natural languages, bodies of knowledge and know-how, as well as social institutions ranging from kinship structures to settlement patterns. The development of that awareness marks the beginning of the Anthropocene (Crutzen and Stoermer, 2000; Zalasiewicz et al., 2015).

Humans have changed the face of the Earth for a long time without being aware of their global impact (Marsh, 1864; Thomas, 1956; Turner et al., 1990; Roberts, 2019). The arrival of the Anthropocene marks a qualitative change of the human-environment relationship and the realization and acknowledgement of this change. The scientific efforts to identify first large-scale impacts of our species on the Earth are a key aspect of this emerging awareness. Another, not less essential, aspect is the fusion of two ways of experiencing the impact of human action on our environment: locally with our senses, embedded in face-to-face conversations, and globally with senses enhanced through scientific instruments, embedded in conversations taking place in a global fabric of communication media.

From the cave paintings of Lascaux to the Golden Gate Bridge, the local impacts of human action are often, although certainly not always, experienced as enhancements of a given environment. So far, however, our global environmental impacts are experienced mainly as deteriorating the environment and causing global risks – from those of climate change to the Covid-19 pandemic. A new kind of disaster risks has emerged: Anthropocene risks. P.W. Keys and colleagues from the Stockholm Resilience Center describe them as risks that “emerge from human-driven processes; interact with global social-ecological connectivity; and exhibit complex, cross-scale relationships”. (Keys et al., 2019, p.667). Their emphasis on global social-ecological connectivity and cross-scale relationships captures the fusion between local and global disaster experiences that is a hallmark of the Covid-19 pandemic.

The emergence of this new kind of disaster risk goes along with changes in systems of disaster risk governance (DRG). In a prescient paper, Jensen et al. (2015) described and analyzed the emergence of a globalized DRG system. They quote a crucial statement from the WEF (2014, p.9) Global Risk Report: “The systemic nature of our most significant risks calls for procedures and institutions that are globally coordinated yet locally flexible. As international systems of finance, supply chains, health, energy, the internet and the environment become more complex and interdependent, their level of resilience determines whether they become bulwarks of global stability or amplifiers of cascading shocks. Strengthening resilience requires overcoming collective action challenges through international cooperation among business, government and civil society.”

That statement is crucial because, as Jensen et al. (2015) point out, it addresses the Sendai priorities 2 and 3 by emphasizing the need of combining global coordination with local flexibility and of doing so in a perspective of strengthening resilience. But the statement does not yet go into priority 1. The changing nature of disaster risks remains unaddressed, and as a result the core of priority 4, i.e. learning to “Build Back Better”, remains utterly vague, pointing to the need for much more research and patient learning by doing.
Conventional Risks in the Modern World

To some extent, the changing nature of disaster risk at the beginning of the Anthropocene can be captured with the distinction between conventional and systemic risks (Renn et al., 2019; Lucas et al., 2018; Jaeger, 2016). We look at conventional risks first. These are the risks that modern societies have learnt to manage in highly effective ways by combining insurance markets with safety enhancing public regulations and investments. This approach originated in London after the great fire of 1666 (Rawlings, 2016; Museum of London, 2016).

Disaster risk reduction is much older, though. Since millennia, the main resource used by human societies to tackle natural and other disasters was solidarity based on gradually evolving social norms. This solidarity evolved from the scale of families and tribes, of villages and cities, all the way to polities, trade guilds and more (Wirtz, 2013). In contrast, modern risk governance is based on two highly abstract concepts of immense practical relevance. First came the idea of probability, introduced just a dozen years before the great London fire by the French mathematicians Pascal and Fermat (Lee, 2016). It allowed to put into business accounting not only the value of something, say, a ship, but also the expected value of an uncertain event, for example a ship coming back safely from a risky journey. Second came the idea of utility, developed nearly a century later by the Swiss mathematician Daniel Bernoulli (Bernoulli 1954 [1738]). It allowed to capture the phenomenon of risk aversion that lies at the core of insurance markets. The fact that people pay insurance fees to avoid some calamity can be represented by saying that they consider the certain utility loss from a regular insurance fee as much smaller than the possible utility loss of the calamity that they can avoid through insurance.

Conventional risks can be described by combining a utility function with a probability function indicating how likely different possible consequences of a given action are. This structure is common to the functioning of insurance markets and to the cost-benefit assessments made – explicitly or implicitly – by public authorities. To reach collective decisions, however, the fact that different people have different preferences (that may be represented by different utility functions) leads to the question of how to aggregate these preferences so as to reach some shared understanding of the common good. One of the key achievements of states is that they solve this problem for the people living in a national territory. They may do so in very different ways: there may be a monarch taking decisions on behalf of a given nation, leaders may be chosen according to one of many possible selection mechanisms, people may vote directly about which one of some alternative options they prefer, etc.

For disaster risk reduction, it is particularly important that a problem analogous to the aggregation of preferences arises with regard to probabilities. While science is in general not considered an authority with regard to what interests and preferences people should have and cultivate, science is able to estimate with more or less precision the probability of events like seeing a shooting star at night or getting lung cancer from smoking. However, assessing the probability of winning a war is usually quite a subjective affair. There are many decision situations where objective probabilities for different possible outcomes are not there to be found; but people still make decisions based on gut feelings about the relevant probabilities. This raises the question of how to aggregate these feelings, often represented as subjective probabilities, in such a way as to lead to a joint decision. States with a monopoly on the legitimate use of violence have procedures to address this problem, too – usually not by
establishing a consensus, but by being able to reach a decision considered legitimate by enough people so that it can be enforced if the need arises.

It is fair to say that over the past centuries many countries that are now industrialized have developed DRG systems with which they can keep the occurrence and consequences of a wide range of disasters within boundaries that by and large they consider acceptable (Renn et al., 2019, p.402). There is always room for improvement and there are disagreements and conflicts of interest, but in these countries floods, droughts, fires, plane crashes, industrial accidents, even hurricanes and earthquakes are seen by authorities and large parts of the population as challenges that can be successfully managed.

But DRG systems are much more than ways of coping with the fact that disasters are part of the human condition since the emergence of our species. The concepts of probability and utility, along with the seemingly boundless development of mathematical techniques they have triggered, have provided the cognitive resources needed to complement the institutions of states able to engage in international relations with the institutions of insurance and financial markets. On this basis, risky endeavours that would otherwise have been avoided became amenable to routine business activities, all the way from trade between Europe and the East Indies to launching satellites in orbits around the Earth. The result may be called the rational action paradigm (Coleman, 1988, Weber, 2019/1922). One of the many breakthroughs achieved on the basis of that paradigm are modern DRG systems.

One of the most important DRG systems originated in the US when in 1803 a congressional act was passed to provide financial assistance to a New Hampshire town devastated by fire (Haddow et al., 2017). This kind of interventions was scaled up in the framework of Roosevelt’s New Deal and has later led first to the Federal Emergency Management and more recently to the Department of Homeland Security. In the US as elsewhere, the tradition of disaster risk reduction would have been impossible without the rational actor paradigm, as this allowed both qualitative and quantitative assessments of the costs and benefits of alternative policy options. The focus on hazards, vulnerability, exposure, coping capacity etc. were steps to get a better understanding of the relevant probabilities and damages (i.e. losses of utility) and of possibilities to reduce them by interventions at different moments in the disaster management cycle (for a comprehensive exposition of the tradition of disaster risk reduction see Kelman et al., 2017).

The efficacy of these systems leads to two questions. First, how can countries without the material, scientific and cultural infrastructure available in highly industrialized countries improve their capability to manage conventional risks? Clearly, part of the answer is for those countries to develop the same kind of infrastructure. For reasons that are far from clear, a range of Asian countries have found ways to do so, but the majority of humankind lives under conditions where natural hazard triggered-disasters as well as industrial ones are still orders of magnitude more damaging and cruel than what modern DRG systems can establish (the relevant literature on root causes of development and underdevelopment is far from offering a robust consensus; as a sample compare Harrison, 2013; Henrich, 2020; Lucas, 2000).

The second question is how humankind can address the new kind of risks generated by the very success of the rational actor paradigm and the modern DRG systems enabled by that paradigm. That reminds of the saying “we can’t solve problems by using the same kind of thinking we used when we created them”, often attributed to Einstein. While he never literally said or wrote that, Einstein did indeed think along such lines (Einstein and Calaprice, 2011),
thereby capturing the challenge of understanding the fundamental change of disaster risks unfolding in the Anthropocene.

Systemic Risks and the Anthropocene

In the period from 1977 to 2017, more than 90 per cent of those who died in large-scale disasters were living in non-OECD countries (Gaillard, 2018). There can be little doubt that making modern DRG systems – based on the rational action paradigm and relying on the combination of insurance markets and regulatory networks provided by public authorities – accessible to more people in those countries would reduce the suffering from disasters. But while modern DRG systems are highly effective in dealing with conventional risks, including many kinds of natural disasters, "Given the pace of change, the traditional concepts of risk have become increasingly inappropriate as a basis of modern global governance" (Goldin and Mariathasan, 2014, p.27). The first time that this became apparent was in the global financial crisis of 2008. An important response was the emergence of a new research field focusing on systemic risks (Haas et al., 2020).

One often finds a tendency to consider a risk as systemic as soon as it threatens the breakdown of some system. This is misleading, as it would turn any risk of a bank run that leaves the bank destroyed into a systemic risk. One may try to fix this obvious weakness by adding ideas like the involvement of non-linear dynamics – but lots of bank runs involve non-linear dynamics without losing the familiar features of conventional risks: probabilities can be assessed, utilities inferred from the behavior of investors, and financial markets continue to thrive despite bankruptcies of banks and other financial intermediaries. Another approach tends to call risks systemic when they affect other systems outside of the system of origin. Again, this is misleading, as it would turn any risk of a bank run where the bankruptcy of the bank leads to losses of its customers into a systemic risk. State guarantees of bank balances, however, treat such risks as the kind of conventional risks states are familiar with as much as insurance companies.

Non-linearities are important for disaster risk reduction, of course, as are interdependencies between heterogeneous systems. The most promising work in these directions currently takes place in the field of disasters and complexity (Etkin, 2016). However, complexity as such is highly relevant to conventional risks, too. Cancer research and its importance for health insurance are a case in point. The novelty of Covid-19 and other Anthropocene risks is rooted in the multi-scale complexity linking local disasters with the danger of global catastrophes.

What made the risk of a financial breakdown after the Lehman bankruptcy in September 2008 a global systemic risk was the fact that “key decision-makers considered a collapse of the global financial system as perfectly possible and definitely catastrophic, which is why they took dramatic action to stabilize that system. When meeting at the Paris climate change conference in November 2015, key decision-makers considered not a collapse, but a catastrophic future of the global climate system as perfectly possible in the longer term, which led them to initiate a coordinated process to avoid such a future. More generally [...] agents are faced with a systemic risk if they believe that the possible futures at a global bifurcation point include developments that they deem catastrophic” (Renn et al., 2019, p.407).

A global bifurcation point here means a historical moment where very different futures are possible at a planetary scale, and where the actual course of events may depend on human actions and decisions that normally would have no influence at that grand scale. And catastrophic here means that a possible future is considered so dreadful that no trade-off with
previously normal benefits would be acceptable. In technical terms, the agents under consideration entertain lexical preferences with regard to the problem at hand – a perfectly reasonable preference structure, but one that excludes certain trade-offs that other agents might consider obvious. As an example, the Fridays for Future movement (Marquardt, 2020) is characterized by a clear refusal of global warming beyond the goal of the Paris climate accord even if such warming should promise additional consumption worldwide.

A fundamental problem with systemic risks like the ones of global financial crises, of global warming, rising inequality, pandemics, and more, is the fact that out of different possible global futures there is only one that we will actually know with some accuracy – the one that will be realized (Jaeger, 2016). There is an important lesson from the logic of quantum systems here. While different futures will have probability distributions for different variables, there are no joint probability distributions of all variables in all futures. That is why Fiedler et al. (2021, p.87) are right to emphasize, in view of climate risks, that “The rules by which climate science can be used appropriately to inform assessments of how climate change will impact financial risk have not yet been developed.”

For the same reason their statement that “Methods and procedures to manage and control climate risk should be developed as for any other type of risk” (Fiedler et al., 2021, p.92) is problematic. They rightly advocate a shift from one-way communication where climate researchers communicate their findings to businesses, who then process these results into financial risk assessments, towards a continuous two-way dialogue where such assessments are the outcome of an on-going exchange between the two groups. But there are two reasons why this dialogue cannot follow the path of conventional risk governance.

Not surprisingly, these reasons relate to the role of utility and probability. As far as utility is concerned, some conceivable global future may be considered catastrophic by some, bearable by others. As already stated, states have procedures to aggregate individual preferences into national interests. These procedures may be more or less fair and reasonable; the key point is that they are effective. At the global scale, no institutions with that capability exist.

With regard to probability, we have already noticed the fact that it may be impossible to identify important probability distributions in futures that will not be realised. What is more, if an agent – be it a company, a nation, an individual – wants to assess probabilities for possible outcomes of her actions she needs some probabilities for the actions by other agents. But in novel choice situations these probabilities are not there to be found.

These are not intellectual quibbles. “COVID-19 has been a stress test for our globalized society. The results, thus far, have not been encouraging. While responses and outcomes have varied across regions and countries, the pandemic has also revealed severe weaknesses in coordination at all scales, from local and regional to national and global” (Caniglia et al., 2021). “We have failed in our collective capacity to come together in solidarity to create a protective web of human security” (Johnson Sirleaf and Clark, 2021). The situation is similar in other areas of Anthropocene risks, like cybersecurity. “Risk governance models that have worked well in the past for physical and financial assets are, for the most part, proving inadequate for cyber risk” (Sumner et al., 2020). At the present stage, we are far from a DRG system that would be adequate to the realities of the Anthropocene and the global systemic risks it engenders (Centeno et al., 2015). It may well be that at the global scale different nations, interest groups, people and organizations differ so much in their preferences.
and their guesses about the future that for effective coordination to become feasible far-reaching institutional and procedural innovations will be indispensable.

Transforming the science-society interface

Developing the knowledge, institutions, and practices called for to tackle Anthropocene risks will take at least several decades. Redefining the global financial system beyond its present Dollar-centered and risk-prone structure, e.g., cannot happen over night (Haas et al., 2020). For global climate policy to achieve the goal of climate neutrality by the declared deadline of 2050, i.e. three decades from now, huge obstacles need to be overcome. During these decades, we will need to develop methods to deal with Anthropocene risks, the faster the better. The next step, then, is to develop methods of inquiry that allow to assess in novel ways the local and global dimensions of Anthropocene risks in view of different courses of action.

The required methods must be able to deal with complexity, ambiguity and diversity so as to achieve a fusion of local and global contexts. Complexity needs sophisticated use of information technologies to best capture and communicate scientific research in the face of deep uncertainty (Walker et al., 2013); addressing ambiguity requires human conversations rooted in ordinary language, while understanding and managing diversity demand the combination of both. In any case, science and society need to learn together at local and global scales in ways that imply a deep transformation of the present interface between science and society.

An example of a research method that offers important opportunities in this regard is the Decision Theater (Boukherroub et al., 2018, Roach, 1986, Tolle, 1971). After a long period of experimentation, mainly performed at Arizona State University (ASU, 2020), the Decision Theater methodology has now reached a stage where it can be implemented as a format for joint inquiries bringing together researchers and stakeholders interested in how to act in the face of specific systemic risks (Wolf, 2021, Global Climate Forum, 2018).

The basic approach of the Decision Theater (DT) is to integrate empirical data, interactive modeling, and a transdisciplinary dialogue format in a sequence of sessions of two or more hours where stakeholders discuss among themselves and with researchers about the risks in question, be they those of climate change, financial crises, pandemic, and more.

As an example, consider the question what a collective – be it a village, an organization, a city, a nation, etc. – may learn from the experience of a pandemic. Quite often, communities learn very little from disasters: they go back to the way they operated before, until the next disaster hits. On the other hand, leaders of a given community may decide to invest in resources that will be helpful in view of a return of the same kind of pandemic, perhaps by expanding intensive care units although they will be idle most of the time, and although the next pandemic will need a different kind of resources. Or people may change their ways of greeting, avoiding contagion pathways by not shaking hands anymore but finding other greeting rituals in everyday life.

In such a situation a DT may gather a random group of members of the community in question and start with an open discussion about the painful experience of the last pandemic. Science enters via an exploratory computer model of how a next pandemic – most likely quite different from the last one – might unfold. Where official data are lacking, search engine statistics, remote sensing, etc. often provide equivalent or even better data. The participants are offered a choice between a small number of options, perhaps the ones of doing nothing,
investing in more intensive care units, or changing greeting habits. They discuss these options and choose one they want to experiment with in the model.

The model has a multi-agent structure and some of the agents in the model are similar to the participants in the DT. The key point is to represent the relevant decision-makers, including stakeholders like those involved in the DT event, in an interactive multi-agent model that people can experiment with and that researchers may modify as a result of the discussion (Bishop et al., 2008, Parrott, 2017, Voinov and Bousquet, 2010). Whatever option the group will choose, the model will display possible consequences based on the state of research. It is essential that the model offers more than one possible consequence – by pure chance, doing nothing may turn out to result in a rather successful way of coping with the next pandemic, but it may as well increase vulnerability in dramatic ways.

After having jointly experimented with the model, the group reflects on the experiences they have gathered. This last step is usually the most important one, be it for decision-makers, for researchers, and for participants who usually don’t try to play an active role in shaping the future of their community. The reflection on the shared experience may well lead to criticism of the model, challenging the researchers to introduce other options for action in the model – perhaps establishing exchanges of experience with other communities who experienced the same pandemic, or creating regular events about public health in the community, etc.

The Decision Theater method builds on the focus group methodology, well-established in social research, environmental management, and other fields (Nyumba et al. 2018). But by involving the researchers in an iterative process of modifying their models of the situation, the DT engages them in a learning process absent in traditional focus group research: it challenges the models researchers have of the situation, and this in turn enables them to tailor their models to the actual needs of decision support.

The last point is of critical importance for actual decision-makers. Faced with an urgent decision problem that requires scientific input, as is the case with a pandemic, the data and models offered by science are usually shaped by the internal logic of scientific research, not by the actual decision situation. Virologists may have models of a critical virus, its properties and its effects under different conditions, and their models are as indispensable as they are impressive. But whatever decision a person in a position of authority may take, a crucial question is what degree of compliance she can expect in the specific conditions met when implementing that decision. This requires a different kind of knowledge, and building models combining just these two kinds of expertise is already quite a challenging task. In reality, many more kinds of expertise matter, and usually none of them is complete, leading to problems of deep uncertainty. For the decision-maker, this need not be a huge drawback. The hardest part of making a decision in the face of a complex problem is not to identify the best option, but to be creative in finding viable options that were unknown or simply ignored so far. In the final reflection phase of the DT event, skilled decision-makers can be challenged and inspired to mobilize exactly that kind of creativity.

After the researchers and the decision-makers, the third key group are the rather passive members of the community under consideration. In a way they may also discover a new option of future behavior, namely, becoming more active and engaging with other community members. In many situations, this is one of the most important learning steps a community can undertake in the wake of a disaster. A spirit of community and mutual responsibility is one of the most valuable cultural resources that makes a community more resilient. This can be investigated in terms of social capital as in the classic paper by Coleman (1988), in terms of
social norms as in the work of Nobel laureate E. Ostrom (2000), and research using the DT methodology may lead to further approaches.

The DT method offers a new kind of interface between science and society, complementing the more traditional interface that has served modern societies so well in the management and governance of conventional risks. The traditional interface supports the governance of conventional risks by enabling society to solve problems on the basis of reliable knowledge provided by science. This process is typically based on an information flow from scientific publications to briefing documents prepared for decision-makers by their staffers, and used by decision-makers in the search for the optimal, or at least a satisficing strategy. This conventional interface is one of the great achievements of modernity, and it will be more, not less important in the beginning Anthropocene. But it will lose its dominant role by being complemented by a kind of interface where science helps to formulate problems that can only be solved in processes of joint learning and discovery, as presently discussed under the heading of a co-creation of knowledge (Ruoslahti, 2020).

In view of Anthropocene risks, an important example of questions that science can help formulate and clarify, but cannot answer on its own, are questions of timing in risk governance. Consider the risks of sea-level rise in coastal cities, usually due to a combination of subsidence and climate change. To manage these risks, it is crucial to start the necessary investments early on, but without locking-in the city in question in a trajectory that miss more favorable opportunities if one would take the time needed to learn what kind and amount of investment fits the bill (Hinkel et al., 2015).

Sticking to the Anthropocene risks of climate change, an even thornier timing question arises when considering the sequencing of investment for mitigation. On the one hand, it would look nice to start reducing all greenhouse gas emissions at the fastest speed possible in the short run. But attempts in this direction may miss important learning opportunities, both by gathering new experiences and by observing the experiences of others. On the other hand, a simple strategy of wait and see as long as possible would have disastrous consequences at a global scale.

Science can and should help formulate this kind of timing questions in detailed and reliable ways. The results would be questions and elements of answers, but there is no optimal strategy to be found here, be it by science or by anybody else. The Decision Theater can help tackle this challenge by establishing well-structured deliberations aiming at robust actions (Ferraro et al., 2015). These are actions that, without claiming optimality, satisfy a set of reasonable criteria, send useful signals to other agents, and are open to substantial amendment in light of new evidence. Because the governance of Anthropocene risks needs to consider machine-processed data and sophisticated computer models, this requires a co-production where a digital decision support system is continually amended on the basis of the deliberations using it. The DT method is useful for this kind of purpose.

Of course the DT is but one method for science and society to learn how to address Anthropocene risks. There will be others, and there will be new insights we cannot anticipate. What we can know is that science will not find a recipe for successful governance of global systemic risks that humankind will then happily implement. Such governance can only emerge out of a coevolutionary process involving the continuously changing world of science together with the existing and emerging institutions and collectives that enable humankind to shape its global environment.
Conclusion

Anthropocene risks confront humankind with an unprecedented challenge. Believing that we can master it with the existing knowledge and instruments is not only mistaken, but a fallacy that will amplify the disasters we will have to deal with. The DT offers a useful new instrument, but much more will be needed, starting by carefully taking stock of the rich toolbox provided by disaster risk science in view of this new challenge. We do not need to go into this task here, as it has been prepared by the huge work of Shi (2018) and Shi et al. (2020, see also Joint Research Centre, 2014). In the same spirit, the rich tradition of risk analysis has to be harnessed for the new challenges we are faced with.

In view of Anthropocene risks, the insights and tools available for the analysis, management and governance of conventional risks, and especially for conventional disaster risks, will continue to be useful and often indispensable. But the new kind of risks will require complementing that toolbox with new methods, concepts, and empirical data. And it will require a new role of science, not as the ultimate source of reliable knowledge, but as a partner in the co-creation of knowledge necessary to tackle Anthropocene risks (Caniglia et al., 2021). It will not be sufficient to bring different scientific disciplines to the task in a cooperative fashion – hard as that is –, rather it will be essential to create a true dialogue between researchers and stakeholders. The common language of such conversations cannot be some fancy scientific terminology, but has to be based on natural language, used in such a way as to enrich specialized terminology in order to create mutual understanding and trust. The important investigations about transdisciplinary research of the past years have shown that such an approach is both feasible and necessary (Byrne et al., 2016, Hirsch-Hadorn, 2006, du Plessis et al., 2014, Mielke et al., 2016).

The joint inquiry aiming at global DRG systems adequate to the demands of the Anthropocene is likely to take decades. The reason is that such a DRG will need new institutional settings at a global scale. Again, Covid-19 provides essential insights (Laubichler et al., in preparation). The WHO is an example of an institution providing steppingstones on the long road to a DRG system needed in the health sector of the 21st century. As Bowles and Carlin (2020) argue, such a DRG system cannot be based solely on the interplay of nation states and market-oriented businesses. Additional regulatory structures and platforms for knowledge exchange and decision-making will be needed, perhaps building on scientific associations, on today’s NGOs, and including future trade unions as well as professional associations.

In a similar way, the UNFCCC process may provide steppingstones on the path towards a DRG system for the energy sector beyond the fossil age. At some stage, institutions like the IMF may play a similar midwife role for the financial sector, the IEEE for managing the systemic risks of cyberspace. The joint inquiry about the systemic disaster risks we will face in the 21st century might result in a polycentric ecosystem of global, national, and local institutions as envisaged by Ostrom (2009). Ideally, this would enable nations to peacefully respect each other’s sovereignty while coordinating their actions with whatever institutions will emerge out of the interest to jointly shape a global future where systemic disaster risks are no more the threat we are facing today.

The development of the rational action paradigm has helped reduce conventional disaster risks; moreover, it has opened up opportunities to enhance the well-being of at least a considerable part of humankind. The development of new ways of thinking and acting that will help reduce Anthropocene risks, on the other hand, holds promise not only of avoiding global
catastrophes we are presently struggling to avoid, but also of unlocking a potential of unprecedented prosperity for humankind as a whole.
References


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