IRGC workshop on Slow-Developing Catastrophic Risks (SDCR) held on 24-26 August 2011, in collaboration with the Istituto Veneto di Scienze, Lettere ed Arti, in Venice

Over the course of 3 days, IRGC convened a small group of scientists and policymakers to explore the topic of how to avoid the catastrophic consequences of certain risks, which develop slowly and are thus often "invisible", with their main impacts becoming apparent only in the long term. The term "catastrophe" is used to describe a tipping point, a critical transition, regime shift or even a collapse, but does not imply any judgement about whether the change is good or bad. Some of the main outcomes of their exploration are presented below.

Slow-developing catastrophic risks (SDCRs) often arise from complex systems. Ecosystems, for example, are associated with a number of important SDCRs, where tipping points, if reached, can lead to regime shifts with significant consequences, even total collapse. Desertification, depletion of water resources and biodiversity loss are such risks. In complex socio-economic systems, too, SDCRs deserve greater policy attention. Gradually progressing demographic imbalances in many societies may cause social unrest or unaffordable health or pension expenditures, leading to long-term fiscal risks and unsustainable levels of public debt. The increasing complexity of financial markets and systems also has the effect of "hiding" the warning signs of growing imbalances and masking the slow movement towards potential collapse.

How to characterise SDCRs

To characterise SDCRs, we can first use the following elements:

- change takes place so slowly that the risk may not be noticed, or it may be ignored because no adverse outcome appears imminent
- asymmetry of information and moral hazard may be present
- we are interested in imperceptibly drifting systems (open dissipative system with many degrees of freedom) with bifurcations
- the risk is at an early stage of knowledge, it is still under-analysed and not understood

Additional questions include:
Relating to the intrinsic features of the risk:

1. Is it difficult to identify the elements of the problem and understand how they relate to each other? (Is the analytical part difficult to deal with?)
2. Is it possible (or almost possible) to model the risk and its evolution? (We thus exclude many low probability high impact risks, where catastrophes occur suddenly with little to no warning, or without slow build up)
3. Are there interconnections with other risks? (Most SMCRs evolve in interconnected systems)
4. Do awareness, perception, culture, or values play a role in understanding the risk?

Relating to the science-policy interaction about the risk:

5. Is it difficult for scientists to communicate the risk to decision-makers?
6. Are scientists able to make recommendations that policymakers will find actionable and realistic? (Being pragmatic, is there anything serious that can realistically be done about it?)

Relating to the management of the risk:

7. What is the degree of rationality applied in the current management of the risk? (bounded political rationality)
8. Is it difficult to establish risk ownership and risk liability?
9. Are there conflicts between stakeholders' values and interests?
10. Is the risk politically and economically "difficult" to deal with? (For example, are we faced with a social dilemma, a public good, or a commons problem? Do we know what we want? Do we have in mind a 'desirable outcome' of risk management?)

Is modelling able to simulate the evolution of such risks?

Tools have been developed for improving the anticipation and management of critical transitions/catastrophes. Modelling has its limitations, but both statistical and dynamic models exist that can and should be used for understanding and anticipating changes in systems.

Changes in complex adaptive systems

Our society and the world we live in are complex adaptive systems – networks of individuals whose interactions reflect on each other, often in a highly non-linear way. These interactions may be broadly classified as stabilizing negative feedback loops and destabilizing positive feedback loops.
We are concerned with slowly changing systems where dominating negative feedback processes give an illusion of stability, but which are in fact slowly changing and moving towards a point where positive feedback and other runaway destabilizing processes take over and take the system to another, often less desirable state. Most real life systems, from families to forests, from stock markets to the sea, from economies to ecosystems, are of this nature. The problem (if it is a problem; sometimes the transition can be to a "better" state) is built in.

We are particularly concerned to identify systems that are approaching such critical transitions and to provide warnings to the individuals and communities involved in time to take effective action, either to prevent or modify the transition or to adapt to its consequences.

Are there warnings that precede regime shifts and can help anticipate them?

Statistical analysis of how a system as a whole is changing over time, or dynamic analysis of the processes that are happening within the network itself, can reveal warning signs that a system is approaching a critical transition. The warning signs that scientists have so far been able to identify come into two broad classes:

- Statistical analysis of how the system as a whole is changing with time.
- Dynamic analysis of the processes that are happening in the network itself.

However, because these modes of analysis are neither simple nor easy, the results are often not easy to turn into policy – it can be difficult for scientists to give advice that is not punctuated by caveats.

Statistical analysis has revealed that systems approaching a critical transition display a characteristic set of warning signs. These warning signs include increased variability, slower recovery from perturbations (to respond or adapt to change, which is know as "critical slowing down", increased autocorrelation, flickering and stochastic resonance, among others. Statistical signatures for critical slowing down include an increasing occurrence of extreme states and increasingly wild swings between extreme states.
Dynamic analysis means trying to understand the actual processes that are going on in the network and predicting their consequences. This is impossible at the micro-level, but may be useful at a more "coarse-grained" level. For example, we know that "decoupling" some networks (such as those of international banking) can help to prevent the collapse of one part spreading rapidly to other parts.

Neither of these approaches is at all easy. Statistical analysis means collecting large amounts of relevant data. This can be impractical, although the amount needed can sometimes be reduced by using a suitably generalized model. Dynamic analysis of networks is also at a fairly elementary stage. These problems mean that it can be difficult for scientists to give advice that is not surrounded by caveats. For example, reducing the linkages in a network can make it less susceptible to shocks, but also less efficient. Increasing the number and strength of the linkages can make it more efficient, and also more able to resist random shocks, but at the same time render it vulnerable to targeted attack.

How can scientists and decision-makers work together to deal with these risks and act to avoid or modify adverse outcomes?

Getting people to heed and act on the warning signs, even when those signs are relatively unambiguous, is a major problem, especially when those signs point towards global catastrophes. The tragedy of the commons is alive and well when it comes to coordinated action between nations, or even between individuals in a community. The key is communication, and showing how the coming transition, and also the warning signs that precede it, will hurt individuals and communities in the two places that matter most – in the hip pocket, and in their lifestyle. These concrete facts need to be identified and communicated effectively if individuals and communities are to be convinced to take action now, rather than when it is too late, in dealing with slowly moving changes that have potentially catastrophic consequences.

There is a natural gap between the scientific and policymaking communities: policymakers need actionable results, are often frustrated by the limitations of the science and may oversimplify reality, while scientists may not understand the constraints of policymaking and the limits of bounded political rationality. The interests and responsibilities of scientists and policymakers may be quite different, but the two groups must learn to communicate in a way that is useful for both – such communication should be bi-directional and structured in such a way as to prioritise clarity and understanding (and avoid information overload). In this respect, building trust and issues of perception are key, as distrust and mutual misperceptions are obstacles to building a constructive relationship. These issues matter also for relationships between scientists and policymakers on the one hand, and the general public on the other hand.

Policymakers and scientists alike must also consider the 'human factor' in their analyses and decisions. Many SDCRs may be human induced, for example as a result of previous policies creating the wrong incentives. Reward structures, moral hazard and incentives must be considered in the context of human behaviour and cognition (cognitive biases, deterministic thinking and subjective perceptions of probability) since these human factors could not only impact the course of the risk's slow development, but also provide targets for action to mitigate of modify the risk.

What can policymakers do to avoid undesirable catastrophes/regime shifts?

Policy-makers need to ask themselves a number of important, pragmatic questions as to how the science of complexity can be best used for policy purposes when addressing slow-moving risks:

- What is the goal? Is it to monitor or to control? What decisions need to be made?
- What is the best tool for the job? To focus on statistical warning signs or on the dynamics of the system?
- Over what time scale does policy need to be implemented? Is this possible in practice? If not, what can be done to improve the situation?
- How can we get away from a reliance on warning signs?

Countries and governments differ in how they approach long-term challenges and how they use science and knowledge in dealing with them. Some countries focus on the necessity to reason in rational terms, and to stay as close as possible to fact-based and science-based recommendations. For example, if long-term availability of water resources is at risk, strong regulations, incentives and technical systems will be put in place to ensure sustainable provision. Other countries rely on building a strong national identity and sometimes ideological leadership, to adopt solutions that are supported by strong and effective leaders. In this way, even unpopular decisions can be made, for the sake of preserving long-term sustainability and avoiding systemic collapse. The third group of countries relies on a combination of scientific knowledge and public concern. These countries want to give a voice to the public at large and favour inclusive processes for solving, collectively and in a coordinated manner, some of the potential problems that slow-developing catastrophic risks can cause.

In conceptual terms, all three approaches have their pros and cons. This reflects the fact that science and society need a good fit and that this fit may differ between countries. No policymaker would say that science is unimportant to him, but the way scientific advice is integrated in public decision-making is and will continue to be a challenge in the years ahead.

Can an intellectual framework support efforts to deal with these risks?

We believe that an intellectual framework will not do the whole job, but it can nevertheless provide generic guidelines to (a) identify and characterise the risk (possibly in a way that fragments it into sub-elements that can be more easily dealt with); (b) assess and anticipate future evolutions; (c) evaluate whether a policy decision can and needs to be taken; (d) develop management options; (e) decide upon and implement governance schemes; and (f) successfully communicate what is happening at each stage of the process.

A characterisation and taxonomy of SDCR will help to improve their recognition and management. It would be useful to develop these, in the next stage of IRGC's initiative on SDCR.

How can policy makers better deal with SDCR?

Governments are ultimately responsible for safeguarding long-term sustainability, and may be interested in considering the following guidelines for managing SDCR:

- Be as rational as possible in the face of difficult trade-offs, explain and communicate about the need to rely on and use scientific knowledge.
- Identify who can "own" the SDCR. Risk ownership, a term used to describe the fact that only those who have a personal stake in a risk will effectively deal with it, refers to creating links between cause and effect, between risk and reward. By identifying a possible reward for those who decide to engage and spend money to mitigate an SCDR (who will get return on their investment), the chances of successfully dealing with it will be higher.
- Establish political and business links between risk and opportunity. Communicate about such opportunity.
- Learn how to better manage moral hazard by looking to some of the organisations that habitually face, and deal with, such issues (in particular the insurance industry). Many SDCR involve moral hazard in the sense that they are created by some but affect others, who have little capacity to act on the source. The insurance and financial sectors have developed methods for dealing with the secondary risks created by the mitigation of the primary risk.
- Work on improving risk absorbing systems and building resilience in order to decrease overall vulnerability.
- Provide positive incentives and rewards for 'good behaviour', as a way to make people accountable for their acts.
- Communicate, in particular to raise awareness and to create an appropriate risk culture, but don't necessarily look for consensus.