GENEVA GLOBAL INITIATIVE

WHITE PAPER

Beyond Resilience:

Global Systemic Risk, Systemic Failure, & Societal Responsiveness

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November 2018

OVERVIEW

There is a growing gap between the risk – understood as likelihood times impact – of catastrophic systemic failure in complex society, and societal understanding and preparedness. This white paper outlines why risk needs to be reconsidered, the extent of societies capacity to respond, and presents a risk posture that links our transforming risk environment with contingency planning and preparedness.

A) Societal Risk is Being Transformed

Deepening Vulnerability: As the human systems that enable societal functioning (the grid, supply chains, the financial system, telecommunications, behavioral coordination) become ever more globalised, complex, inter-dependent and high-speed, our vulnerability to large-scale systemic failure is increasing. In particular modern societies – including Western Europe, Japan and the United States – could rapidly transition from the familiar functioning to crises undermining food security, access to water, sanitation, the function of the economy, public health, communications, emergency services, public order and governance. This transition period may last from weeks to a few years, depending on conditions. The initial trigger could be a major pandemic, a financial system collapse, a cyber-attack on critical infrastructure, a natural disaster, a protracted environmental catastrophe, a socio-political crisis, or some confluence of stresses and shocks. If the initial affected region or network is of sufficient scale, is critically connected, and preparedness is weak, recovery may become impossible and the impacted region/network may itself become a source of destabilising global contagion. Such a breakdown would mean reliance on localised resources without most of the infrastructures and capacities currently taken for granted. There could be diverse outcomes – depending on natural, social and physical capital, the stresses from adjacent regions, and levels of prior preparedness.

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Growing Drivers of Stress and Shocks: We have now entered a period that we call an *Axial Stress Phase*, where societies globally are and will be increasingly exposed to major stressors linked to: resource constraints (e.g. food, oil, water), sink-related constraints (e.g. impacts of climate change, ecosystem collapses) and internal constraints (e.g. credit hyper-extension, fraying socio-political trust, declining marginal returns to problem solving, war).

Interactions:Interactions among stressors and their potential amplification through increasingly vulnerable systems will manifest as growing social and economic tension, an increasing intensity and frequency of shocks, rising volatility and uncertainty, impact non-linearity, and declining resilience and adaptive capacity. This further raises the likelihood of large-scale systemic failure ranging from localised and reversible, to global and irreversible.

B) There is a Response Gap

Societies are adaptive to their historical experience of risk, not to the transforming risk environment they have now entered. At present, the predominant policy focus is still on avoiding and mitigating risk, not preparing for the consequences should such measures fail. A few countries have begun to consider major in-country catastrophic system failure. However, this has been closer to 'testing the water' than a full-fledged institutionalisation of large spectrum analysis and contingency planning. Little is said of irreversible catastrophes, although they are increasingly acknowledged in private. Most countries have not even begun rudimentary preparation, nor have the capacity to run analysis and assessments for potential catastrophic system failures. There is no intergovernmental catastrophic systemic risk program or process.

C) A Strategic Posture to Address the Response Gap

A new posture is needed, one which: 1) acknowledges escalating systemic risk up to, and including, large-scale irreversible catastrophes; 2) takes a *risk management* perspective – while accepting that other futures may be possible, the rising probability of systemic failures, and their very high-to-catastrophic impacts warrants urgent attention to plausible collapse event(s); and, 3) focuses upon contingency planning for such outcomes, rather than on stressor mitigation: 4) and acknowledges the need for whole-society preparedness.

A context called *Hazard-independent Catastrophic Impact Preparedness* [HiCIP], can find common purpose between those concerned with systemic failure arising from diverse hazards, including: severe global pandemics, major cyber/ hybrid attacks on critical infrastructure; financial system collapses; environmental and natural catastrophes, etc. The HiCIP context additionally helps to address highly confidence-dependent risks, such as financial collapse, where explicit attention can itself have a destabilising effect.

Naturally, there are major hurdles: psychological, cultural, analytical, and institutional to addressing these issues. The advantages of engaging governments and societies are multiple even beyond the direct benefits. They serve to opens up conversations about the policy and societal responses in an era of increasing instability and stress, which is becoming acknowledged as the new normal. They deepen the awareness that complex interdependency means that escalating international tensions, or rash decisions can ultimately rebound on everybody. And, a commitment to support the collective welfare of citizens in situations of prolonged crisis fosters the legitimacy of governments and enhances the capacities of civil society at a time when it is being increasingly tested.

GENEVA GLOBAL INITIATIVE

CONTENTS

1. INTRODUCTION

> *"The complexity of modern society is such that if you take out one or two little pieces of the jigsaw, the whole thing collapses".*
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> — Lord Arbuthnot,
> former chair of the United Kingdom House of Commons Defense Committee, presently advisor to the Electric Infrastructure Security Council.

Despite the recessions, natural disasters and political turmoil, we have lived through a time where much of what humans care about has been improving. This can be measured in terms of increasing life expectancy, food security, access to sanitation, prosperity and education, and the decreasing numbers of people living in extreme poverty, under threat of personal violence, and/or without the institutional means to protect their rights and interests. Past experience shapes our expectations of the future, so it is natural to assume that technological, economic and social progress will ensure some form of continuity, regardless of the inevitable setbacks and disturbances. However, the underpinning of these expectations represents a period which is an anomalous and extreme outlier in human history [Fig. 1].

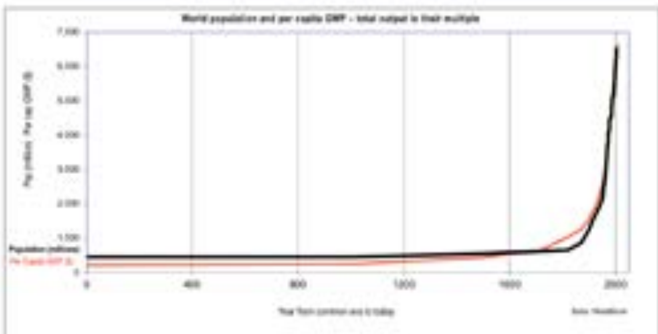

Figure 1. *Human population and per capita Gross World Product, seen here for the last 2000 years, have seen explosive growth in the last 250 years. This has been enabled by the growing complexity and integration of a global civilisation, built and sustained by rising ecological inputs. The relative scale of the rise and fall of earlier complex societies (the Roman Empire, the Mayan civilisation etc.) are dwarfed by the scale of the recent inflexion.*

The systems that have come to embody and sustain this prosperity tend to be taken for granted. The casual assumptions – that supermarkets, factories and businesses operate; that power, fuel, sanitation, hospitals and tele-communications are at hand; and that government works – have come to depend upon the coherent operation of an increasingly complex and integrated global civilisation. The staggering conditionality that underpins the operation of normal life is mostly unseen because it works so effectively; while habituation and affluence have dulled our sensitivity to what is at stake should it fail. Complex societies are naturally resilient to a range of stresses and shocks. That is, they act to maintain critical functions, and have an inherent tendency to return to 'normal' – the pre-crisis/ stress trajectory. Thus, while "The Great Recession" of 2008 caused discomfort, it didn't shut down critical systems underpinning food security, sanitation, production, public health or governance. In 2012 "Super-storm Sandy" was locally devastating, but the stable surround of the United States, and its experience of responding to hurricanes, could rapidly support the re-normalisation of the affected region.

These two examples may be considered as major shocks, but this is only relative to a period of general stability. After all, the Great Recession only led to a one year drop in global economic activity of less than two percent, in a context where three percent compound annual growth is normal. It was but a minor fluctuation on a robust trend. Societies' capacity to respond to stress and shocks has evolved in, and adapted to, this benign environment, where known and unknown risks are assumed to be manageable, and post-crisis reversion to the previous trend is expected.

However, there is growing recognition that those complex infrastructures and systems that sustain the normal operation of society, and which are highly resilient to small stresses and shocks, contain severe intrinsic vulnerabilities to large shocks. If the grid is incapacitated (due to a natural disaster or a cyber-attack); or the financial system fails (due to systemic banking collapse), the operations across the whole society can shut down. The more unprepared a society is, the deeper the impact and the more difficult it is to enact a recovery.

In a highly interdependent global system, shocks and stresses can propagate through supply chains, financial systems, communications and mass human movement. Further, a major global shock that impacts a region with high *centrality* – one that contains critical sustaining interdependencies with the rest of the world – can ignite destabilising global contagion.

In a similar manner, a failure of a global region or network of high centrality, such as the financial system, or global productivity (from a severe pandemic) can begin to shut down the global flow of goods and services. In such cases the possibility of irreversible global systemic collapse increases. In a high speed, Just-in-Time [JIT] economy, these processes can be very rapid. As societies and economies move along paths that tend toward further economic growth and efficiency, and solve problems by adding further complexity, the vulnerability will increase.

However, the increasing vulnerability to reversible and irreversible systemic failure is only one part of a transformation of risk. Another one is that the conditions that support global systems' stability and integration are under increasing stress on multiple fronts, thus constricting the limits of societal systems' resilience.

Just as years of seemingly robust health might obscure the creeping stresses of an unhealthy lifestyle until quite suddenly a heart-attack threatens one's life, or the accumulation of illnesses means that a mere winter cold can leave a weakened body fighting for survival – the systems we depend upon may seem robust, but are under accumulating pressure. That is coming from climate change, water stress, global indebtedness (a functional financial system is the foundation and coordination system of all production and trade), looming constraints on food and oil production (the most critical and sensitive of all inputs to the global economy), to name just a few. These are increasingly compounding, interacting and propagating through those same vulnerable internal systems upon which we depend.

For example, current social and political tensions in Europe were influenced by the refugee crisis whose impact was amplified by the fallout from the 2008 financial crisis that had undermined trust within and between polities across the European Union. The refugee crisis itself was in part driven by changing local conditions (*e.g.* war in Syria influenced by: increased demographic and water stress, declining domestic oil production, droughts) and international conditions, such as high and volatile food prices (influenced by drought in Russia, side effects of US quantitative easing, high international oil prices, biofuel production).

The first point here is that the interactions are heterogeneous – one cannot consider the impacts of the financial crisis, climate change, or distant state collapse in isolation because global socio-economic stability is increasingly interwoven. Secondly, stress and shocks are contributing to the generation of new stresses and uncertainties. For example: Brexit and the Trump phenomenon, trade wars, and increasing inter- and intra-state tensions. Thirdly, strained societies can lose resilience, and become more vulnerable to further crises. Notable examples include: the reduced capacity of central banks to respond to the next crisis as global indebtedness has soared and interest rates remain extremely low; societies are more polarized; quantitative easing has generated new bubbles and popular angst over inequality; and China is no longer a solution for depressed home demand, but a potential new source of systemic risk in the financial system.

In conditions of both increasing vulnerability *and* stresses, the risk of systemic breakdown across scales increases. Rising debt, coupled with increasing volatility and downward pressures on economic growth (including from oil and food constraints, and deflationary forces) mean financial system failure of the type avoided in 2008 becomes more likely as time passes. Critical infrastructures are increasingly exposed to natural catastrophes, while major cyberattacks or war become more likely as international tensions increase, and system entanglements become opaque.

Compounding events will become more common. For example, synchronous climatic stresses affecting global food supplies; rising socio-political and economic stress amplifying the impact of food price spikes; or a series of major hurricanes in high-centrality regions concurrent with a period of heightened financial tension - can have non-linear impacts – bigger than the sum of individual hazards alone. At the same time, declining resilience means that recovery from a localised systems failure is constrained, while impacts outside the affected region/ network become more susceptible to contagion. In such a context, the paths to global systemic instability and failure multiply, as the likelihood increases.

Under such conditions our ability to adapt, mitigate or build resilience at scale becomes more difficult. Such responses represent a cost in ecological, social and financial terms which is harder to bear as the struggle to maintain existing conditions takes precedence. Societies become increasingly locked into a process of destabilisation.

One of the recognised failures of risk management is that preparedness and contingency planning is adaptive to historical conditions and struggles to understand and operationalise transforming and new risk environments. We have no experience of a large-scale systemic failure in a complex society to draw upon, even if we are cognizant of the changing conditions. One consequence of this is that there are only a handful of countries doing anything about large-scale systemic failure, and such efforts still remain at a rudimentary stage.

In what follows, we first outline the reasons for this transformation of risk, and briefly explores systemic collapse through government assessments, near-misses and current contingency planning. We then gives a perspective which frames how catastrophic risk management might be approached.

2. THE TRANSFORMATION OF RISK

2.1 Globally Integrated Systemic Risk

There is a growing recognition that the risk to human welfare and societal functioning is being transformed[3,4]. To understand the implications of this it is necessary to consider risk in a holistic sense[5,6]. In this characterisation, we bring forth the concept of *Globally Integrated Systemic risk*. It acknowledges the fact that dependencies are indeed globalised and constrained in structure and behaviour, and that a growing number of critical stresses will transmit and interact world-wide[7]. As the system becomes more tightly integrated and stressed, one can no longer deliberate over environmental and socio-economic crises – and specific solutions to them – in isolation, but must consider the emergent behaviour of the system as a whole. Its analytical methodology is rooted in the study of complex systems, and risk analysis. Such a perspective acknowledges collective system constraints, heterogeneity, feedback, path dependence, irreversibility, and the existence of tipping points. Siloed analysis and modelling, which represents the current way of apprehending the issues we face, remains blind to this transforming reality.

We have entered a period where the risks we face are becoming more extreme in their impacts, more probable in their likelihood, and potentially irreversible in their duration. This transformation arises from a convergence which can be broadly formulated as follows:

1) Increasing Vulnerability

Firstly, as the networks that maintain our welfare and the general coherence of civilisation grow in scale and become more integrated, complex, interdependent, delocalised, high-speed, synchronised and efficient vulnerability is increasing

The tightening spatial and temporal correlation between the growing complexity of goods and services flowing through civilisation implies a declining volatility through global systems. Those include production processes, supply-chains; infrastructures; behavioural norms, institutional legitimacy, and trust. If interruptions to the flow of production were common, for example, due to political unrest, blackouts, flooding or storms, bank failure or wars, then such tight correlations would not have evolved. One of the defining characteristics of the process of civilisation is volatility suppression, see appendix I.

More complexity and interdependence mean that a failure of one part of the system can cause disturbance and disruption in other vital parts and regions across the globe in a

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[3] Global Risk Report 2018, World Economic Forum. http://www3.weforum.org/docs/WEF_GRR18_Report.pdf

[4] Centeno, M. A., Nag, M., Patterson, T. S., Shaver, A., Windawi, A. J., 2015. “The Emergence of Global Systemic Risk”. Annual Review of Sociology 41:65-85 DOI: 10.1146/annurev-soc-073014-112317

[5] Homer-Dixon, T., Walker, B., Biggs, R., Crépin, A.-S., Folke, C., Lambin, E. F., Peterson, G. D., Rockström, J., Scheffer, M., Steffen, W., Troell, M., 2015. “Synchronous failure: the emerging causal architecture of global crisis”. Ecology and Society 20(3):6. DOI: 10.5751/ES-07681-200306

[6] Helbing, D., 2013. “Globally networked risks and how to respond”. Nature 497:51–59 DOI: 10.1038/nature12047

[7] Taylor, G. The next 20 years: a time of transformation. Journal of Future Studies December 2014, 19(2): 113-124.

manner that may not be obvious. As global systems increase in speed, in the form of maintenance and input turnover times, financial flows, JIT logistics, and human movement – contagion processes can propagate rapidly through and across networks. Delocalisation means that, outside the vanishingly few actually self-sufficient pockets of the world, no country, critical infrastructure, business, community or person can control the conditions of their own operational persistence, and thus be truly resilient.

Like the homeostatic regulation of temperature in humans, complex society and its sub-systems act to persist and stabilise in the face of stresses and shocks. But the bounds of resilience have narrowed as systemic volatility declined, making the system more brittle to the range, intensity and frequency larger shocks we can expect in a more systemically stressed world (see next section). The coherence and stability of society can be threatened when resilience is undermined, and a shock of sufficient scale hits a high-centrality part of a socio-economic network. In this case, a tipping point can be passed where the stabilising forces are over whelmed, and some contagion processes undermine critical inter-dependent systems in a reinforcing cycle of disintegration. It is the underlying *level* of complexity and interdependence that determines the collapse *depth*: it is the *speed* of civilisational processes that determines the collapse *rate*. And, it is the complexity, interdependence and scale of the affected region that largely delineates the scope for recovery/ non-recovery.

The result is a loss in complexity and the intermediating processes that sustain societal welfare in all its dimensions. It can also be considered as a step-change loss in the capacity to use energy and other resources. From the point of view of societal operations, it would represent a shut-down in the circulation of goods and services.

It should be noted that the complexity of our societies already represents an *intrinsic* vulnerability. The changing nature of our dependencies means we are much more exposed to the effects on critical infrastructure of a major coronal mass ejection now then during the1859, so-called, Carrington Event, or a catastrophic natural disaster such a major earthquake along the San Andreas fault. A pandemic of the scale of the 1918 influenza, which infected about a third of the global population and killed about 5% would, have far greater socio-economic implications now. And, despite the advances in early-warning systems and vaccine development, global transport networks and the increased opportunities for animal-human spillover mean that another major pandemic is almost certain. Had the efforts to 'save' the financial system in 2007/8 not succeeded, and this was never certain, the operations of the global economy could have shut-down. But the likelihood of large-scale systemic disruption is, and will continue to increase, this is what we turn to next.

2) Axial Stressors[8]

Secondly, there is an array of increasingly pressing, large-scale drivers of stress and shocks that can test such vulnerabilities. These can be described as *Axial Stressors* since they are persistent and growing, they arise from the operation of civilisation itself and are critical to its operation and stability.

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[8] The Axial Age was a name given by Karl Jaspers to the period of roughly the 8th to 3rd century BCE which he argued was a pivot or transformative point in human history. It transcended the emergence of new mentalities from the Greco-Roman world to Judea, Persia, India and China, and marked a revolution in the development of new ideas, universal religions and empires, markets and trade networks. It seems to offer at least narratively a beginning to our present end-point — a globalised integrated world with substantial shared institutions, cultural adaptions and world-views sustained by trade and markets on the cusp of precipitous transformation

They include: a) declining marginal returns on the ecosystem-based inputs required to maintain and grow our civilisation – most pressingly: food, oil and water; b) the rising impacts of waste and ecosystem interference arising from it – most prominently climate change; and c) growing stress *within* the operation of civilisation – especially: credit hyper-expansion, declining marginal returns to complexity and problem solving, and fraying societal trust and cooperation.

Collectively, these act to constrain economic activity, increase volatility, raise the cost of sustaining and maintaining existing systems, and make problem-solving more difficult[9].

3) Emergent Interactions

Thirdly is the emergent behavior of the growing Axial Stressors and their interactions through increasingly vulnerable global systems.

The fabric of conditions that maintain and coordinate the inputs required for societal function, and that is adaptive to the historical, volatility-suppressed period becomes itself a growing source of risk transmission. This is likely to manifest in growing economic, social and political tension, and an increase in the frequency, intensity, and duration of shocks, and compounding events. Many new pathways for stress and shocks are likely to appear, further increasing volatility and intrinsic uncertainty. Societies are likely to find that recovery to the historical trend is more difficult as heterogeneous and repeated shocks have evermore non-linear impacts, while resilience is compromised.

Instability is increasingly destabilising, while resilience and adaptive capacity are lost. Rising volatility, and an undermining of a systems capacity to recover from shocks (called *critical slowing down*) are common early-warning signals that a given configuration is becoming more susceptible to collapse[10].

4) Systemic Lock-In

Finally, as it is the systems and networks we depend upon that are themselves undermining our dependencies, our trajectory is marked by *systemic lock-in*. That is, we are locked into crisis-inducing dynamics which we will be largely unable to change.
We should bear in mind that we did not design global civilisation, it self-organised. We do not understand it, except in parts; and we do not control it, except within niches. The more unstable the system becomes, and the more radical the surgery we wish to do to avert a crisis, the more we risk compromising the extant systems we depend upon.

In *Appendix I* there is a further discussion of complexity and volatility suppression, while in *Appendix 2* we show a graphical representation of the evolution of risk.

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[9] Tainter, J. (1988) The Collapse of Complex Societies. New Studies in Archaeology. Cambridge.

[10] Scheffer, M. *et. al.* 2012 "Anticipating Critical Transitions". Science 338: 334. http://science.sciencemag.org/content/338/6105/344.full

2.2 Four Risk Regimes

Schematically, we can characterise the impact on societies in four phases, the first is the *Historic Growth Phase* to which we are adaptive, followed by: *Axial Stress Phase*, *Systemic Collapse Phase*, and *Divergent Localised Adaptation Phase.*

1) Historic Growth Phase

This is the phase represented by the exponential growth, complexity, and integration of global civilisation, as represented in figure:1. While this phase always had periods of socio-economic tensions, and some transmission of shocks, large-scale system integration was maintained, and recovery to trend assumed. The bounds of resilience of the system and its sub-systems was forged in this generally stabilising, low volatility period (appendix: 1).

This period shaped our assumptions of the world - from our expectation that we can buy food in the supermarket, and have sanitation and communications, to investments in renewable energy, pensions, critical infrastructure, and education. It also provided the analytical frameworks behind economic growth models (including the Intergovernmental Panel on Climate Change projections). All take for granted the continuity of systems integration.

2) Axial Stress Phase

This phase, which we argue we have already entered, assumes that the general critical operations of civilisation – the flow of goods and services, critical infrastructures, and socio-political stability – are maintained at scale, even though there may be increasing localised disruptions and failures.

However, emergent interactions increase the headwinds against economic growth and raise the costs of maintaining the status quo while generating new sources of risk and uncertainty. Populations, industries and countries are exposed to chronic economic, social and political stresses and supply/ demand shocks, supply chain disruptions, environmental crises, oil and food price volatility, recessions, debt defaults and migrant flows. Systems strive to adapt and absorb them. But the persistence of stressors and the rising frequency and scale of shocks makes reversion to trend progressively more difficult, with each new disruption having an increasingly non-linear impact. Net overall resilience and adaptive capacity declines.

Broadly, in Axial Stress period one could anticipate:

- The divergence between historically adaptive expectations and the emerging realities to deepen. No government, no matter how selfless and astute, will be able to meet those expectations.
- Growing tension between the natural response of increasing tribalism (including inter and intra-state conflict) and globalized interdependency, amplifying societal stress.

•Social discount rates rise – which express itself as more trade-offs between the need to maintain immediate stability at the cost of undermining near-future stability.

•Cognitive and institutional paralysis and overload to intensify.

In such a context it becomes more and more difficult to mitigate stressors and build resilience at scale as the economic and social costs of maintaining stability rise, while capacities decline.

3) Systemic Collapse Phase

This phase is when the general critical operations of society are lost at a large scale. It is when system integration and synchronisation break down as critical inter-dependent subsystems fail, causing other subsystems to fail. The complexity, interdependence, process speed and delocalisation of current, habituated dependency mean such a breakdown can be rapid, deep and potentially irreversible. Localised failure is a feature of the Axial Stress Phase, where the outside region may have a significantly reduced capacity to respond and repair. It is nevertheless possible that with preparedness/contingency planning partial recovery or just amelioration of suffering becomes easier.

If the initially affected region (e.g., the United Kingdom, Germany, California) or network (e.g., global financial system, or a production shock from a severe global pandemic) is of high centrality, the suite of contagion processes can collapse the entire civilisation.
One potential driver of such a civilisational collapse event, though it may have a diversity of initial triggers, is a global financial collapse[11]. Any credit-based system is inherently a call on future productive capacity, and by implication, assumes the continuity of systems integration and the resource input flows that sustain it. The Axial Stressor-induced volatility and constraints on economic growth will have put continuing strain on an already over-extended financial system. In such a collapse, the suite of monetary system failure, collapsed banks, vanished credit and an inability to ascertain currencies value arrest commercial transactions. This cuts inputs into production processes. In an efficient, highly sophisticated, JIT economy, the loss of critical inputs rapidly cascades through the entirety of societal operations. The effort to re-establish some form of monetary system is undermined as production grinds to a halt, and the future becomes very uncertain – which is the ultimate backing for a currency. Some vital inputs might be commandeered or bartered, but given the current diversity of supporting flows necessary to maintain a society, infrastructure, factory or family, a systemic failure proceeds.

Once contagion processes are underway, the transition to a societal arrest can occur in a matter of days. Food, telecommunications, water, sanitation, healthcare, transport, emergency services and governance are severely impacted. Recovery is impossible because coherence has been lost, and societal concerns of necessity focus on survival and adaption. The impacts may include persistent critical infrastructure failure, significant disease and pandemic outbreaks, institutional paralysis, state failure, food shortages and famine.

The risks of famine can be intuited from the fact that in industrialized societies the supply of food from farm to warehouse to supermarket can rapidly vanish. Without a financial system

[11] Korowicz, D. (2012) Trade Off: Financial System Supply-Chain Cross Contagion - a study in global systemic collapse. Feasta. www.korowiczhumansystems.com.

and minimal transport, linking food from farms to urban populations is exceedingly hard. Moreover, without industrially produced seeds, fertiliser, pesticides, farm machinery, spare parts, fuels and irrigation – production can catastrophically fail. International food trade almost ceases as countries focus upon their citizens.

With the triumvirate of production-distribution-exchange/payment compromised, the foundations of food security are perilous. Nevertheless, solid contingency planning may ameliorate some of the situation. For example, livestock can be driven to cities to support populations, buy time, and free up land for cultivation. However, building up food production, from an adequate supply of native seeds to the recycling of nutrients to the need to train and transition a large number of agricultural workers is a formidable challenge that needs planning.

4) Divergent Localised Adaptation Phase

The third stage is how different regions – shaped by varying geographical, social, economic and ecological histories – adapt to the enforced localisation and chronic emergencies. In time some international trade might pick up, and some regions stabilise at a much lower standard of living/ socio-economic complexity, but overall the situation remains severely trying. Most complex technologies are lost, including critical infrastructures, military systems, capacities to extract and refine oil, produce synthetic fertilisers, pharmaceuticals etc.
It is from this point that we confront the chasm between provisioning our basic needs (e.g. food, water, society) and our profound maladaptation to that task. It is also where we face the implications of our long-term undermining of ecological services that could be ignored as long as civilisational operations were maintained. This includes, for example, depleted soil, compromised bio-diversity and hydrological cycles. Moreover, we have to deal with the ongoing and growing implications of climate change even if the Systemic Collapse Phase has considerably reduced our capacity to emit greenhouse gasses. Our ability to adjust to the direct and indirect impacts is from a position with little adaptive capacity and persistent food insecurity, population decline, large population displacements, physical insecurity, and loss of collective intellectual capital.

However, this does not mean that there would not be places and times that people are secure, content, adapting to new realities, and living meaningful lives.
Localised outcomes over time become harder to assess as there is potentially a much greater range of conditions and responses with broader path dependency.

3. GOVERNMENT ASSESSMENTS, EXERCISES AND NEAR-MISSES

"If the banks are shutting their doors, and the cashpoints aren't working, and people go to Tesco and their cards aren't being accepted, the whole thing will just explode… If you can't buy food or petrol or medicine for your kids, people will just start breaking the windows and helping themselves. And as soon as people see that on TV, that's the end, because everyone will think 'that's OK now, that's just what we all have to do'. It'll be anarchy. That's what could happen tomorrow. I'm serious".

— UK Prime Minister Gordon Brown to his advisor the night before he part-nationalised UK banks, 2008[12].

As demonstrated earlier, the potential for a large-scale systemic collapse is already intrinsically present. However, attempting to assess the impact is difficult as we have no experience of such events.

Economic modelling, to which we typically revert, has a myriad of fundamental problems: Such models tend to be blind to the role of energy, complexity, and even credit dynamics; they are parametrised by a historically stable period; and they tend towards equilibrium. Models will assume systemic stability – *ceteris paribus* – while what is at question is a whole-system failure.

Nevertheless, significant events such as the UK 2000 fuel blockades or the 2011 Japanese earthquake gave us some important insight into systemic vulnerability[13,14]. For example, the former demonstrated that, if the 'right' part of the economy is impacted, contagion through societal systems can be rapid. One week seems to be the limit before major disruption to society commences.

The other main tools for exploring impacts are desk assessments and large-scale multi-agency exercises. Understandably, the ones undertaken to-date tend to be classified. What is publicly available tends to be focused on potentially hostile threats from other people, since we are naturally more attuned to them than to more diffuse and unintentional developments that might be equally damaging. Hence, the security of the grid has become of growing interest.

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[12] Damian McBride (2014) *Power Trip: A Decade of Policy, Plots and Spin*, Biteback Publishing.

[13] https://en.wikipedia.org/wiki/Fuel_protests_in_the_United_Kingdom

[14] Infrastructure Public Safety and Emergency Preparedness Canada (PSEPC) (2005): Impact of the September 2000 fuel price protests on UK critical Infrastructure. Incident Analysis: IA05-002

A notable United States governments' study exploring the implications of an electro-magnetic pulse (EMP) attack on the operations of society gives a detailed analysis of how complex interdependent systems of a country can collectively fail if a significant part of its electric infrastructure were to cease to function for an extended period[15]. The focus was not so much on the effect of a high-altitude nuclear detonation (the direct nuclear impact is minimal), but on the damage to critical electronic and electrical systems whose effects then cascade through energy, telecommunications and the infrastructure of finance, which rapidly leads to a crisis through the whole of socio-economic systems including the production of food, water and sanitation, and rudimentary healthcare. Economic production would shut down, and "*at some point, the degradation of infra-structure could have irreversible effects on the country's ability to support its population*." What the report did not consider, however, is the impact on the rest of the world. Given the United States has such high centrality, the supply-chain and financial system contagion would likely cause a global systemic collapse, with the most developed countries being at highest risk.

The more internationally-focused Electric Infrastructure Security Council has been running high-level workshops and analysis which confirm the concerns about the inherent vulnerability of today's society to major power grid failure[16]. The hazards driving such concerns are a sophisticated cyber-attack; an EMP attack; a solar coronal mass ejection; a major natural or environmental disaster; or a confluence of stresses and shocks that collectively initiates a failure. Of course, a proximate shock such as a financial collapse or severe pandemic would also ultimately lead to grid failure, as systems are inter-dependent. In another example, the 2014 United Kingdom Department of Energy and Climate Change (DECC) undertook Exercise Hopkinson to see what would happen if a severe storm caused a two-week blackout of just two million homes in the south-east of England affecting twenty-five million people (about 40 percent of the population)[17]. The consequences could equally serve as a reference for a cyber-attack. The findings were that: transport becomes paralysed from lack of fuel and electric signaling; mobile phone coverage starts to fail after two hours; certain types of sewage treatment fail after six hours with unavoidable discharge into rivers; water becomes unavailable; panic buying (assuming the availability of cash), hoarding, and doubts over food supplies rapidly emerge; there is increased mortality and unburied dead; industrial production stops; and there is rapid descent into public disorder unless the perception of security is maintained. The scale of the affected region overwhelms the UK's capacity to respond, and indeed the whole country is compromised by supply-chain contagion and a financial system breakdown.

Notably, a two-week blackout period does not mean the crises are contained to two weeks and then cease. It would have fomented long-term difficulties for the country, even if power was restored after two weeks.

What Exercise Hopkinson did not regard, again, are the international implications. Potentially such a blackout could trigger runaway implications outside the country's borders, given the UK's global centrality. Supply-chains feeding the unaffected region would be arrested, shutting or curtailing production elsewhere and driving supply-chain contagion.

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[15] Report of the Commission to Assess the Threat to the United States of an Electro-Magnetic Pulse (EMP) attack (2008) http://www.empcommission.org/docs/A2473-EMP_Commission-7MB.pdf

[16] https://www.eiscouncil.org/

[17] https://www.telegraph.co.uk/news/earth/energy/11311725/Britain-unprepared-for-severe-blackouts-secret-Government-report-reveals.html

The heavily indebted (and '*too big to fail*') UK government and banking system would experience unprecedented bond market and currency volatility, as well as a banking crisis, driving financial system contagion. This contagion would feed back into the UK. What tipping points are crossed, and the extent of global network destabilisation, is intrinsically hard to predict. However, one can say that systemic vulnerability increases the likelihood of large-scale failure, while the experience of the axial stress period makes igniting shocks more probably, and societies less resilient to contagion processes.

But there are other keystone systems besides the grid. The Global Financial Crisis of 2008 and the Eurozone crisis of 2011 could be considered a catastrophe avoided, though we rarely ponder what was close to, but didn't happen.

Because access to money, the solvency of the banking system, and the stability of money and credit underpin all trade within and between countries, such a disruption would have halted trade across the real economy. The inability to complete transactions would have amplified firstly through supply-chain contagion, reinforcing a failure in the web of conditions supporting system integration. As production – which is the bedrock collateral for debt and monetary stability – began to freeze, the ability of governments and central banks to stabilise the financial system would have been undermined, further entrenching the shutdown in production and societal function.

That there is little public discussion or publications regarding a financial collapse reflects the valid anxiety that such information – with an official imprimatur – could potentially raise public and market fears in the next financial crisis that could become a self-fulfilling prophesy. Financial collapse is a highly reflexive risk and as such absent from most government appraisals.

Other triggers of potential catastrophic systemic failure that governments have considered include: a major global pandemic[18], natural disasters, environmental shocks, inter-state conflict, or even a shut-down of Russian gas supplies into Europe[19]. Because one can never be sure where a tipping point lies, and the wider resilience of socio-economic systems, even a disorderly Brexit[20], especially if it occurred when other UK and global systems were stressed, could conceivably result in run-away contagion, especially domestically.

[18] Korowicz, D. (2013) Catastrophic Shocks through Complex Socio-Economic Systems- a pandemic perspective. www.davidkorowicz.com/publications

[19] http://www.spiegel.de/wirtschaft/soziales/gas-russland-boykott-haette-fuer-deutschland-drastische-folgen-a-997769.html

[20] What To Expect of a No-Deal Brexit https://www.economist.com/briefing/2018/11/24/what-to-expect-from-a-no-deal-brexit

4. THE PREPAREDNESS GAP

> *"There are signs of strain in many of these systems: our accelerating pace of change is testing the absorptive capacities of institutions, communities and individuals. When risk cascades through a complex system, the danger is not of incremental damage but of 'runaway collapse' or an abrupt transition to a new, suboptimal status quo ".*
>
> — Global Risk Report, 2018. World Economic Forum[21].

The awareness that systemic failure is a possibility is growing, though the conceptualisation of the process and implications remains very limited.

It is only relatively recently that a small number of governments have begun to run large-scale systemic collapse exercises, war-gaming, and scenario planning. Some of these involve hundreds of people across various agencies, the private sector, and civil society. It can take a year to plan and implement, and demand a significant investment. Countries undertaking such assessments tend to already have a large military and contingency infrastructure. However, the focus of those we know of, again, tends to be of a time-limited shock (such as a two-week blackout), and not an ongoing, irreversible catastrophe. Although it is indeed acknowledged that contagion processes may cause such an outcome. Given our unfamiliarity to such events and their complex conditionality, it is unsurprising that response failures will be found even in countries attempting to address this new risk environment. To illustrate, Exercise Hopkinson almost immediately exposed severe shortcomings of UK contingency planning. For example, fuel was assumed to be available for generators and emergency vehicles, however, without electric pumps, much fuel would, in fact, be inaccessible.

Recently some countries also have been trying to increase whole-society preparedness. "*Society is vulnerable, so we need to prepare ourselves as individuals,*" said Dan Eliasson of the Swedish Civil Contingencies Agency at the May 2018 launch of a booklet *If Crisis or War Comes* directed at supporting household preparedness and resilience[22]. In 2016, the Federal Government of Germany requested citizens to stock up on food, water and other essentials in the case of a major societal shock[23]. The media coverage of these initiatives tended to emphasize the possibility of armed conflict, however their context pointed to more profound extant concerns around growing systemic vulnerability, sources, and intensities of hazard.

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21 https://www.weforum.org/reports/the-global-risks-report-2018

22 https://www.dinsakerhet.se/siteassets/dinsakerhet.se/broschyren-om-krisen-eller-kriget-kommer/om-krisen-eller-kriget-kommer---engelska.pdf

23 http://www.loc.gov/law/foreign-news/article/germany-government-publishes-civil-defense-concept/

Sweden's Defence Commission in December 2017 recommended the state builds strategic food reserves for three months. Research done for the Civil Contingencies Agency confirmed that without the ability to import fuel and fertilisers, the country could not feed itself. National production of biodiesel, seeds and organic fertiliser would reduce vulnerability to severe disruption[24]. It is important to note doing this would raise the cost of food, which in turn would amplify economic, social, and financial risks as the Axial Stress Phase progresses. This is an example of the loss of adaptive capacity and systemic lock-in. But such exercises only reveal what might happen and how society is vulnerable. Planning and enacting a national and international response are the next steps.

Despite the few isolated cases, it would be fair to assume that the majority of developed/ high-complexity countries have not undertaken vulnerability analysis to *systemic* failure. It also means that the capacity to execute major exercises and tailor them to specific countries' conditions is very limited.

Unprepared countries expose not only their citizens, but can act as an amplifier of risk to other countries. Given transnational interdependencies, each country's security is enhanced when others are prepared. Such readiness could be the difference between a relatively localised catastrophe that can be contained, and a runaway global systemic collapse. Assessments and preparedness for irreversible systemic failure would require a significant investment. Analysis tools, testing methodologies, expertise, preparedness and response protocols and country-wide requirements are unavailable, although the US Department of Homeland Security is understood to be doing some work in this regard.

Finally, existing international institutions (such as the United Nations Sendai Framework on Disaster Risk Reduction, the Intergovernmental Panel on Climate Change, the Sustainable Development Goals; World Business Council for Sustainable Development; Global Compact; or the Central Banks) are also not in concordance with the transformation of risk we describe here. Their efforts are at best on reducing risks or mitigating the stressors; and not on the impacts of – and preparedness for – the consequences and the convergence of risks which are likely to be more persistent, graver and potentially irreversible.

[24] Braw, E. https://www.defenseone.com/ideas/2018/05/lets-talk-about-food-and-what-happens-crisis/148440/

5. NEW STRATEGIC POSTURE IS NECESSARY

> *"We acknowledge that governments should continue to focus most attention on more likely small-scale outbreak threats, but some modicum of attention should be paid to the extreme end of the risk spectrum - pandemic events that could profoundly affect the arc of history. To date, that extreme end has gone largely ignored in even the wealthiest nations. The consequences could be, will be, catastrophic."*
>
> — Clade X, comment on pandemic scenario exercise, The Johns Hopkins Centre for Health Security[25].

5.1 Risk Posture

Given the reality of global dependencies and inherent vulnerabilities; the range of growing environmental, economic, financial and socio-political stresses; and the potential for interactions and amplification – we argue that the G*lobally Integrated Systemic Risk* lens which we propose provides the appropriate framework to analyse our evolving risk environment.

Acknowledging that there may be alternative views of evolving risk, we maintain that given the scale of the potential impacts, even surmising very low likelihood, would warrant a serious commitment to investing political, economic and social capital in preparedness. Importantly, from a risk management perspective, committing to engage in such a matter is not in conflict with wishing another, kinder future, is more likely; nor does it preclude the many mitigation efforts.

The growing risks, the magnitude of the challenge, and the potential speed at which destabilisation can emerge necessitates a rapid ramp-up of expertise and capacities. It can only be achieved at meaningful scales through state-driven collaboration. Globalised integration and the capacity for cross-border contagion requires the institutionalisation of catastrophic risk management within countries and across borders – hence the axiom: "*In your preparedness, our security."*

The extent and multi-dimensional implications for preparing for a collapse, and response necessitates a *whole society response*. Governments do not have the capacity to manage a societal response. What is needed is a mix of top-down, and bottom-up preparedness. This is already being developed in Scandinavia[26]. The German governments' communications on the need for home and community-level resilience shows that the public need not be unduly alarmed, provided it is done with wisdom.

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[25] [25] https://www.weforum.org/agenda/2018/07/infectious-disease-pandemic-clade-x-johns-hopkins/

[26] Braw, E (2018) Scandinavia's Homeland Defence- a model for other countries? https://rusi.org/commentary/scandinavia's-homeland-defence-model-other-countries. Royal United Services Institute for Defence and Security Studies.

It is also important to note that in some cases the public has shown great proactive foresight about growing risks and the need for community resilience for a more volatile world, for example, the *Transition Network*[27]. The Rockefeller Foundation supported *100 Resilient Cities* fosters mid-level resilience[28]. These organisations are not focussed on foundational resilience (what is needed when virtually all societal systems fail, over an extended area, for a prolonged period), nevertheless they are examples for where cooperating partnerships can be found.

The current Axial Stress period itself warrants considerable attention and new methods of management and preparedness of its own. It will progressively challenge governance, institutional capacities, and social cohesion. For many people, habituated to historical trends, already this period may begin to look like a disaster in its own right. Nevertheless, decisions made now and throughout this time will have direct impacts on the capacity to respond to the subsequent phase of Systemic Collapse, through societies social, natural, and physical capital, and collective preparedness. Acknowledging the potential of collapse can clarify avenues for productive work that can support societal resilience, and at the same time foster societal welfare in the Axial Stress Phase. For example, using the resources of the unemployed for building resilience (urban food security, ecological restoration, local vulnerability/resource mapping) would not only give a meaningful role to people, but would softly help societies begin to acclimatise to new realities, demonstrate government responsiveness to collective welfare and reduce the risks of severe social tensions.

Acknowledging the potential of systemic collapse can also indicate what *not* to do. For example, the current move in some countries to phase out physical cash means that in the event of a localised and transient systemic failure, there would be no means of exchange whatsoever – a factor that could prolong and deepen a crisis. Another example would require a reassessment of building nuclear power plants, accounting for the possibility that systemic failure could undermine the long-term core cooling capacity of those facilities. However, the Axial Stress Phase itself should not be the primary focus, given the potential impacts of a collapse. Preparedness for the Systemic Collapse Phase and the ensuing Divergent Localised Adaptation Phase should be a priority of its own.

As we mentioned before, because societal systems are interdependent, diverse hazards (environmental shock, natural disaster, war, pandemic, cyber-attack, financial collapse, and so on) – or, a combination of them – can push a vulnerable societal system across a tipping point towards systemic failure. But irrespective of the initial driver(s), the outcome is the same: a shutdown in the flow of goods and services. By focusing on the *impact* of such a disintegration, one is in effect preparing for a situation triggered by many different potential drivers. We maintain that the HiCIP is thus the most efficient framework in which to undertake such planning, because: (1) It allows for a pooling of resources and expertise across the currently relatively isolated pandemic, grid failure, environmental, and financial failure preparedness efforts. (2) It provides a cover for considering the impact of highly

[27] https://transitionnetwork.org

[28] http://www.100resilientcities.org

reflexive risks[29] (such as a collapse of the financial system), which when explicitly considered on their own – could be destabilising. (3) It allows for professionals to contribute without requiring that they abandon their personal views of the future. Further discussion of the HiCIP is given in Appendix 3.

The focus is preparedness and contingency planning for systemic collapse includes:

- How to assess vulnerabilities, run exercises, contingency planning and the coordination of preparedness;
- How to responsibly engage the whole of society;
- Develop capacities at all scales;
- How to use the axial stress period to build societal cooperation while building foundational resilience.
- How to deal with collapse as a process;
- How to navigate and position the system into the longer-term if there is no full recovery possible;
- How to design means by which a region or country can manage/ recover from a severe but transient shock;
- How to develop international mechanisms to buttress against contagion, and respond to collapse;
- Determine what are the emergency systems to immediately support basic needs if large-scale collapse occurs;
- How to detect and assess the early warning signs; and
- How to develop and disseminate that capacity in the context of the Axial Stress phase.

5.2 Political and Cultural Challenge

Human behavior and outlooks are framed by historical and habituated experience, reinforced by cognitive biases and in-group conformity. The lack of institutional preparedness preceding the global financial crisis is a recent example. Such hurdles are likely to be even more pronounced when considering catastrophic collapse. Therefore, one cannot expect immediate or overwhelming government, institutional and societal support for such positioning. However, attitudes are beginning to shift, and may continue to do so as the socio-economic-ecological environment deteriorates. Never-the-less, whole-scale mobilisation in both unlikely and probably counter-productive, as it may be de-stabilising (the Reflexivity Trap).

Admittedly, once considered in any detail, the idea of risk managing/ preparedness for systemic collapse on a societal scale is genuinely overwhelming. Even more so, when it becomes clear that the end goal is not working to prevent a catastrophe, but at best to reduce harm both in the short and long term, and in doing so, tilting the odds towards what supports the best in human behavior in times that threaten to expose the worst. It will still be

[29] The Reflexivity Trap: *The actions to prevent a crisis, or preparations for dealing with the aftermath, may help precipitate the crisis. Therefore to avoid precipitation, the preparation has to be low key and below the radar of the public and markets. This limits the extent and scope of preparation, thereby increasing the risks of a chaotic, unprepared response.*

a catastrophe, but by having a process through which one can begin to address the challenge, some of the nausea can be channeled through practical action.

The aim is to engage, encourage and empower those who could exert influence within their institutions and create a formal program or platform. One way of doing this is by legitimising the concerns — being able to point to, and introduce other participants from affiliated countries, and connecting professional expertise. Additionally, since conflict-related concerns about systemic failure are by now markedly on the rise, the HiCIP approach allows us to considerably broaden the range of participants and varieties of scenarios. Whole-society preparedness is already called for by those analysing the situation from armed conflict/ energy/ pandemic/ grid failure perspectives – for example, the Swedish Contingency Agency, and NATO. However, the public, no more than civil servants and politicians, are likely be convinced about, and respond to, collapse risks without much-concerted effort. The best that might be expected is engaged, proactive, and impactful constituencies within society. But ultimately a whole society coordination strategies will become necessary as an integral element of the preparedness process.

5.3. Overarching Goals

The ultimate goal is to reduce risks to human welfare and natural systems in reversible and irreversible collapse events and to facilitate better paths for decisions rather than worse ones.

- To legitimise grave concerns that are now lying outside the established social norms.
- To create robust, institutional structures that can promptly operationalise *hazard-independent* catastrophic risk management.
- To engender a sense of shared vulnerability and common purpose nationally and internationally.
- To demonstrate that by responding pro-actively to what may appear to be an overwhelming challenge is in itself an act of hope, and a call to collective purpose – which is central to preserving social trust.
- To responsibly occupy areas of potential fear, and by doing so shutting down the space for dangerous social actors.
- To increase the chances of a more astute, pro-social crisis management.
- To generate realistic, genuinely anticipated, well-rehearsed, logistically sound emergency plans.
- To effect whole-society responses.

6. CONCLUSION

We are blind to our dependencies, complacent of our vulnerabilities. Our temporal myopia has led us to assume a form of continuity based upon an extraordinary 250-year moment in human history. But the accelerating growth in societal complexity is imperiling the foundations of our welfare, while at the same time we confront growing stresses on multiple fronts. One outcome is that societies will have to face the growing possibility of large-scale systemic failures, from local and reversible, to global and irreversible.

There may be other possible futures. We are already overwhelmingly invested, materially, culturally, and emotionally in some variants of systemic continuity. It would surely be prudent given the transformation of risk that, as a society, we engage in some form of preparedness, as a form of insurance, given the scale of potential consequences.

It is in the nature of the transformation that the possibility of large-scale systemic failure can emerge with dis-orientating speed. Thus there is an urgency to begin to engage in societal preparedness. Not to avoid what might be inevitable, but to respond in ways that reduce suffering, and build upon what's best in our human story.

APPENDIX: 1 COMPLEXITY, VOLATILITY SUPPRESSION, & SYSTEMIC DESTABILISATION

A 1.1 Complexity

We exist behaviourally and structurally through our dependencies in a highly organised state. Consider that a modern car factory will assemble from some 10,000 inputs, not counting the individual employee skill sets or the production infrastructure. If each of those inputs requires *another* factory to assemble an average of 1,000 inputs (assuming less complex components), with each of those inputs *in turn* requiring an average of 500 inputs, then already, just three steps along the supply-chain, there are potentially 5 billion interactions. Of course, it can be argued that many inputs may be common so the figure might be considerably less. However, such supply chains are sustained within the globalised fabric of civilisation, so they merge into diversely networked supply-webs. They depend upon transport networks, grid operations, water supply, financial and banking systems, socio-political stability, legal systems, factories upon factories, refineries, mines and oil wells and the extraction equipment and their supply-chains, and people, skills and the education systems that sustain them. They depend upon available natural resources, and the equipment and absence of war that makes them accessible. They depend upon social norms, trust and legitimacy, systems of law, and cultural expectations.They require globalised economies of scale across all the supply-web. For people to afford the cars, they need to ply their trade in their own niche which also depends upon global systems integration. The speed of global systems from JIT logistics, the temporal reliability behind international air travel, algorithm executed sub-microsecond financial transactions, and an always-on media point to a world which is getting faster and more temporally correlated. In such a manner we begin to observe a singular and integrated global system.

All of this represents a growth in complexity – more distinct parts, specialised roles, connectivity, informational content, and interaction speed. We cannot see the extent of the conditionality upon which our civilisation rests. We can only gesture towards its complexity as above. Beyond a few steps in any good or service the imagination becomes overwhelmed and the dependencies opaque. That level of complexity and coherence achieved by civilisation is because it is a self-organising process. There is nobody in control, no designer. Each person and group operate within their niche. The emergent behaviour of multiple niches operating across many scales and subject to feedback gives rise to civilisation. It is the need of every niche to sustain itself that collectively integrates and stabilises civilisation. As people need to work to realise their expectations and standard of living, businesses and critical infrastructures must likewise depend upon sustained relationships with employees, customers, and suppliers to maintain their organisation and existence. Countries act to sustain and grow standards of living and maintain the systems underpinning socio-economic complexity. It is the imperative of persistence that gives rise to dependency, and the interactions of a myriad localised dependencies that give rise to the interdependence of civilisation.

A 1.2 What is Civilisation Optimising?

In such a conception civilisation has, in a sense, a mind of its own. What then is it 'trying' to optimise?

Civilisation is a process of organisation in time. At each moment, it is poised between the persistence of systems integration that sustains human life and society along paths to which we have become adaptive and the change imposed by the interactions within civilisation and the wider ecosystem on which it depends.

Self-organising, natural systems – from the beginning of life to ecosystems, to human behaviour to civilisation – have evolved to optimise the capture of available energy, subject to being able to persist within dynamic and volatile environments. This represents the fact that all organisation of matter is created and sustained by the flow of energy through a system[30, 31]. If an organism does not eat, if the sun disappears, if fuels stop flowing, then the system cannot be maintained. Secondly, persistence has favoured systems that leave more offspring and can respond to a dynamic environment by adding complexity (sexual reproduction, an eye, a brain, clothing, irrigation, mutualistic and cooperative interactions, civilisation). But this requires a higher energetic operating cost – or energy per unit time (*power*). Thus, evolution has selected systems biased towards the effective capture and efficient utilisation of energy. Because the environment in which systems persist will always have some volatility, systems will never be fully efficient, some energy must be put towards maintaining resilience and adaptive capacity. This optimisation, often referred to as the M*aximum Power Principle (MPP)*, operates across life and economies[32,33]. It should be noted that the MMP is not a law, but a heuristic explanation of evolutionary processes and complexity growth, that is consistent with (non-equilibrium) thermodynamics. Clearly, also more than energy is required (nutrients, minerals, information systems) at any level of complexity, so there are many more constraints, but as energy is the master-resource of all the organisation of matter, the MMP represents a foundational meta-principle.

Living systems will expand until hitting the ceiling presented by environmental or other species' limits. In an ecosystem or society with relatively fixed energy flows, some form of mutualised regulation evolves between the diversity of parts. *Homo sapiens*, shaped by eons of scarcity and harsh environments, have in an evolutionary blink of the eye, become the superlative limit jumpers. Our ability to cooperate beyond kin and the cultures' capacity for rapid adaptability and collective information management made us the pre-eminent energy and resource prospectors. First agriculture, then the recent exploitation of fossil energy allowed us to complexify our collective human system, subject to our archaic behaviours flexibly expressed through culture. The inflexion in Figure:1 is fundamentally an expression of this – no fossil energy, no inflexion. From a related perspective society may only spend about 10 percent of its GDP on energy, but without energy, GDP would plummet to zero. A similar portion of GDP is spent on food energy, but without it, again, the population would drop to zero. This intimates why looming constraints on oil and food can have such a non-linear impact. They are the structural pillars which sustain our complex society.

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30 Judson,O. (2017) *The Energy Expansions of Evolution* Nature Ecology & Evolution vol. 1 No. 0138

31 Herrmann-Pillath, C. (2015) *Energy, growth, and evolution: Towards a naturalistic ontology of economics* Ecological Economics, vol. 119, issue C, 432-442

32 Hall, C. A. S. 2004. The continuing importance of maximum power. Ecol. Modell. 178: 107 113.

33 Odum, H. T. 1995. Self-organization and maximum empower. In: Hall, C. (ed.), Maximum power: the ideas and applications of H. T. Odum. Univ. Press of Colorado, pp. 311 330

From embedded human behaviours refracted through the stable climate of the Holocene to the location of farms and cities, roads and infrastructures, technological dependencies, economies of scale, culture, and expectations – societal systems evolve on stable or predictable substrates, locking in patterns, which become the base and catalyst for further complexity. When society faces new problems, its response is almost always to add to the creation of complexity, which is dependent upon and integrated with the fabric of extant conditions at any time. Whether it is building wind turbines, weapons systems, organising a campaign to advocate for de-growth, or developing healthcare, ones' aim is to capture resources to manifest that end. Our cultural mechanism to do this is through money which represents the *power* – literally as well as figuratively – to organise and sustain matter.

A 1.3 Volatility Suppression

There might seem to be a paradox. How is it that civilisation can be evermore complex, yet at the same time show increasing stability and low variance? That is, given the growing number of time-sensitive inputs and the web of supporting conditions behind them – why are disruptions not common? One answer is that if disruptions were common, such tightly coupled global integration could have not evolved as constituent systems would have not survived.

One outcome of the M*aximum Power Principle* is that systems act to stabilise their environments and reduce volatility, as this increases their operational efficiency in drawing energy and resources needed to persist and adapt. A related feature is that any system's environment is always dynamic and variable to some degree. A system, be it an organism or a civilization, must be resilient to that variability – can respond to stress and shocks and persist – otherwise, it will fail. However, resilience costs in energetic, resource, and financial terms. This means that there is a trade-off between efficiency and resilience. We can glimpse how this happens by a few examples relevant to our discussion.

Suppressing volatility is an economic opportunity. Making investments in further complexity in the form of lean production systems and JIT logistics yields growing returns as efficiencies are gained, inventories drop, cash, and premises are freed up. Companies which embrace such efficiencies are better able to out-compete those that lag behind, helping spread the innovations which in turn helps to stabilise the system further through economies of scale. Conversely, a company might decide to be more resilient to supply-chain disruption than its rivals by investing in inventory, but it stands to lose competitiveness.

The same is valid for entire sectors of the economy. Industrialised agriculture is both highly efficient and volatility-suppressing (monocultures, fertilisers, irrigation, plant protection products, JIT, financial hedging instruments). This has enabled a fall in food prices over the twentieth century, freeing up income and manpower, and helping to expand other parts of the economy. At the same time, profit margins are very low for farmers and supermarkets, the former are often carrying large debt servicing commitments. Building resilience to input disruption, arable soil deterioration, pollinator loss or climate impacts costs in terms of lowered efficiency, lower yields, and the higher costs of new infrastructure. Higher food costs impact the wider society through constraints on discretionary consumption, rising bad debts, and social pressures.

A third example highlights cultural and institutional norms. Globalisation and integration of world trade have connected more people, drove economies of scale, and overall was a win-win for increasing prosperity. But this required cooperation with strangers far across the world from places with different cultures and who previously had little or no allegiance with each other[34]. To reap the benefits of a growing and globalising economy, each social in-group need to be regarded by the distant others with whom they trade as trustworthy. Each also has an interest in preventing a free-loader on the groups' good name. From this have grown institutions of trust and deterrence, regulatory, and cultural convergences to enhance and police cooperation ('good standing,' government probity, international legal frameworks, the EU, IMF). This, in turn, relies on states, political legitimacy, and norms that shape how culture delineates appropriate and sanctioned behaviour. In such a manner, trust builds compliance, which brings benefits, which builds trust. The rewards of global integration encourage good governance, and it may have been a feature of the post-war growth in democracies, though this may now be reversing[35]. We have habituated to this – our dependencies manifesting the evolving and tightening global systemic constraints. However, should constraints on growth and volatility increase, then the benefits of future cooperation might be seen to fall; while the necessity of maintaining an in-group's near-term interests even at the cost of defection from cooperation rise. However, building trust is a slower process than losing it. Thus the re-enforcing (positive feedback) cycle of growth and cultural and institutional integration can be superseded by a fast re-enforcing cycle of socio-economic disintegration.

A 1.4 The Emergence of the Suppressed

The flip-side of complexity growth is that there are a potentially vast number of conditions and places through which shocks and stresses can potentially impact a person, a business, country, or region. In a volatility-suppressed state, this merely represents a *latent hazard*. But what happens to this state as the Axial Stress period progresses?

One way to represent a system, or system-of-systems' state or configuration is as a ball in a basin or well. Systems act to maintain their configuration, represented by the ball at the bottom of the well. There is always some internal and environmental volatility that cause the state to shift about, but once the ball remains within the basin, the system acts to return the state to its preferred state. For example, the human body has an optimal/ preferred temperature, represented by the ball at the bottom of a well. The width of the well represents the range of temperatures that define a state commensurate with being alive. When it gets too hot or too cold, the ball is displaced, but the body has evolved mechanisms to recover by perspiring or shivering, thereby returning the ball to its optimum (*negative feedback*). However, if the dis-placement is too great, a tipping point, or *critical transition*, may be passed, leading to a new state – in this case: dead. If a person is old or suffering from some ailement, the barrier to a critical transition may be lowered. In this portrayal, the diameter of the basin denotes the safe operating space of the ball/state, the height of the barrier, the resilience.

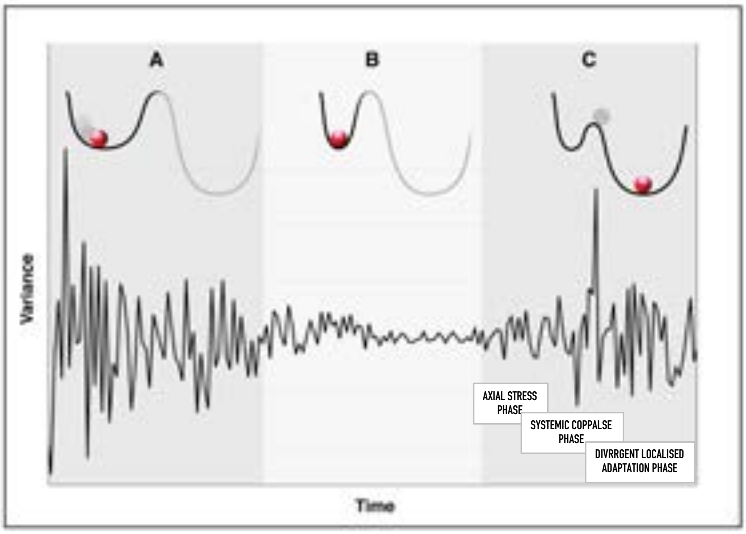
Figure 2. first shows volatility suppression in global systems. Growing complexity is in positive feed-back with volatility suppression, tightening coupling and latent hazard. This means, for example, that a factory or society's tolerance for temporal disruption to supply chains becomes narrower – a) to b). We have seen that it is optimisation and competition that drives this narrowing. If a given system's operating space narrows too much or is not resilient to the variety and scale of potential shocks within the environment it is evolving in, it may go through a phase shift – namely fail/ dissipate and disappear. On the other hand, if it does not optimise enough, or remains

[34] Seabright, P. (2010) The Company of Strangers: A natural history of economic life. Princeton University Press.

[35] https://www.economist.com/graphic-detail/2018/01/31/democracy-continues-its-disturbing-retreat

considerably more resilient than is needed given the shocks it might typically expect to encounter, then it is more likely to be out-competed by more efficient systems.

Figure: 2. *This modelled schematic shows the decline in variance or volatility across civilisational systems (supply-chains, international cooperation, agricultural systems) and then an increase associated with the Axial Stress phase. It also shows potential-state diagrams associated with the a) high volatility past (wide well) b) the present low volatility period (narrow well), and c) the Axial Stress/ Collapse/ Diversified Adaption periods.*



More broadly, in societies with long experience of high-reliability electric power, generators are un-common (unlike parts of India, for example). Critical manufacturing with low substitutability (insulin, electrical transformers), or dense JIT networks are more likely to be situated in regions with higher levels of political stability and with resilience to environmental or other hazards of a scale experienced over the time in which those dependencies evolved; and the experience of reliable food supplies to cities means inventories are very low – reflected in the phrase that in event of a shock *we only nine meals from anarchy.*

As the Axial Stress period develops, the intensity and frequency of shocks increases. Repeated stresses and shocks can reduce the resilience of systems as discussed in the main text, and shown in Figure 2. c) as a reduced barrier to a tipping point. Now, with more and greater shocks, *and* lowered resilience, the chance of the system transitioning to a new collapsed state begins to rise non-linearly. This applies across all scales, from businesses to infrastructure and state failure, to very-large-scale systemic failure. What was *latent hazard* becomes increasingly manifested, and through its interactions, becomes a source of systemic destabilisation.

This foregrounds the central idea of *irreversibility*. It is much easier for a system to evolve on a rising energy/ complexity gradient than to reverse, or transform. This is reflected in the difficulty of a narrow bowl becoming wider, and/ or building resilience as the Axial Stress period evolves, that is, going from c) to b) to a), which would seem to be an appropriate response. But the system will tend to be locked into a highly optimised and correlated state.

This is ubiquitous. Societies would rather become wealthier than poorer. Or referring to the examples, rebuilding inventories costs. As the Axial Stress phase progresses, customers are likely to have less to spend, while the adaptive capacity (money in the bank) of the business is likely to decline. Raising prices can make the company uncompetitive in a declining market, potentially killing the business. So, it may have to just dig-in, because it can't dig-out, cutting costs as much as possible even at the growing risk of supply-chain disruption shutting production.

A farmer is in a similar position. Between customers with less disposable income and harder-to-service debts, and transforming farming systems (both slow and expensive), the option of digging in, because you can't dig out, again, becomes a dominant dynamic. Furthermore, the rising, or spiking of food prices is likely to add to systemic risk given its potential for non-linear impacts on society.

Similarly, building redundancies in critical infrastructure is expensive, especially when the chance of disruption is growing, customers are under more economic pressure, and uncertain outlooks raise the cost of financing.

As civilisation has complexified, it has locked into place new dependencies, expectations, and economies of scale. Any reversal is moving to a less optimised state, so will of necessity begin to under-mine the stability of the system. Furthermore, given that we do not control or understand the conditions that support operational persistence, the idea that there could be a controlled 'de-growth' or a conscious rearrangement of civilisation's parts is likely very slim. Indeed, by trying to change an increasingly vulnerable system, we risk undermining the critical services it provides.

APPENDIX 2: A GRAPHICAL REPRESENTATION OF THE TRANSFORMATION OF RISK

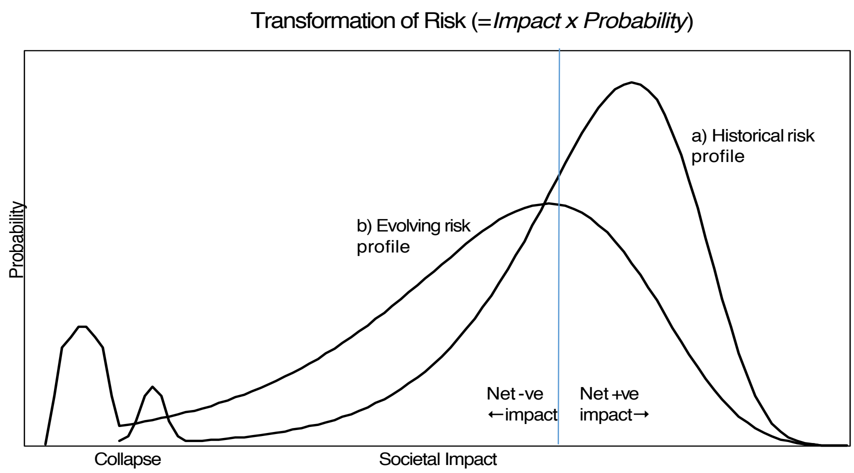
One way to represent all of these interactions and frame it in terms of risk is presented schematically in *Figure 2*. It shows the probability of societal welfare denoted as impact, from profoundly negative to positive. Over the course of the twentieth century, as complexity and integration increased, a citizen or nation could look forward to a higher standard of living (lower child mortality, better health care, lower levels of violence, democratisation, and so on). In the years ahead, thus there is a high probability of a net positive impact. Of course, there is a limit to how positive, partially because we habituate to previous positive increments. There was always a risk that a recession, could cause a negative impact, or in the case of war, depression or pandemic, an extremely negative impact such as a collapse, that is a continued failure of the systems we depend upon for our basic welfare. This is represented as the historical risk profile.

However, this risk is being transformed. Firstly, there is a rising probability of more negative impacts from financial, economic, ecological and socio-political sources, and this has the effect of shifting the historical profile to the left. Secondly, those risks can propagate, interact and amplify through global net-works thus 'fattening' the evolving curve – increasing variance.

This can also be understood as rising uncertainty and volatility. It is the experience of this transformation of risk that defines the Axial Stress Phase.

One can also observe that in the evolving regime the probability of collapse rises in addition to having a more significant negative impact. It rises because the civilisation and its constituent systems lose resilience, while the effect of the axial stressors are relentless – *instability is destabilising*. The impact is greater be-cause as time goes on more people are exposed due to population growth. Growing complexity/integration/efficiency tighten couplings and reduce modularity and diversity in the system that might help absorb impacts or seed some recovery. In addition, the continued persistence of civilisation is steadily undermining natural systems (e.g., pollination, hydrological services, soil and water quality/ availability) that we will have to depend upon without the buffer of technology following a collapse. Further, the ability to sustain a population should there be a collapse is increasingly undermined by socio-economic drivers embedding maladaptive path-dependent practices. For example, increasing efficiencies and complex inputs within industrialised agriculture being necessitated to maintain immediate socio-economic system stability in the Axial Stress Phase (e.g., the avoidance of rising food costs with its potential to further stress a weakened system) rather than more expensive collapse-resilient adaptations and investments.

Figure: 3 *This schematic shows two asymmetric fat-tailed distributions denoting the changing probability of positive and negative impacts on societal welfare. The risk profile for citizens and society is changing. The shift towards more negative impacts and increasing variance define the Axial Stress Phase*



APPENDIX 3: THE PROBABILITY OF COLLAPSE & HAZARD INDEPENDENT CATASTROPHIC RISK

The complexity, interdependence, and speed of civilisational processes represent an intrinsic vulnerability. Because modern systems are interdependent and networked, the failure of any key system can cause the failure of other interdependent systems.

Therefore, any shock, hitting one or more key systems can topple the entire integrated system if resilience is overcome and a tipping point passed. Thus, diverse types of shocks – if they have sufficient scale and impact centrality – can have a common outcome or impact, namely, a shutdown in the flow of goods and services in the economy.

Such a collapse has then multi-dimensional implications for food security, critical services such as water, waste, health, transport, communications, the financial and monetary system, government services and ultimately the survival of populations.

We can consider different shocks such as a natural disaster, a shutdown of the electric grid by a cyber-attack; a financial collapse; or a pandemic driving an integrated socio-economic system from its coherent state to its collapsed state (given scale and centrality conditions). Alternatively, we can consider a combination of shocks and stresses, which on their own cannot collapse the system, but in concert can.

Whether a given shock causes a system to cross a tipping point, and begin a process of disintegration depends upon the system's resilience and vulnerability. When a system loses resilience and becomes more vulnerable, a smaller shock may be sufficient to trigger a collapse.

This gives us a way to re-frame catastrophic risk and risk management. Rather than focus on the vector causing the collapse (at any scale), we focus on the outcome, the risk of collapse $R_c = P_c \times I_c$. Since the collapse impact, I_c , is common:

$$R_c = I_c \times [\text{The sum of independent probabilities of collapse}] + [\text{the sum of the conditional (multiplicative) probabilities of collapse}]$$

We can write this in formal mathematical terms, but it's clearer to give a simple example:

$$R_{collapse} = P_{Collaps} \times I_{collapse} = I_{collapse} \times [P^{>c}_{financial} + P^{>c}_{pandemic} + P^{>c}_{Natural\ disaster} + P^{>c}_{EMP} \ldots].$$

$$+ [(P^{<c}_{financial\ crisis} \times P^{<c}_{cyber\text{-}attack})^{>c} + (P^{<c}_{financial} \times P^{<c}_{pandemic} \times P^{<c}_{neighbouring\ state\ failure})^{>c}$$

$$+ (P^{<c}_{hurricane} \times P^{<c}_{economic\ shock})^{>c} \ldots]$$

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Where ‘$P_{>c}$’ donates the shock or stress that can drive a system across a tipping point and towards collapse, and ‘$P_{<c}$’ donates a sub-tipping point shock. ‘C’ then is an indicator of the systems resilience and vulnerability.

Framing it this way allows us to note:

a. The probability of collapse is higher than is generally recognised, and can come from multiple sources, or combinations of them.

b. In the Axial Stress phase, the resilience of socio-economic systems is falling and vulnerability is rising. This means that the barrier to a critical transition is falling (‘c’). Therefore $P_{collapse}$ is rising across the system as many vulnerabilities are shared – even if the scale and centrality of potential shocks were to remain constant.

c. In the Axial Stress phase, there are a greater range, intensity, and frequency of shocks. This means a higher chance of a shock or combination of them driving the system across a critical transition. This also contributes to $P_{collapse}$ rising.

d. The best use of management resources for catastrophic risk is to focus on the collapse outcome rather than the siloed, shock-specific contemporary risk management approach. This allows for more common ground, efficiency and the sharing of expertise. We call this Hazard Independent Catastrophic Risk Management.

e. Preparing for a financial system catastrophe is highly reflexive. That is, actions to prepare for a financial collapse can create instability by draining confidence, particularly if it has an official imprimatur. This means preparations must be done below the radar of markets and the public – meaning any, problem-specific preparations are likely to be poorly construed and poorly implemented. But because of common outcomes, non- or low-reflexive risks such as pandemics can be used as cover, achieving similar aims.