Resilience to Global Catastrophe

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Introduction

The field of global catastrophic risk (GCR) studies the prospect of extreme harm to global human civilization, up to and including the possibility of human extinction. GCR has attracted substantial interest because the extreme severity of global catastrophe makes it an important class of risk, even if the probabilities are low. For example, in the 1990s, the US Congress and NASA established the Spaceguard Survey for detecting large asteroids and comets that could collide with Earth, even though the probability of such a collision was around one-in-500,000 per year (Morrison, 1992). Other notable GCRs include artificial intelligence, global warming, nuclear war, pandemic disease outbreaks, and supervolcano eruptions.

While GCR has been defined in a variety of ways, Baum and Handoh (2014, p.17) define it as “the risk of crossing a large and damaging human system threshold”. This definition posits global catastrophe as an event that exceeds the resilience of global human civilization, potentially sending humanity into a fundamentally different state of existence, as in the notion of civilization collapse. Resilience in this context can be defined as a system’s capacity to withstand disturbances while remaining in the same general state.

Over the course of human history, there have been several regional-scale civilization collapses, including the Akkadian Empire, the Old and New Kingdoms of Egypt, and the Mayan civilization (Butzer & Endfield, 2012). The historical collapses are believed to be generally due to a mix of social and environmental causes, though the empirical evidence is often limited due to the long time that has lapsed since these events. For example, the Akkadian Empire in Mesopotamia, approximately 4,300-4,200 years ago, is believed to have collapsed due to military destruction of economic networks and possibly also climatic drought or other environmental stressors, though the role of environmental stressors is controversial, and the Old Kingdom of Egypt, approximately 4,700 to 4,200 years ago, is believed to have collapsed due to a succession struggle following the long reign of Pepi II, Akkadian military destruction, and a catastrophic failure of the Nile (Butzer, 2012).

While these historical collapses provide some insight, the collapse of modern global civilization would be unprecedented. Modern global civilization is of a scale and complexity that is fundamentally different from the civilizations that have previously collapsed. Civilization today has tightly interconnected global networks, advanced science and technology, and a population of over seven billion. None of the historical civilizations had anything close to this. These features of modern

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global civilization can increase its resilience in some ways and decrease it in others. For example, global trade enables populations in one part of the world to help out populations in another part of the world during a regional catastrophe, but global just-in-time supply chains can cause cascading global failures due to failure in one link of the chain.

The lack of direct precedent makes GCR a difficult class of risk to analyze. Neither the probability nor the severity of global catastrophe can be directly quantified using historical data. Likewise, it is difficult to say just how resilient global human civilization is to global catastrophe—how severe an event global human civilization can endure without collapsing. It is nonetheless important to study the matter, in order to assess how serious the threat of collapse may be and to evaluate potential opportunities to increase humanity's resilience.

Risk vs. resilience for global catastrophe

Risk and resilience are both conceptual paradigms for helping understand and address potential adverse events. The risk paradigm tends to emphasize quantitative evaluations of the probability and severity of potential adverse events and the effect of policy measures on the probability and severity. The resilience paradigm tends to emphasize the capacity of a system to cope with, recover from, or otherwise endure adverse events that may occur (Walker, Anderies, Kinzig, & Ryan, 2006; Park, Seager, Rao, & Convertino, 2013).

It has been proposed that the resilience paradigm may be more appropriate for highly uncertain potential adverse events (see Park et al. 2013). The basic idea is that, in the absence of robust information about a threat, a sound approach is to focus on increasing resilience, on grounds that certain measures can increase a system's resilience to a wide range of threats. For example, households can increase their resilience to many threats by stockpiling food, water, medical supplies, and other basic necessities. These measures can be helpful even if it is not known which threat will manifest.

Similarly, certain measures may increase the resilience of global human civilization to a wide range of threats (Jebari, 2015). For example, civilization could establish dedicated refuges to protect select populations during a wide range of global catastrophe scenarios, including "surprise" scenarios that may have not yet been imagined. Thus, refuges have been considered as a response to GCR (Baum, Denkenberger, & Haqq-Misra, 2015; Jebari, 2015; Turchin & Green, 2017). Given the ambiguity inherent to global catastrophe, this perspective suggests an important role for resilience in policy for global catastrophe.

An alternative perspective proposes that the risk and resilience paradigms are both appropriate for these sorts of ambiguous threats (Baum, 2015). Per this perspective, resilience measures can be quantified as policies to reduce the severity of an event if it occurs. It may be difficult to quantify the effect with precision, but the risk paradigm is capable of handling imprecise quantification. There can presumably be at least some basic quantification, such as the assessment that the resilience-increasing measure decreases the risk instead of increasing it. Furthermore, whereas the resilience paradigm focuses on reducing severity, the risk paradigm also includes reducing probability. For many GCRs (and other risks), there are important policy opportunities to reduce the probability that should not be neglected by focusing on resilience.

It is nonetheless the case that the field of GCR often neglects resilience. One reason for this may be that scholars of GCR tend to come from intellectual backgrounds in which resilience is not prominent.

Another likely reason is that attention goes primarily to how to prevent global catastrophes from occurring, with limited attention to how to respond to these events if they occur (Maher & Baum, 2013). Some focus on prevention is warranted—it would certainly be better if global catastrophes did not occur in the first place. However, prevention is not guaranteed to succeed, suggesting an important role for measures to limit the severity. The resilience paradigm can draw attention to this side of the issue and provide insights into what to do about it, which is a valuable contribution.

This raises the question: how resilient is humanity to global catastrophe? Answering this question requires covering some details that are distinct from resilience at smaller scales.

On the extreme end is the concept of minimum viable population (MVP), defined as the smallest isolated population that has a high (commonly 90%) probability of surviving for many generations. MVP is mostly used in conservation biology for non-human species, but in the context of GCR, it applies to the human species. The human MVP has been estimated variously at 150 to 40,000 (Lynch, Conery, & Burger, 1995; Impey, 2015). A resilient human population would need at least this number of members co-located and able to reproduce. This idea has been taken up in proposals for dedicated refuges to ensure a viable survivor population (see Jebari, 2015).

On the opposite end is the possibility of collapse from much smaller catastrophes. At issue here is the fragility of global civilization. It is often observed that small initial events can cause cascading effects, toppling relatively large systems. However, regional catastrophes leave other regions intact and able to assist with the recovery. An important open question is what it would take for there to be a global failure, such that there would not be a recovery. This sort of question is studied in the field of global systemic risk (see Centeno, Nag, Patterson, Shaver, & Windawi, 2015).

Drawbacks of resilience to global catastrophe

An important question for all efforts to increase resilience is whether doing so reduces interest in preventing adverse events from occurring, an effect sometimes referred to as moral hazard. There is some precedence for this effect in the context of GCR. For example, civil defense for surviving nuclear war has generated concerns that nations would attempt to fight and win instead of focusing on deterrence and prevention (Weinberg, 1969).

There is reason to believe that moral hazard is relatively limited for GCR. This is because global catastrophe is likely seen as so overwhelmingly horrible that the only sensible policy is to prevent it from occurring in the first place. Such an attitude is a plausible explanation for why there is so little attention to resilience to global catastrophe. Additional attention to resilience may be unlikely to make people inclined to accept the onset of global catastrophe. Alternatively, belief in the resilience of human civilization could prompt some to underestimate the severity of some global catastrophes. An extreme example of this is in the argument that human extinction risks are categorically more important than sub-extinction GCRs, an argument that is often found in the GCR literature (see Parfit, 1984; Matheny, 2007). However, this argument implicitly assumes a long-term resilience of human civilization, such that there would be a full recovery from sub-extinction global catastrophes. A recent study finds that this assumption lacks empirical support (Baum et al., 2018). More generally, belief that human civilization could endure major shocks could reduce interest in reducing GCR. However, this matter has not been studied rigorously, and definitive conclusions cannot be made at this time.

How resilience can reduce the risk of global catastrophe

While moral hazard may be a way for resilience to increase the risk of global catastrophe, there are also important ways that attention to resilience can decrease the risk. The value of resilience can be seen via the important example of resilience to global food supply catastrophes.

There are several GCRs that are believed to threaten the global food supply. For example, nuclear war burns cities and other areas, sending large amounts of particulate matter into the stratosphere, which then blocks incoming sunlight worldwide, disrupting agriculture. An India-Pakistan nuclear war scenario has been found to cause reductions to major crop yields in the range of 10 to 50% (see Xia, Robock, Mills, Stenke, & Helfand, 2015). Large asteroid and comet collisions and volcano eruptions can have similar effects. Other global food supply threats could include crop pathogens and abrupt global warming. These various catastrophes could create relatively abrupt shocks to the global food supply, on time scales of years to decades. Slower events, such as gradual global warming and the depletion of agriculturally significant natural resources (such as phosphate rock), can also have large effects on the food supply, though they offer more opportunity for civilization to adapt.

Several measures can be taken to increase resilience to global food supply catastrophes (Baum, Denkenberger, Pearce, Robock, & Winkler, 2015). The simplest is to make the most of the remaining food supply. In particular, crops can be shifted from livestock feed to direct human consumption. Under present (non-catastrophe) conditions, bypassing livestock could yield enough calories for four billion people (Cassidy, West, Gerber, & Foley, 2013). Post-catastrophe, this figure could be substantially reduced, but it may nonetheless help keep many people alive.

Another measure is to stockpile food prior to the catastrophe. In principle, the amount of food that can be stockpiled is virtually unlimited. In practice, however, food stockpiling is expensive, labor-intensive, and cuts into the pre-catastrophe food supply. Food stockpiles are best suited to a more limited role for more moderate catastrophes, especially those of short duration. Existing food stockpiles could support the global human population for an estimated 4-7 months (Denkenberger & Pearce, 2014), which is insufficient for many global catastrophe scenarios. Another potential role for food stockpiles is to ensure the survival of a select population, such as in continuity of government facilities, survivalist communities, or dedicated refuges designed to ensure an MVP.

A third measure is to develop capacity to produce food in unconventional ways. For example, if sunlight becomes unavailable, it may be possible to produce food via other means (Denkenberger & Pearce, 2014). Ultimately, food does not need sunlight—it needs energy. Non-sunlight energy sources could include fossil fuels, nuclear power, and energy stored in trees and other biomass. This option is attractive because it can succeed for catastrophes of all sizes with no expensive reductions in pre-catastrophe food supply. However, it may require technological development and institutional support that thus far has not been made. Thus, this is the sort of policy measure that could result from greater emphasis on resilience to global catastrophe.

Conclusion

While it should be hoped that global catastrophe will never occur, there is no guarantee that efforts to prevent global catastrophe will succeed. Therefore, efforts to increase humanity's resilience to global catastrophe constitute an important class of policy—one that has thus far received rather limited attention. The continuity of global human civilization and the human species are essential policy goals. There are promising options for increasing resilience to global catastrophe. These options should be pursued.

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