

Extreme risks and the insurance industry

The 2013 update and its implications for insurers

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Abstract

Towers Watson has updated its list of potential extreme risks to the world's economic, social and political stability. The list has been expanded and reorganized as a result of further research on the topic. A new approach to prioritization has also been introduced. This paper describes the results and discusses the implications for insurers.

Introduction

Extreme risks are potential events that are very unlikely to occur but would have a significant impact on the global economy, existing social orders, and/or current political regimes. Historical examples would include: the formation of OPEC and the oil embargo, altering the structure of the global energy market and fostering a global wave of inflation; the two world wars, each of which fundamentally altered the world political order; and the arrival of Europeans (with smallpox) in North America, killing off an estimated 90% of Native Americans in New England. For the dinosaurs the list would include the Yucatan asteroid and the ensuing global winter, causing their extinction.

Extreme risks are not quite the same as emerging risks. Extreme risks are generally ever-present, although our awareness of them, and their likelihood, may be heightened by current events. While emerging risks have received a great deal of attention within the insurance industry, we believe that extreme risks deserve 'equal time'.

While a few risks are binary (for example, an alien invasion), extreme risks are generally at the far tail of spectral risks that include more manageable manifestations. For example minor asteroids strike the earth with relative frequency, sometimes even causing quite severe, but localized damage. The extreme risk in this case is a monstrous asteroid that would cause devastation on a global scale, potentially threatening the existence of the human race.

Because they are rare, extreme risks can't be assessed via traditional techniques such as looking at their historical frequency of occurrence. Relevant data is often not available for sufficiently long historical periods, and when it is available one must make heroic assumptions that the underlying processes are stationary. Identification and assessment of extreme risks is therefore hard, requiring thoughtful, subjective analysis.

A team at Towers Watson has been studying the issue of extreme risks since 2008. We published our first list of extreme risks in 2009, and updated the list in 2011. Since then our thinking has continued to develop. This year our 2013 update expands the list of extreme risks

from fifteen to thirty, to accommodate additional risks that don't have financial or economic origins.

Why should one care about extreme risks?

The recent global financial crisis, while perhaps not reaching the same level of significance as the above examples, has shown us that risk management must consider low-likelihood, but potentially high-impact events. A robust risk management approach will not focus solely on a particular percentile of risk distributions developed from historical patterns of behavior. To be robust, the approach must look out into the 'tail' to consider extreme risk events that may be highly unlikely but would have a profound impact.

Increasingly, we view the world as a series of interrelated complex adaptive systems, covering markets, political regimes and other social structures. These systems reflect the collective interactions of the participants (driven mostly by human behaviors, especially fear and overconfidence), and are susceptible to sudden and violent regime change when tipping-point events occur. This can be especially true when participants react to an event and adapt reflexively to it, often in a manner that tends to magnify its impact. And, the complexity of these systems has been increasing with advancing technology, increased speed of decision-making, expanded regulations and increased globalization. Extreme events often contemplate significant evolution of these systems, where the regime changes taking place will often render historical event probability distributions irrelevant. Readers interested in a more detailed tour of this topic can find it in our longer white paper.ⁱ

Our limited understanding of the complex world can have a material impact on our ability to assess and mitigate risk. Our proneness to error can dominate when the extreme events involve poorly understood natural phenomena, complex social dynamics or new technology.ⁱⁱ This means that errors in our estimates of the likelihood of extreme risks could be significant. In fact, the whole history of scientific progress is one of correcting flaws in the previous body of knowledge. Extreme events may be much less extreme than we originally thought. This has certainly been the pattern with "hundred-year" hurricanes, and with financial market movements that bank risk models indicated were "in the range of ten to twenty-five standard deviations from the mean".

Extreme risks are also more relevant in the context of long-term financial security schemes, such as defined benefit pensions, long-term disability plans, life insurance, annuities, and casualty insurance where claim settlements stretch over long time periods. This relevance was captured quite eloquently by Lloyd Blankfein, CEO of Goldman Sachs, when he pointed out that, 'most risk management is really just advanced contingency planning and disciplining yourself to realize that, given enough time, very low probability events not only can happen, but they absolutely will happen. The definition of infinity is that if you wait long enough, everything happens.'ⁱⁱⁱ

Beneficiaries of these long-term security schemes face risk *serially*, compounded over the duration of their participation in the scheme. This seemingly naïve statement, as we argued in a recent paper^{iv}, is in fact often overlooked in the areas of finance and economics when thinking

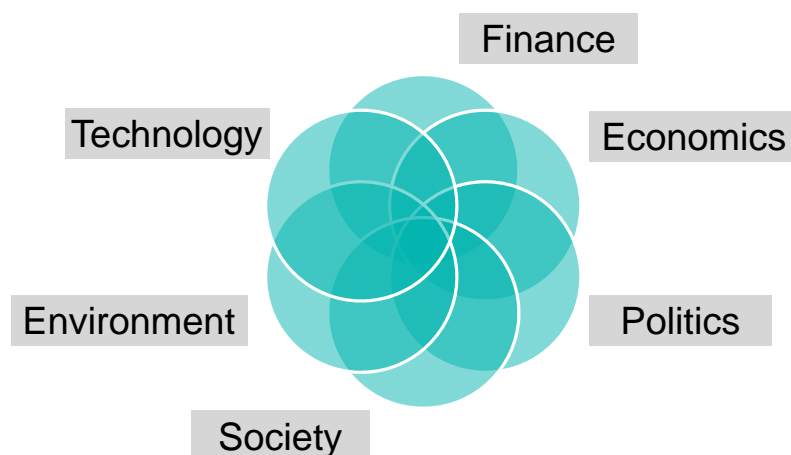
about risk and expected return — but it has a profound impact on how an extreme risk event should be considered. While the average person has a 1-in-700,000 chance of being struck by lightning in a single year, those odds drop to 1-in-6,000 over a lifetime. And, it is of little comfort if you are the one who is hit. After all, you can't go back and choose to live in a different parallel universe where the lightning doesn't strike you (as is often assumed in financial economics). To keep the promises inherent in these long-term schemes managers and fiduciaries of them therefore need to be concerned with extreme risks that could threaten their survival over the long term.

Our inventory of extreme risks can serve as a pump-priming starting point for risk officers, who will need to assess the relevance of each extreme risk to their business and develop a response plan for those risks with sufficient relevance. We discuss this more fully in a subsequent section.

Current list of extreme risks

In the risk identification phase of our latest review we have elected to classify extreme risks in six broad categories, as shown in **Figure 01**. These provide a convenient framework for thinking about potential sources of risk, and the form, in extremis, they might take. The categories are more fully defined in the next section.

Figure 01: Categories for extreme risks



Within the categories, we defined each extreme risk in three dimensions: its underlying causal drivers, its precipitating events, and its ensuing impacts, as illustrated in **Figure 02**.

For example, the root causes of anarchy might be dissatisfaction with income inequality and the failure of government to deliver a rising standard of living, facilitated by modern communication technology; the precipitating events could be widespread extreme social disorder in a major country, typified by mass demonstrations with widespread looting, rioting, and loss of life,

directed against the government and related institutions; and the impacts could include significant economic disruption, rising unemployment, with the potential for a banking and a currency crisis.

Figure 02: Illustration of the three dimensions defining extreme risks

Extreme Risk	Underlying Causes	Events	Impacts
Anarchy	Income inequality, perceptions of unfairness, dissatisfaction with government performance, populism, hyper-communication capabilities	Social disorder, rioting, attacks on governmental institutions	Government collapse, economic disruption and lay-offs, exit of foreign investment

In theory, to avoid overlap one should define extreme risks using only one of the three dimensions described above. However, in the process of developing detailed descriptions of each extreme risk along the three dimensions, we concluded that defining the risks using only one dimension was impractical. Our categories are therefore a blending of precipitating events and ensuing impacts. (In some cases there is even argument over whether a risk is a precipitating event or an ensuing impact — for example a banking crisis could be viewed as either). In our analysis we recognized that, while we could identify a number of precipitating events that would lead to disastrous impacts, we could never identify all potential events that would lead to disastrous financial and economic impacts. We therefore elected to include those two impact areas in our classification framework, an imperfect concession to the practical limits of what is knowable.

Our current list of thirty extreme risks, within the six categories is outlined below^V. The Appendix provides additional detail on the definition of each risk.

Extreme financial risks are those in which there is an inability to meet financial liabilities, on a massive scale, leading to a collapse of the financial system. This could occur as a liquidity issue, such as a banking crisis, where institutions have insufficient liquid assets to meet their current demands for payment, even if the institutions have more assets than liabilities. Alternatively the financial crisis could be driven by insolvency, such as an insurance crisis or a sovereign default, where assets are insufficient to meet liabilities. As in our last report, there are three flavors of extreme financial risks.

- **F1: Banking crisis.** Central banks are unable / unwilling to supply sufficient liquidity to institutions. Failure to make payments cascades rapidly through the financial system, causing banking, and eventually real economic activity to stop.
- **F2: Insurance crisis.** Catastrophic events cause failures at major insurers, leading to withdrawal from markets by others. The failures create adverse wealth effects for beneficiaries and/or the lack of availability disrupts commerce.
- **F3: Sovereign default.** Non-payment by a major sovereign borrower causes market panic and adversely disrupts the global economy in a major way. Failure to make payments could

cascade rapidly through the financial system, especially if there was a loss of trust within the system.

Extreme economic risks are those where there is some form of major shock to the economic system: a shock to growth, a shock to price levels, or a collapse in trust that is essential to the working of the economic system. Generally these shocks stem from some form of fundamental imbalance in the economy that reaches a tipping point. Growth shocks can take the form of a depression or stagnation. Price level shocks can occur in opposite directions: rising prices in hyperinflation or falling prices in deflation. In both cases the 'incorrect' price signals cause serious economic damage and destruction of wealth. A collapse in trust could occur in the current monetary system, leading to the abandonment of fiat money; or in the value of a major currency, creating a currency crisis; or in the economic system as a whole, leading to the break-down of capitalism. In our current list, there are now seven flavors of extreme economic risks.

- **E1: Abandonment of fiat money.** A collapse in confidence in the purchasing power of paper currency and the consequent return to a gold standard.
- **E2: Break-down of capitalism.** Distrust in the private capital/property system, causing a collapse in economic activity and asset prices.
- **E3: Currency crisis.** A significant devaluation of a major currency that becomes self-fulfilling, with loss of purchasing power.
- **E4: Deflation.** Goods and services prices fall for a long period, transferring wealth from borrowers to savers; often associated with a depression.
- **E5: Depression.** A rapid and painful contraction in economic activity, leading to a deep trough in economic output, massive increases in unemployment, restriction of credit, and shrinking investments.
- **E6: Hyperinflation.** Prices increase rapidly, wiping out savings, provoking extreme consumption and hoarding of real assets.
- **E7: Stagnation.** A prolonged period of little or no economic growth, usually accompanied by high unemployment and growing political dissatisfaction.

Extreme political risks are derived from policy decisions that turn out to be poor choices. In some cases the policy decisions may be quite direct, while in others they may be more subtle, however in all cases poor prior policy decisions are a necessary, if not sufficient, condition for these risks to eventuate. Extreme political risks come in five flavors:

- **P1: Anarchy.** Income inequality, supported by modern communication, fosters extreme social disorder in a major state, leading to government and economic collapse.
- **P2: Global trade collapse.** A protectionist backlash against cross-border mobility of labor, goods and capital, causing global trade to collapse.
- **P3: Political extremism.** The rise to power in a major economy of an oppressive government, leading to mass murders and threat to global peace.
- **P4: Terrorism.** A major ideologically-driven attack on an important target, inflicting large-scale human and financial damage. (Here we are thinking of an event worse than 9/11.)

- **P5: World War III.** A military war among many of the world's major countries, killing many millions, destroying physical and human capital.

Extreme environmental risks are threats to human safety and well-being arising from a disruption to planet earth's environment. Two of our risks (alien invasion and cosmic threats) are exogenous to earth and largely beyond our control; two of the risks (biodiversity collapse and global temperature change) could be caused by humans, and are perhaps within our control. In considering our list of environmental risks, one could easily question the seriousness of including alien invasion. We would respond to this question by suggesting that risk management is planning in advance the actions one would take in response to events, and the value of the exercise is in scanning the horizon with the broadest possible mind. Do we know enough to conclude with certainty that a particular event is not possible? The irreversibility of time thinking shows that there is a world of difference between a 0% probability and a vanishingly small probability. Besides, at the assessment stage it is likely that many organizations might have filters that would work to drop alien invasion from further consideration. Extreme environmental risks come in five flavors:

- **e1: Alien invasion.** An invasion of non-peace-seeking aliens that seek either to remove the planet's resources or to enslave /exterminate human life.
- **e2: Biodiversity collapse** Destruction of the world ecosystem leading to problems with human food and water supplies, disease, or climate issues.
- **e3: Cosmic threats.** Planetary risks such as a big meteorite impact, changed orbit due to a passing asteroid, or giant solar flare / magnetic storm.
- **e4: Global temperature change.** Earth's climate tips into a less-habitable state (hot or cold), disrupting social and economic systems.
- **e5: Natural catastrophe.** A confluence of major earthquakes, tsunamis, hurricanes, flooding and/or volcanic eruptions with major global effects.

Extreme social risks are threats that could adversely affect the smooth functioning of society. It should be noted that that the risks in our categorization are not independent, and it should be clear that the social risks also link to policy decisions, the environment, and in some cases technology. This is obvious in the case of food / water / energy crisis, which will have political, environmental, and technological drivers as well as offsets. Three of the risks are health-related, representing different extremes. Extreme social risks come in five flavors:

- **S1: Extreme longevity.** Advances in medicine or genome science significantly increase life expectancy, overwhelming support systems and stressing intergenerational politics.
- **S2: Food / water / energy crisis.** A major shortfall in the supply of, or access to some combination of food, water or energy, causing severe societal issues.
- **S3: Health progress backfire.** Massive rise in morbidity or mental ill-health, perhaps due to an unintended consequence of new health practice.
- **S4: Organized crime.** A significant increase in the scale of illegal operation in a major economy, threatening the viability of legitimate economic activity.
- **S5: Pandemic.** A new disease, that hits the 'sweet spot' by being both highly infectious and often fatal, spreads through human, animal or plant populations worldwide.

Extreme technological risks are those that arise from our increasing reliance on technology to achieve greater efficiency in production and global communication. The risks range from a failure in current technology (nuclear contamination, infrastructure failure), through the possible consequences of emerging technology (cyber warfare, biotech catastrophe) to the unknowable future event of the technological singularity.

- **T1: Biotech catastrophe.** Biological technology (genome, nano-technology, etc.) is applied in a destructive way, either intentionally or inadvertently. This risk overlaps somewhat with S3, health progress back-fire.
- **T2: Cyber warfare.** Computer sabotage/espionage on a major scale, with severe damage to infrastructure, financial, medical or defence systems. This risk might act as a precipitant to economic or financial risks.
- **T3: Infrastructure failure.** An interruption of a major infrastructure network, disrupting economies or impacting basic needs. An example would be the loss of the electricity grid for an extended period, particularly during the winter.
- **T4: Nuclear contamination.** A major nuclear event, leading to lethal effects on individuals or large radioactivity release to the environment.
- **T5: Technological singularity.** Technological advancement proceeds beyond the point of human understanding or control, threatening human life. The 'singularity' refers to the point where a machine achieves intelligence comparable to that of humans.

Risk assessment

To be useful, any exercise of this type must go beyond mere risk identification, to an assessment of which risks are most material. Having identified thirty extreme risks, we have assessed them in terms of their relative *likelihood* and their potential *impact*.^{vi} Our assessments were general, and not specific to any particular industry or geography. Since extreme events involve widespread human suffering, destruction of wealth, or loss of income; we expect many industries and regions to be adversely affected. (In the next section we show some alternative risk assessments that are specific to the insurance industry.) Finally, in reviewing our assessments, keep in mind that for each event we are considering the worst-case scenario, rather than more commonplace manifestations along each event spectrum.

The results of our assessments are shown in **Figure 03**, and illustrated graphically in **Figure 04**.

We assessed the likelihood of each extreme risk using a four-point scale ranging from 'unlikely' for events that have happened from time to time historically, or might very well happen within the next ten years; to 'extremely unlikely' for events that might manifest themselves on a time scale of several hundred years or more. Any probabilities attached to the scale are highly subjective, as there is no scientific way to measure the likelihood of extreme events such as these; however, it is still useful in this context to roughly gauge the relative likelihood of each type of event.

We assessed impact along two dimensions, *intensity* and *scope*.^{vii} The intensity of the event was assigned one of three states, labelled 'endurable', 'crushing', and 'existential'. For an individual, the three states would correspond roughly to a broken leg, paralysis, and death.

Intensity assignments reflected what we could learn about these types of events, given their rarity, and are also quite subjective.

The scope of the event considers both its spatial and temporal aspects, by using four state assignments, labelled 'local', 'global', 'trans-generational', and 'pan-generational'. The first two imply a temporary impact that is either regional or global in scope. The last two imply a lasting impact, either one that would affect a few generations before fading out or one that would affect all subsequent generations (or subsequent potential generations in the case of extinction of the species).

Figure 03: Extreme risks assessment table for top fifteen risks

	Likelihood 1-Unlikely 2-Very unlikely 3-Highly unlikely 4-Extremely unlikely	Uncertainty H-High M-Medium L-Low	Impact Intensity 1-Endurable 2-Crushing 3-Existential	Impact Scope 1-Local 2-Global 3-Trans-generational 4-Pan-generational
Financial				
F1 Banking crisis	2	L	1	2
F2 Insurance crisis	3	L	1	2
F3 Sovereign default	2	L	2	1
Economic				
E3 Currency crisis	2	L	1	2
E4 Deflation	2	L	1	1
E5 Depression	2	L	2	2
E7 Stagnation	1	L	1	1
Political				
P2 Global trade collapse	1	M	1	2
P4 Terrorism	2	M	1	1
Environmental				
e4 Global temperature change	2	L	2	3
Social				
S1 Extreme longevity	3	L	1	2
S2 Food / water / energy crisis	1	L	2	1
S3 Health progress backfire	2	M	1	3
Technological				
T3 Infrastructure failure	2	M	1	1
T4 Nuclear contamination	2	M	2	1

Finally, we assigned to each risk a score relating to its uncertainty, either in terms of its likelihood or its impact. We used a simple 'low', 'medium', 'high' to assess uncertainty. As will be discussed subsequently, uncertainty is an important consideration in risk prioritization.

The sharp-eyed reader will have noticed that none of the top fifteen extreme risks are assessed as 'Extremely unlikely', 'Existential', 'Highly uncertain', or 'Pan-generational'. This is the result of

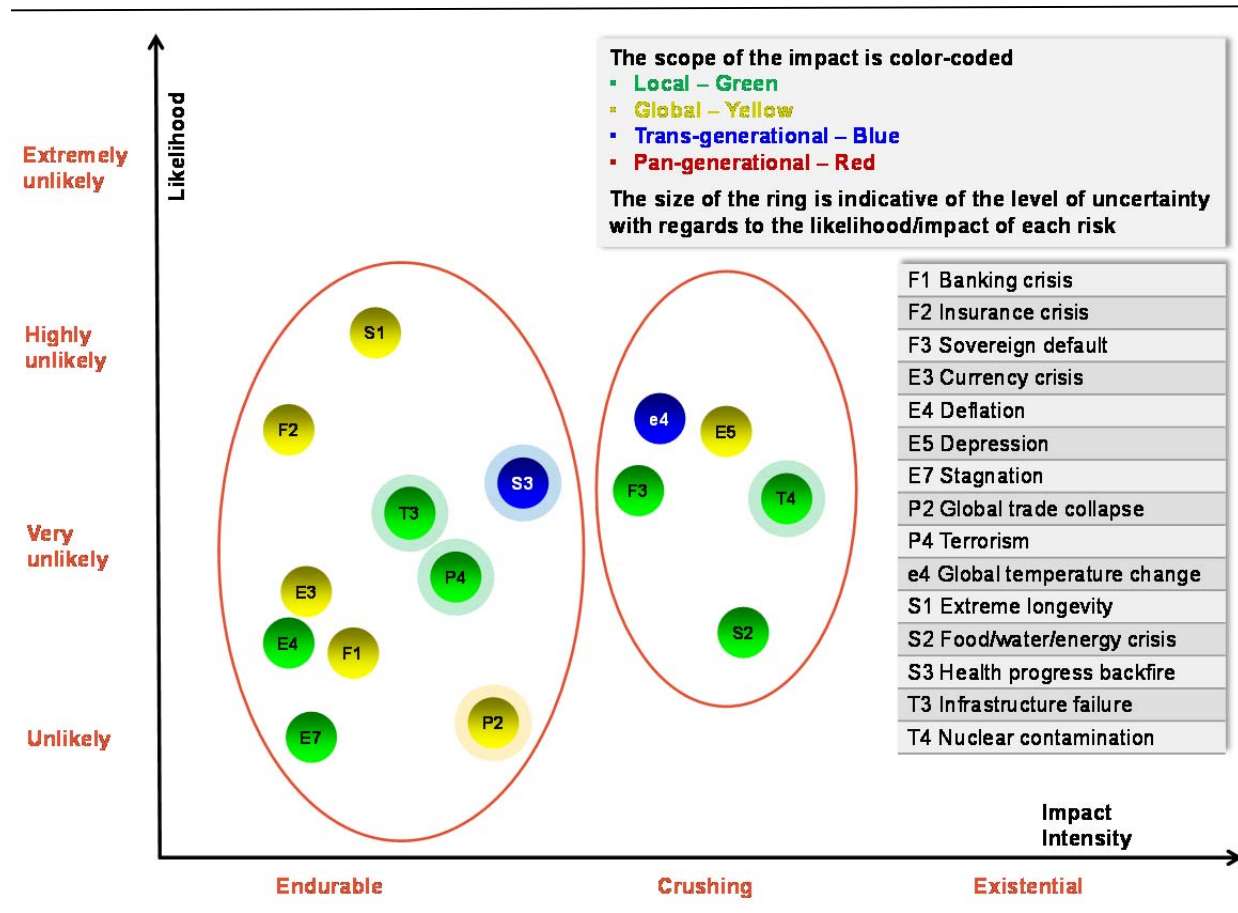
our filtering process, described later, which removed the bottom fifteen risks as requiring less attention for the purpose of further analysis. For example, while we certainly believe that an alien invasion is a potentially existential risk, we do not believe it is a priority risk deserving focused attention.

The results of our assessments are displayed graphically in **Figure 04**, where likelihood and intensity are represented by the two respective axes, scope is represented by the color of the dot, and uncertainty is represented by the fuzziness of the dot.

There is a general upward slope towards top-right, implying that the worst risks are also the least likely. The two risks below are exceptions, as we assessed them as having both very low likelihood and relatively low impact (measured on a global societal scale).

- *S1 Extreme longevity*
- *F2 Insurance crisis*

Figure 04: Extreme risks assessment



For ease of exposition, we have split the risks in Figure 04 into two regions, indicated by the ellipses. The first group comprises the five risks with crushing intensity of impact, meaning that the human, wealth and income effects would be dramatic. For all of these risks we expect the effect on financial assets to be global and materially negative. While the value of liabilities might also fall, the impact is uncertain, and would likely depend on local circumstance. In the case of *E4 Depression*, falling interest rates are likely to drive the value of liabilities higher.

The second group consists of ten risks that we assessed as being of endurable intensity. They are less homogeneous in terms of their impact. Health progress back-fire would reduce pension and annuity liabilities, but probably increase health and disability insurance liabilities. Extreme longevity would explicitly increase pension and annuity liabilities, but would reduce life insurance liabilities.

Association

As we have noted, the thirty extreme risks are not entirely independent. We therefore show an ‘association’ matrix in **Figure 05**. We use the term association to convey that this is a qualitative assessment of whether there is likely to be any causality between the events.

Figure 05: Extreme risks association matrix

	F1	F2	F3	E3	E4	E5	E7	P2	P4	e4	S1	S2	S3	T3	T4
F1 Banking crisis				L		L	L								
F2 Insurance crisis															
F3 Sovereign default	L	H		H		L	L								
E3 Currency crisis	L	L	L			L	L				L				
E4 Deflation			L			L	H								
E5 Depression	H	L	H		H		L				L			L	
E7 Stagnation		L	L		H										
P2 Global trade collapse						L	L					H		L	
P4 Terrorism														H	L
e4 Global temperature change							L					H	L	L	
S1 Extreme longevity		H	L									L			
S2 Food/water/energy crisis							L								
S3 Health progress backfire															
T3 Infrastructure failure												L			
T4 Nuclear contamination												L		L	

To read Figure 05, select a risk in an individual row, then read across to see which other risks could be caused by it. A blank cell means that we do not believe there is any causal linkage between the selected risk and the risk listed at the top of the column. An ‘L’ for low means that we think the selected row risk could cause the risk listed at the top of the column, or be a contributing factor. An ‘H; for high means we believe there is material causality between the

selected row risk and the column risk. For example, reading across the third row shows that we believe a sovereign default of a major country could cause or contribute to a banking crisis (F1), a depression (E5) and/or stagnation (E7); and a sovereign default is likely to or will cause an insurance crisis (F2) and a currency crisis (E3).

Of course, Figure 05 can be read down the columns as well, to see what an event along the top of the grid might be caused by.

There is a significant clustering of associated risks within the financial and economic categories, which should not be surprising. Within these categories, an insurance crisis appears to be a relatively self-contained event in that it is assessed to be unlikely to trigger any of the other extreme risks considered here (the row F2 is empty). This is consistent with the view of many insurers that the industry poses little systemic risk to the broader economy. Similarly, terrorism (P4) is also relatively independent as both the row ('causes') and column ('caused by') have very few entries.

It is worth noting that many of the risks in these categories are assessed as potentially causing both *E5 Depression* and *E7 Stagnation*. These are both a negative shock to economic growth but are typically only distinguishable after the event. So while it would be possible for a depression to be followed by a decade or two of stagnation we would consider this a rare event and, rather, we would typically expect only one of these extreme risks to manifest.

Our ranking of the risks

The final part of our assessment of the extreme risks is a ranking of their importance. We created a general priority ranking, by combining together the four assessment scores in Figure 03 into a single ranking. The intuition is straightforward. The more likely a risk, the higher up the ranking it should be. Likewise, the greater the intensity of impact and the larger the scope of impact, the higher up the ranking the risk should be. Finally, we concluded that the higher the uncertainty about the risk, the lower the ranking should be. The rationale is that it is hard to develop any sort of concrete mitigation plan for risks that are highly uncertain. Our ranking of the risks is shown in **Figure 06**.

At the top of our ranking is *S2 Food / water / energy crisis*. This ranking stems primarily from our assessment that this is one of the most likely risks (see Figure 04), and that there is relatively little uncertainty attached to either the likelihood or the impact. The consequences, locally crushing, are not particularly severe relative to the identified thirty extreme risks (indicating that this aspect is not a driver in our weighting scheme), but are relatively severe relative to others in the top fifteen. The second-ranked risk, *E7 Stagnation*, differs only in respect the intensity of impact, which is assessed as being endurable rather than crushing.

Many of the top fifteen are financial or economic risks, which is not unexpected. In a sense these are broader risks that could be caused by a variety of events and circumstances. Another notable risk, ranked third within our top fifteen, is *e4 Global temperature change*, which we also assessed as relatively likely, with little uncertainty as to its crushing, trans-generational impact.

The power of the ranking system is that it combines and trades-off the four scores in a consistent manner. Different weights could be applied by others, if they wanted to make different trade-offs. The point of the exercise is however to get to an unbiased prioritization of the risks for developing management actions.

The prioritization of the extreme risks must go beyond ranking them by their likelihood, or by the severity of their impact. Some of the risks with existential impacts, such as alien invasion and extreme natural catastrophes, offer little opportunity for planning, given the uncertainties associated with their likelihood and the nature of their potential impact. For this reason, it is probably a better use of one's time and energy to devote planning attention to events with greater certainty as to their likelihood and impact.

Figure 06: Our general ranking of the extreme risks

Rank	Risk	Implications for insurers
1	S2 Food / water / energy crisis	Some potential impact on morbidity and mortality; investment winners and losers in affected goods and their substitutes; otherwise little impact
2	E7 Stagnation	Poor investment returns for sustained period; rise in fraudulent claims; rise in bond defaults; otherwise little impact
3	E4 Global temperature change	Some areas become less habitable, others become more habitable, leading to significant migration, with commensurate shifts in property values
4	E5 Depression	High unemployment increases utilization of disability benefits; rise in fraudulent claims; rise in bond defaults; equities decline
5	P2 Global trade collapse	Little impact on insurers, beyond investment losses from multinationals; imposition of excise taxes could impede global reinsurance activity
6	F1 Banking crisis	Little impact on insurers, beyond investment losses from banks; disruption in policyholder payments and credit facilities
7	F3 Sovereign default	Major impact on those insurers holding debt in defaulting country, possibly some contagion losses if other sovereigns are downgraded; likely to lead to at least a regional insurance crisis
8	E3 Currency crisis	Major impact in cross-border investments, otherwise little impact; multinationals experience significant gains and losses on balance sheet translation
9	E4 Deflation	Declining price levels create favorable P&C insurance claim cost trends; value of life insurance benefits rises
10	S3 Health progress backfire	Significant adverse impact on morbidity, and potentially on mortality
11	T4 Nuclear contamination	Significant adverse impact on morbidity, and potentially on mortality; loss of property value and claims of 'loss of use' in affected areas
12	S1 Extreme longevity	Favorable impact on life insurers; critically adverse impact on pensions, disability, and annuities
13	F2 Insurance crisis	Adverse
14	P4 Terrorism	Major property, life, disability and health losses, unless war exclusion is invoked (not invoked for 9/11); could spawn an insurance availability crisis
15	T3 Infrastructure failure	Potential for massive property losses (e.g., freezing pipes in winter), that could overwhelm P&C insurers; potentially some morbidity and mortality issues

Insurance industry implications

While interesting in its own right, we believe the consideration of extreme risks can be useful in helping to develop more robust risk management processes. In addition to focusing our research efforts on the identification and assessment of extreme risks in general, we also devoted some time to thinking about these risks in the context of the insurance industry.

The right-hand column of Figure 06 in the previous section provides our initial thoughts regarding the broad implications for insurers of our top fifteen extreme risks. While some extreme risks are important to insurers, others are not. For example, *T3 Infrastructure failure* is ranked last on our list, but could be devastating to insurers if it led to substantial property losses. Conversely, many of the economic extreme risks such as *E7 Stagnation* could have only a minor impact on insurers. This is consistent with past experience, as US insurers were not significantly affected by the Depression in the 1930s.

Of course our general prioritization might not be appropriate for insurers, and there may be extreme risks in the bottom fifteen that deserve to be elevated in an insurance-specific context.

To supplement our own research and assessment of extreme risks, we reached out to the insurance industry to get an external, industry-specific ranking. Over the summer we invited insurance executives to provide their own views on which extreme risks matter most to the insurance industry.

We used a relatively new way of gathering views and ideas – a wiki survey. Wiki-surveys are a new approach to surveys that try to overcome some of the shortcomings of traditional surveys. Analysis of traditional surveys strongly suggest that they are often flawed, because the responses are highly constrained (multiple choice, rank from a given list, etc.). The alternative, allowing free-form text responses, isn't much of a solution because the results are so hard to analyse. Wiki-surveys are an attempt to overcome the constraints of traditional surveys, and are based on research by Matthew Salganik, of Princeton University^{viii}. They pose questions in a simple form, such as that shown in **Figure 07**, in which survey participants are asked to rank two randomly selected choices drawn from an initial seed list. Participants may 'play' for as long as they want, responding successively to alternative random pairings, until their views on the entire seed list have been captured. And, once they are familiar with the seed list, participants also have the option of suggesting additions to the list which will then be voted on by subsequent participants.

Salganik's research suggests that this survey approach produces more insight and more accurately captures the views of the participants than traditional survey formats, where for example the participants might be presented with the entire list and asked to rank them.

Figure 07: Wiki-survey question format

Over the long term, which is the biggest extreme risk for the insurance industry?

Risk A **Risk B**

Submit your own idea...

We asked the very question posed in Figure 07 in our 2013 extreme risk survey, seeding the survey with our twenty-nine extreme risks. (We excluded *F2 Insurance Crisis* from the list, as being self-evidently the top priority for the insurance industry.)

The response was quite strong, suggesting a high level of interest in the subject. We received over 30,000 votes from 565 unique internet server addresses (roughly a measure of the number of companies responding, with multiple people often responding from the same company).

Responses came from all over the globe, as can be seen in **Figure 08**.

Figure 08: World map of wiki-survey votes



Figure 09 displays the prioritization of the extreme risks based on the wiki-survey, including both our original seeded risks and those added by survey participants. Here the ranking is based on the score from the survey, which is calculated as the empirical chance that the risk would win against another randomly chosen risk. For example, a score of 100 would mean that the risk is expected to win every time, as it did in the survey. Conversely, a score of 0 would mean that the risk is expected to lose every time.

Figure 09: Wiki-survey ranking of the extreme risks

Rank	Risk Description	Wins	Losses	Score	Source
1	Pandemic: A new, highly infectious and fatal disease spreads through human, animal or plant populations worldwide	1095	427	71.9	Seeded
2	Natural catastrophe: A confluence of major earthquakes, tsunamis, hurricanes, flooding and/or volcanic eruptions with major global effects	1009	521	65.9	Seeded
3	Food/water/energy crisis: A major shortfall in the supply of, or access to, food/water/energy, causing severe societal issues	1054	554	65.5	Seeded
4	Cyber warfare: Computer sabotage/espionage at a major scale, with severe damage to infrastructure, financial, medical or defense systems	1009	538	65.2	Seeded
5	Technology: Large quantity of personal, business, or government data stored in clouds are found to be hacked, compromised, or misused	173	96	64.2	Submitted
6	Depression: A deep and protracted trough in economic output, massive increase in unemployment, restriction of credit, shrinking investment	1012	573	63.8	Seeded
7	Banking crisis: Central banks unable/unwilling to supply liquidity in the next crisis, causing banking and real economic activity to stop	960	560	63.1	Seeded
8	An extreme event that causes property damage, supply chain failures, business interruption and death on a significant scale	329	192	63.1	Submitted
9	Rise in extreme weather: Events exceed the capacity of insurance industry and governments to respond, with physical and social implications	495	290	63.0	Submitted
10	Sovereign default: Non-payment by a major sovereign borrower, causes market panic and adversely disrupts the global economy	988	603	62.1	Seeded
11	Hyperinflation: Prices increase rapidly, wiping out savings, provoking extreme consumption and hoarding of real assets	981	601	62.0	Seeded
12	Infrastructure failure: An interruption of a major infrastructure network, disrupting economies or impacting basic needs	943	590	61.5	Seeded
13	Default with knock-on effects: extreme event leading to default of major insurer/reinsurer, then resulting in difficulties for many others	267	189	58.5	Submitted
14	Terrorism: A major ideologically-driven attack on an important target, inflicting large scale human and financial damage	907	665	57.7	Seeded
15	EU break-up with political turmoil and wars	285	220	56.4	Submitted

A few observations from Figure 09 are:

- In general, about a dozen risks were identified as being broadly more important than the rest, with scores above 60%. However, within this group of a dozen risks the survey did not discriminate strongly as to the specific prioritization. (Pandemic is arguably an exception, with the highest score of 71.9%.)

- After pandemic, natural catastrophe and food/water/energy crisis were voted by respondents as the next most important extreme risks for the insurance industry to worry about.
- We would suggest that the next two risks on the list, cyber warfare (#4) and threats relating to data stored in the cloud (#5), are closely related with one being a more extreme version of the other. In developing our initial list of extreme risks we spent considerable time merging similar identified risks into a single risk with a broader theme. Many of the risks nominated by participants are ones that we identified initially, but ultimately placed them within a broader risk category. One shortcoming of the wiki-survey format is that the risk descriptions are limited to 140 characters (a tweet), and it is therefore not surprising that participants identified specific risks that we were unable to enumerate in the limited space available.
- Survey participants submitted a total of twenty-eight additional extreme risks, of which five made it into the top fifteen. Risk #8 was submitted by a respondent and refers to an unidentified event that causes property damage, supply chain failures, business interruption and death on a significant scale. While the risk description clearly sets out the liabilities the insurance industry would face, it is a shame the source of the risk is not identified as this would give some idea as to whether and how the risk might be managed. We believe that the discipline of articulating the underlying causal drivers, the precipitating events, and the ensuing impacts of each extreme risk event will lead to a more usable list.
- The relative ranking of depression (#6) and inflation (#11) are interesting, given the historical experience of the insurance industry. As was mentioned earlier, the Depression in the 1930s had little impact on the insurance industry. In contrast, the inflation of the 1980s was devastating to U.S. P&C insurers, with many of the major brands (Aetna, Continental, Home, USF&G) eventually forced to merge with others rather than go out of business. Perhaps survey participants are too young to recall this liability crisis.
- A clustering of risks could be made from risk #9, rise in extreme weather that exceeds the capacity of insurance industry, which could be argued, is one of several potential manifestations of global temperature change (#26, not listed), as are rising sea temperatures (#17, not listed).
- While we don't show the bottom end of the ranking, readers will be encouraged that *e1 alien invasion* was ranked last in the survey. Also near the bottom were several participant nominations of risks very specific to the insurance industry, such as change in life insurance tax policy, and breakdown of the automobile insurance market. These nominations did not garner support from other participants.
- While we were hopeful that the wiki-survey approach might overcome the 'anchoring biases' associated with these types of surveys (in which recent events tend to affect the participant rankings), we suspect it did not. For example cyber-warfare was in the news at the time of the survey, and this may have propelled it in the survey rankings. Perhaps further work on the survey design will help to assure that we get an unbiased, long-term view in the future.

In **Figure 10** we compare our general ranking of the risks to the results of the global insurance wiki-survey, focusing on the eight risks with the greatest disparity in ranking. (Risks suggested by participants are excluded.) We would expect some differences, as the wiki-survey ranking reflects the importance of the events to the insurance industry, rather than society at large. This is the case, for example with *P2 Global Trade Collapse* and *E4 Deflation*, which we ranked highly but insurance professionals ranked rather low. Survey participants may believe that these events would have a lesser impact on the insurance industry than on other sectors of the economy (or they may have assessed the likelihood or level of uncertainty differently), with other risks being of higher priority.

Figure 10: Greatest disparity in risk ranking

Seed risk	Survey rank	Our rank	Our view
Pandemic	1	17	Bad, but uncertain as to its form
Natural catastrophe	2	26	We are focusing on more extreme events, where there will be 'bigger fish to fry' than the state of the insurance industry
Cyber warfare	4	21	Very uncertain; could be inconvenient for insurers, or could bring the business to a standstill
Hyperinflation	7	25	Unlikely, local, no one dies; but really bad for P&C insurers
Stagnation	19	2	'So what' for insurers
Temperature change	18	3	Fundamental disagreement as to importance
Global trade collapse	17	5	'So what' for insurers
Deflation	22	9	'So what' for insurers

While many of the differences in ranking make sense, a few stand out as surprising. We ranked *e4 Global Temperature Change* highly, as our number three priority, believing that, at the extreme, it has the potential to be globally crushing with trans-generational impact. In contrast, survey participants prioritized it down at eighteen for the insurance industry. We simply don't agree with this result, and believe that it stems from a misinterpretation of the extreme risk event. In such an event, massive shifts in property values would occur and mass migrations of population would be necessary. Coastal properties would become uninsurable and arid regions such as the south western US could become uninhabitable. In such an environment insurers are likely to experience significant stress on both sides of their balance sheets.

Conversely, survey participants ranked *e5 Natural Catastrophe* highly, as their number two priority for the insurance industry. In contrast, we prioritized it down at twenty-six. Here we also think the disparity may reflect a difference in interpretation by the survey participants. The extreme event we were positing here is very deep in the tail, at an event sufficiently severe to be potentially existential with global trans-generational effects. Our low ranking reflects our belief

that there is no way to meaningfully plan for this type of event. We would certainly agree that planning for more modest events is critical to the insurance industry. Survey participants appear to agree with our view when presented with greater specifics; a participant added an extreme risk for super-volcano that received very little support from others, ending up ranked 53rd.

Conclusion

Extreme risks matter and they deserve more attention than given thus far. In this paper, we have presented our research into a list of thirty risks extreme risks. What might the next steps be, for risk officers who want to pursue extreme risks further?

Those interested in pursuing extreme risks will first want to consider whether they would add or modify our initial list. While we think our list is a good starting point, we fully acknowledge that it is not possible to anticipate all risks. By definition there are always 'unknown unknowns' out there.

Next would be to conduct a context-specific prioritization, initially by identifying the events that would cause permanent mission impairment to the organization, as these are clearly the risks that matter. Other risks may be important to others, or to society at large, but they are not important if they don't lead to mission impairment.

The prioritization would also consider the ability of the organization to exert any control of the events as they unfold. Particularly for extreme risks that pose existential threats, developing anything beyond a high-level response plan isn't worth it. While an alien invasion would likely impair the organization's mission, it is also unlikely that an individual organization can do much to control the course of events when the invasion happens, as there will be 'much bigger fish to fry'. To a large degree this issue is also reflected in the uncertainty associated with the event.

For spectral events like natural catastrophes, one would need to divide the spectrum into survivable events that deserve attention and priority, and extreme events where there will be 'bigger fish to fry'. This division needs to be done consistently across risks, with an enterprise risk appetite framework.

Finally, the relative likelihood of the events needs to be considered. While research can take you part way, these are ultimately a matter of subjective belief.

For risks that are ranked as high priorities, a thoughtful assessment of appropriate steps to take now, and possible actions in response to the event are in order. In essence the exercise of considering extreme risks is time spent on 'pre-mortems', in which one tries to determine in advance what could, colloquially, kill you. Becoming adept at pre-mortems should help risk officers react more flexibly in the event of an extreme event.

One way to use extreme risks is to employ them in reverse stress-testing exercises, starting from an outcome of organizational failure and exploring the circumstances under which the failure might occur, thus exposing potential vulnerabilities.

We would also advocate establishing some sort of early-warning system to closely monitor what could develop into extreme events. While this is almost certainly easier said than done, there has been some interesting research in this area of trying to predict the unpredictable. For example, Didier Sornette and his Financial Crisis Observatory have plotted a set of early warning signs for unstable, growing systems.^{ix}

Lastly, we would remind readers that the value of the extreme risk exercise lies outside prediction. Assessing extreme risks and developing response plans requires an open mind and a longer term view, focusing on what might occur rather than what is predicted to occur in the near-term.

Appendix

The Appendix provides greater detail on each risk. The discussion is far from exhaustive (an entire paper could be written on each risk), but should give the reader a clear picture of each extreme risk event and spur reflection on its implications and priority to the organization.

The discussion of each risk is organized under three captions: some background and thoughts on underlying drivers for the event, a concrete description of the event itself, and highlights of some of the potential impact and consequences of the event.

Footnotes

ⁱ 'Extreme risks, the irreversibility of time and the retirement anomaly', Towers Watson 2013.

ⁱⁱ 'Existential risk prevention as global priority,' Global Policy, 4(1):15-31, Bostrom, N., 2013.

ⁱⁱⁱ Goldman CEO on risk: The worst 'absolutely will happen', <http://www.cnbc.com/id/100915696>

^{iv} 'The irreversibility of time', Towers Watson, 2012.

^v The order of the risks is alphabetical within each category, and is not significant.

^{vi} We followed a rigorous process to develop our qualitative assessments. In stage one, a team of Towers Watson researchers reviewed the available literature and historical data on each extreme event. Team members then independently developed their initial assessment scores. In stage two the independent scores were compared and debated to produce a single consolidated score for each event. For stage three, the assessment scores were peer reviewed by a senior committee, who suggested further refinements. Finally, in stage four the final assessments were signed off by the peer review committee.

^{vii} Our assessment framework is an adaption of one proposed by Nick Bostrom; see footnote above.

^{viii} "Wiki surveys: Open and quantifiable social data collection", Matthew J. Salganiky and Karen E.C. Levyz, <http://arxiv.org/pdf/1202.0500v1.pdf>

^{ix} See http://www.ted.com/talks/didier_sornette_how_we_can_predict_the_next_financial_crisis.html

Extreme risk: *F1 Banking crisis*

Background and Underlying Factors	Event Description	Potential Consequences
<p>Banking crises have occurred in the past, for example:</p> <ul style="list-style-type: none"> • In 1907 a recession in the U.S. included a panic run on banks, leading to many failures • In 1927 the Shōwa financial crisis resulted in mass bank failures across Japan • In the 1930s the worst systemic banking crisis of the 20th century led to the Great Depression • In the early 1970s the U.K. experienced a banking crisis that required government intervention • In 1991, Sweden experienced a banking crisis • In 1998, the collapse of Long-Term Capital Management required a banking industry bailout to prevent a wider crisis <p>Banking crises are driven by two interrelated factors. The first is a panic, in which depositors believe the banks will fail and seek to withdraw their funds, leading to a liquidity-driven crisis. The second is a balance sheet crisis in which asset values collapse leading to capital shortages. The latter can be caused by excessive loan defaults, collapses in the value of collateral, or investment losses on assets held by the banks.</p> <p>The most recent banking crisis, was a global liquidity-driven crisis, followed by a series of solvency-driven crises including those in Iceland, Ireland, the U.K., the U.S., Spain, Greece, and Italy.</p> <p>Developments that could threaten future bank solvency could include (1) a continued drop in real estate prices, (2) increased corporate defaults and (3) poor economic conditions in general.</p>	<p>The event would be some form of global financial crisis in which banks would be unwilling or unable to supply liquidity to borrowers, because they suffered losses in the value of the assets they held, including losses on the loans they had made. As bank capital ratios fell, depositors could panic and seek to withdraw funds. In such a crisis, government nationalization of the banks is a distinct possibility.</p>	<ul style="list-style-type: none"> • Financial markets seize up, with an ensuing flight to quality; credit spreads widen in the process • Credit shortages transmit to the real economy, adversely impacting trade and business activity • Economic activity declines rapidly, with the potential for a depression; alternatively, government intervention staves of the depression, but stagnation occurs • With the greater possibility of nationalisation of the banks, the state of government finances could become an issue, as efforts to bail out the banks could lead to sovereign defaults, creating a currency crisis
	<p>Likelihood: Very unlikely Uncertainty: Low</p>	<p>Impact intensity: Endurable Impact scope: Global</p>

Extreme risk: *F2 Insurance crisis*

Background and Underlying Factors	Event Description	Potential Consequences
<p>While insolvencies are relatively commonplace among smaller insurers, widespread failures on a global scale are relatively rare.</p> <p>The closest the insurance industry has come to a global crisis in modern times is the inflationary period of the 1980s, which caused casualty insurance liabilities to increase dramatically. Many smaller insurers failed, and many major insurers were forced to exit the market by being acquired (Aetna, Home, USF&G, and Continental are U.S. examples). In the U.K., Lloyd's of London required a rescue plan to avert its collapse. In addition to monetary inflation, the 1980s were characterized by 'social inflation', in which both individual and corporate liability for injurious acts was dramatically expanded. Insurers did not recognize these trends and failed to raise prices to cover their costs. In addition, many insurance supervisors suppressed price increases for political reasons.</p> <p>An insurance crisis could be spawned by asset non-performance, as well as liability cost expansion. A collapse of an entire asset class, such as sovereign debt might cause this. Finally life insurers are subject to disintermediation risk if the yields on their invested assets stayed below the interest rates credited on their policy obligations for an extended period.</p> <p>Advancing technology could also spawn an insurance crisis, for example by facilitating peer-to-peer insurance plans.</p>	<p>The event would be a rash of insurer insolvencies across the globe, either due to declining asset values or rising liability costs, leading to non-performance on in-force insurance contracts and a global supply shortage of new insurance coverage.</p> <p>Surviving insurers may withdraw from markets due to perceived levels of risk</p> <p>As insurer capital ratios fell, some classes of policyholders could create a "run" by seeking to withdraw funds from policies with cash value, or moving existing coverage to other insurers.</p> <p>Likelihood: Highly unlikely Uncertainty: Low</p>	<ul style="list-style-type: none"> Existing mechanisms that deal with insurer insolvencies (such as the "guaranty funds" established in the US) would likely be overwhelmed by the volume of claims against them; government intervention to back-stop these mechanisms would be required, but may not be forthcoming in all markets Adverse wealth effects are experienced by beneficiaries Availability shortages for mandatory coverages such as automobile, property, and health would disrupt the real economy; auto and real estate sales couldn't close because insurance requirements couldn't be met <p>Impact intensity: Endurable Impact scope: Global</p>

Extreme risk: *F3 Sovereign default*

Background and Underlying Factors	Event Description	Potential Consequences
<p>Sovereign default ('restructuring' is the more polite euphemism) refers to non-payment by a sovereign entity of its obligations. Sovereign defaults have been surprisingly common, and not just among emerging countries. It is easily possible to document over 140 sovereign defaults over the centuries (less strict definitions would yield many more) – and that number includes the likes of Germany, France, Italy and Japan in the 20th century.</p> <p>There is clearly a benefit to defaulting – not paying back what you owe allows you to consume more immediately (and possibly into the future).</p> <p>The costs associated with sovereign default fall into two broad types – penalty costs and output costs. Penalty costs are the higher rates charged by external creditors to obtain borrowing in the future. Output costs refer to the drop in production and therefore consumption of the defaulting nation.</p> <p>There has been much alarmist talk about the size of recent budget deficits and hence the required amounts of sovereign debt. Sovereign default is more likely if economic growth remains stuck at a low level; if taxes are not or cannot be increased; and if governments do not (or cannot) reduce spending. The likelihood also increases when the tax burden falls on workers who don't believe the debt is their responsibility (the next generation).</p>	<p>The event would be an extreme level of sovereign default, by a major country or group of countries, in which their obligations are 'restructured' in a way that is economically adverse to the obligees. In all likelihood the event would create a crisis of confidence causing the value of other sovereign debt to plummet, and leading to substantial movements in currency exchange rates.</p>	<ul style="list-style-type: none"> • In the short run the defaulting country is better off because it has reduced its costs, making room for higher consumption • Given the scale of the default, it would be likely to cause market panic and adversely disrupt the global economy; investors would like flee 'bad' asset categories in exchange for those that were believed to be 'safe' • Equity markets would also fall, as uncertainty about the implications would be widespread. • As domestic banks tend to be large holders of sovereign debt, particularly just before a default, the act of default can trigger a banking crisis and therefore an economic crisis • Insurers are also large holders of sovereign debt
<p>Sovereign default is usually preceded by several actions: regulatory changes (wide range of possibilities from changing state pension benefits, tax rates, permissible investments etc.); covert sequestration (for example tax breaks for holding government bonds); or compulsory sequestration (forced conversion of cash to government bonds, making the holding of gold illegal etc.).</p>	<p>Likelihood: Very unlikely Uncertainty: Low</p>	<p>Impact intensity: Crushing Impact scope: Local</p>

Extreme risk: *E1 Abandonment of fiat money*

Background and Underlying Factors	Event Description	Potential Consequences
<p>The fiat money system, exclusively used in every major economy nowadays, is the system where a government agrees to accept non-convertible paper money in payment of taxes and debts. Fiat money is declared by a government to be legal tender (the term derives from Latin and means ‘let it be done’), and therefore does not have any intrinsic value. Its value is dependent on the relative scarcity and the degree to which people trust it.</p> <p>A gold standard is associated with a government guarantee that paper notes are freely convertible into pre-set, fixed quantities of gold. Since the collapse of the Bretton Woods system in 1971, we have been living in a fiat-money world. From a historical point of view, however, a repeated shifting between fiat and gold standards is normal. The United States has thus far avoided hyperinflation by shifting back and forth between a fiat and gold standard over the past 200 years. In a fiat money system, central banks have no upper limit to an expansion of the money supply while in a gold standard system the supply of money is limited by the relatively stable (in the long term) pace of gold mining. The choice is then between a stable economy but unstable monetary policy (fiat money) and a stable monetary policy but unstable economy (gold standard). Since the global financial crisis, money creation around the globe has prevented another depression. All of these efforts would be impossible under a gold standard structure. Nonetheless, should these efforts result in rising inflation or even hyperinflation the return to a gold standard would have a higher probability in future. A deepening distrust of fiat money among investors would have long term investment implications, for example an intensified search for alternative assets as a store of value. Before gold ever came back as a ‘standard’ it would be likely to benefit from any increasing distrust of central banks and the paper money they issue.</p>	<p>The event would be a declaration by one or more major governments that it was returning to the gold standard (or some other precious commodity), in an effort to deal with a collapse in confidence in its paper currency, typically to control monetary inflation.</p> <p>This could occur as an agreement among a group of nations, but that might not be the case; the action could be unilateral.</p> <p>The declaration could cause substantial shifts in currency rates, as investors moved their holdings between gold-standard and fiat money currencies.</p> <p>Likelihood: Highly unlikely Uncertainty: Medium</p>	<ul style="list-style-type: none"> • Under a gold standard, there would be much less opportunity for monetary policy, so the economy would likely become more volatile • Currency exchange rates among those countries adopting the gold standard would become more stable, but exchange rates with those not moving to the standard might move significantly • A big discovery of gold would be inflationary; otherwise prices would stabilize in the long run <p>Impact intensity: Endurable Impact scope: Global</p>

Extreme risk: *E2 Break-down of capitalism*

Background and Underlying Factors	Event Description	Potential Consequences
<p>The headline here is that capitalism is not in crisis but “Capitalism Is the Crisis” . It is the ultimate economic extreme risk where distrust in the private capital/property system causes a collapse in economic activity and asset prices.</p> <p>Capitalism’s basic premise is that the pursuit of self-interest and the right to own private property are morally defensible and legally legitimate. In a pure capitalist economy, the market drives the allocation of resource and any economic decisions. In contrast, socialism advocates public ownership, in which governments determine the means of production and the allocation of wealth. Arguably, however, a fully market-driven economy (i.e., the capitalism in the textbook) has never existed, and neither has a completely centralized economy.</p> <p>In our view, the most likely scenario is moving along from one end of a spectrum where market is king (minimum regulation) to the other end where we could see more onerous regulations and government intervention and control of the economy. The extreme risk, however, is the demise of the capitalist system and the end of the market as the primary means of resource allocation.</p>	<p>The event would be an overturning of the capitalist system, with a concurrent shift to socialism. Government would explicitly assume the management of the economy, including what is produced and consumed, and how income and wealth is to be distributed,</p> <p>The overturning of capitalism would not require a ‘revolution’ in the sense of governmental overthrow. It could be accomplished by changes to existing law and regulation, coupled with a change in public acceptance of socialism (perhaps with a different label) and a rejection of capitalism.</p>	<ul style="list-style-type: none"> • As governments take on resource allocation, the (private) investment activities will collapse or even be terminated. A large amount of wealth destruction is likely during the transition period • Low productivity will result in sluggish economic growth, as the link between productivity and reward is lost. In addition, centralized power increases the problem of corruption which inflicts substantial economic costs • The economy is likely to be subject to extreme uncertainty and a higher risk of failure • Investors should probably worry more about the return of their investments rather than the return on their investments
	<p>Likelihood: Highly unlikely</p> <p>Uncertainty: Medium</p>	<p>Impact intensity: Crushing</p> <p>Impact scope: Trans-generational</p>

Extreme risk: E3 Currency crisis

Background and Underlying Factors	Event Description	Potential Consequences
<p>'Currency crisis' is an alternative term for 'balance of payments crisis' and is therefore, technically, the breaking of a fixed exchange rate. In a looser sense, it can also mean an expectation of a significant self-fulfilling devaluation of a major currency.</p> <p>Ideally, economic management is used to maintain balance and control currency exchange. This could be through policies to make domestic business more efficient (thereby raising exports) or adjusting interest rates up or down to attract or deter capital inflows. Therefore the movement in the exchange rate can be thought of as a safety valve that had to blow because other (painful) economic adjustments were not made — for example, raising interest rates, raising taxes, or reducing foreign tariffs.</p> <p>For a fixed exchange rate, the crisis will manifest itself when the central bank runs out of reserves and can no longer defend the exchange rate.</p>	<p>The event would be a significant devaluation of a major currency that disrupts the world economy by altering the balance of international trade.</p> <p>The lower value of the currency would make imported goods more expensive relative to domestic goods, favoring domestic production; hence imports of foreign goods would decline, hurting the economy of trading partners.</p>	<ul style="list-style-type: none"> • A currency collapse severely reduces a country's purchasing power and hence wealth. • To the extent that domestic borrowing has occurred in foreign currencies, the cost of servicing that debt will rise dramatically, and hence immediately increase the risk of default. • The direct impact on asset values and returns is through the currency, and depends on whether the currency movement is hedged or not: domestic investment in domestic assets will be unaffected; domestic investment in foreign assets will benefit substantially; investment by foreigners in domestic assets will suffer substantially. • The indirect effects are more complicated, as the crisis will only have occurred because of some underlying economic imbalance.
	<p>Likelihood: Very unlikely</p> <p>Uncertainty: Low</p>	<p>Impact intensity: Endurable</p> <p>Impact scope: Global</p>

Extreme risk: *E4 Deflation*

Background and Underlying Factors	Event Description	Potential Consequences
<p>Deflation refers to economic conditions in which prices for goods and services fall for a sustained period.</p> <p>Historically not all episodes of deflation correspond with periods of poor economic growth, particularly when deflation was caused by technological progress that created significant increases in productivity. The ‘disinflation’ we have experienced can be attributed to this effect, as robotics, supply-chain management, and other technologies have increased productivity substantially. New techniques for extracting energy sources have also contributed. Productivity gains can manifest themselves as higher unemployment as workers are displaced.</p> <p>A deflationary spiral is an especially problematic situation where decreases in price lead to lower production, which in turn leads to lower wages and demand, which leads to further decreases in price — creating a vicious circle, where the problem exacerbates its own cause. The Great Depression was regarded by some as a deflationary spiral.</p> <p>Deflation increases the real value of debt, causing a transfer of wealth from borrowers to savers. Confused pricing signals cause under-consumption and under-investment at the cost of jobs and future economic growth. Keynesian economics describes this as a liquidity trap, in which people hoard cash because they expect deflation, leading to insufficient aggregate demand. In this scenario, central banks are incapable of stimulating the economy by lowering interest rates (in a liquidity trap short-term interest rates are typically near zero). In Keynesian economics, the only remaining available lever is fiscal policy; running large deficits to increase aggregate demand.</p>	<p>The event would be a global deflationary spiral, with falling prices over a sustained period, transferring wealth from borrowers to savers.</p>	<ul style="list-style-type: none"> • A long period of persistent deflation can be severely detrimental to economic growth; it is usually accompanied by rising real interest rates, drastic declines in output and persistently high unemployment. Stagnation is likely • Deflation should result in slower growth and rising real debt service costs, which will depress corporate earnings growth and equity returns. The increase in the real discount rate will have a further negative impact on equity prices
	<p>Likelihood: Very unlikely Uncertainty: Low</p>	<p>Impact intensity: Endurable Impact scope: Local</p>

Extreme risk: *E5 Depression*

Background and Underlying Factors	Event Description	Potential Consequences
<p>Most are familiar with the history of the Great Depression in the 1930s. Precipitated by the collapse of a major stock market bubble, and exacerbated by government policies (tightening of money supply, erection of trade barriers), economic activity shrank dramatically. Some economists have suggested that it took a World War to lift the U.S. out of the Depression.</p> <p>The current risk of depression in the West appears to have been reduced through policy action, but remains an extreme risk – in that it may not be possible for governments to counteract any future drop in demand, should that occur. There has been an extended period of over-consumption (by Western consumers) meaning that businesses have built productive capacity to satisfy a level of demand that is unlikely to be reached for a number of years, as Western households increase their savings rate.</p>	<p>The extreme risk event is a rapid and painful contraction in economic activity, leading to a deep decline in output, massive increase in unemployment, restriction of credit, and shrinking investment, in a major economy.</p> <p>Likelihood: Very unlikely Uncertainty: Low</p>	<ul style="list-style-type: none"> • The primary consequence of a depression is typically a sharp and prolonged increase in unemployment. The depth of the trough means that a long period of recovery is required before there is pressure to hire new workers • The subsidiary effects are therefore a drop in consumption, restriction of credit, shrinking output and investment, and numerous bankruptcies. A banking crisis is likely to be a consequence • Depressions can trigger deflation or hyperinflation, adding further complication • Excessive leverage in the system can interact with depression – a self-reinforcing fall in asset values can cause further defaults, bankruptcies, falling incomes and rising unemployment, causing or prolonging economic depression <p>Impact intensity: Crushing Impact scope: Global</p>

Extreme risk: *E6 Hyperinflation*

Background and Underlying Factors	Event Description	Potential Consequences
<p>Traditional quantity-theory-of-money-base view tends to attribute hyperinflation to unchecked budget deficits, leading to a rise in the supply of money and consequently higher prices.</p> <p>James Montier of GMO provides an alternative view that money supply is endogenous, and that budget deficits are often caused by hyperinflation rather than being the source. He discovers that hyperinflation shares several common characteristics such as large supply shocks, big debts denominated in a foreign currency and distributive conflict/transmission mechanism.</p> <p>Regardless of the debate about the root causes of hyperinflation, it is usually accompanied by a widespread unwillingness to hold the money for more than the time needed to trade it for something tangible to avoid further loss. Hyperinflation wipes out the purchasing power of savings, provokes extreme consumption and hoarding of real assets, causes the monetary base to flee the country, and precipitates cessation of investment.</p> <p>Historically, there have been numerous episodes of hyperinflation in various countries, followed by a return to 'hard money' (some form of non-devaluing medium of exchange).</p>	<p>The extreme risk event is inflation being very high or 'out of control' in a major economy, a condition in which prices increase rapidly as money loses its value, wiping out savings, provoking extreme consumption, and hoarding of real assets.</p> <p>Definitions used by the media vary from a cumulative inflation rate over three years approaching 100 per cent to 'inflation exceeding 50 percent a month'. As a rule of thumb, hyperinflation is often reported for short intervals, often per month.</p> <p>The value of savings is wiped out</p>	<ul style="list-style-type: none"> Hyperinflation is often associated with wars (or their aftermath), economic depressions and political or social upheavals. The general population loses confidence in the local currency, preferring to keep its wealth in non-monetary assets or in a relatively stable foreign currency. Amounts of local currency held are immediately invested to maintain purchasing power. Prices may be quoted in a foreign currency.
	<p>Likelihood: Highly unlikely</p> <p>Uncertainty: Medium</p>	<p>Impact intensity: Endurable</p> <p>Impact scope: Local</p>

Extreme risk: *E7 Stagnation*

Background and Underlying Factors	Event Description	Potential Consequences
<p>Compared to Depression, which we define as starting with a very painful contraction phase but is then followed by growth in recovery, stagnation is a prolonged period of little or no economic growth (in a major economy), usually accompanied by high unemployment.</p> <p>Economist Robert Gordon has suggested that economic growth will be slow in Western economies because of six headwinds that will retard growth: demography, education, inequality, globalization, revamping energy systems to address climate change, and de-leveraging of both government and private debt.</p> <p>One of the latest and widely researched cases of economic stagnation is the so called “Lost Decade(s)” for Japan since the early 1990s, when its massive scale speculative asset price bubble collapsed in a catastrophic manner, aggravated by a declining and aging population. Japan’s economy has stagnated for more than two decades ever since and its real GDP growth rate from 1990 onwards has been less than 1% per year, noticeably less than the growth rates achieved in the decades before the stagnation. During the same period, Japan has also experienced a secular decline in the employment-to-population ratio and a secular increase in the unemployment rate. Persistent deflation has become a norm. Despite the deflation, real earnings have been declining steadily which has limited the growth in real private consumption..</p>	<p>The event would be a prolonged period of little or no economic growth, usually accompanied by high unemployment and growing political dissatisfaction as the quality of life does not improve or even declines</p>	<ul style="list-style-type: none"> • Economic stagnation is normally associated with low real interest rates; in such an environment nominal bonds tend to outperform, while risky assets such as equity suffer • Deflation is a likely consequence • Stagnation can foster political unrest, as the lack of economic growth and declining incomes fuel dissatisfaction; a protracted period of ugly, zero-sum politics is likely to feed levels of dissatisfaction
	<p>Likelihood: Unlikely Uncertainty: Low</p>	<p>Impact intensity: Endurable Impact scope: Local</p>

Extreme risk: *P1 Anarchy*

Background and Underlying Factors	Event Description	Potential Consequences
<p>Social unrest can stem from a variety of factors, including the performance of government in providing fair treatment of its citizens and delivering a rising quality of life.</p> <p>Unfortunately we live in a world where income inequality is rising, potentially contributing to a profound level of dissatisfaction, especially during times of economic recession. Clashes between religions, and their proper role in government, could be a contributing factor. Demography could also be a contributing factor, as aging populations demand support from a shrinking workforce. And, new technologies offer hyper-connected communication, making it is easier for a disaffected public to organize itself to orchestrate protests.</p> <p>The Arab Spring that started in 2010 has removed existing rulers in Tunisia, Egypt, Libya and Yemen, prompted by these types of factors. More recently in Egypt, the replacement government has been removed because it was not delivering any measurable improvements in basic services. Similarly, welfare cuts and unemployment during the global financial crisis fuelled protests and anxiety across Europe. Finally, according to <i>Europe China, Research and Advice Network</i>, social unrest in China has been increasing at an alarming rate – 8,700 ‘mass incidents’ were recorded in 1993; by 2005 the number had grown tenfold to 87,000; and estimates for 2010 range between 180,000 and 230,000, highlighting an increasing threat to the stability of world’s second largest economy (Gobel and Ong 2012).</p>	<p>The event would be an extreme form of social disorder in a major country, typified by mass demonstrations with widespread looting and rioting, directed against the government and related institutions. Work stoppages and infrastructure damage would likely interfere with the delivery of basic goods and services. The disorder would be sufficiently extreme to result in the loss of power by the government.</p>	<ul style="list-style-type: none"> • Delivery of basic goods and services are disrupted. Workers are unable or unwilling to do their jobs, and businesses close. Unemployment rises and the economy shrinks substantially or collapses. • Loan defaults create a banking crisis • Lack of confidence and balance of trade issues create a currency crisis
	<p>Likelihood: Very unlikely Uncertainty: Medium</p>	<p>Impact intensity: Crushing Impact scope: Local</p>

Extreme risk: P2 Global Trade Collapse

Background and Underlying Factors	Event Description	Potential Consequences
<p>Protectionism is the policy of restricting trade with the aim of ‘protecting’ businesses and workers in the domestic economy from the full force of external competition.</p> <p>The last wave of major protectionism were tariffs introduced in the 1930s to ‘counteract’ the Depression. These had the opposite effect.</p> <p>Since World War II the trend has been for the steady, gradual reduction in trade barriers through the formation of the EU and other trade initiatives. There is still strong political opposition to these changes, particularly from labor unions; this opposition tends to gain strength during recessions.</p> <p>There have been a number of studies that suggest an increase in barriers to trade since the global financial crisis (Lowrey 2012).</p> <p>The concern is that short-term political expediency can override long-term economic logic with the extreme risk being a populist backlash against cross-border mobility of labor, goods, and capital, causing global trade and investment to collapse.</p>	<p>The event would be an extreme populist backlash against cross-border trade, labor mobility, and foreign investment, causing politicians to enact substantial barriers. As other countries would be expected to retaliate, a collapse in global trade and investment would occur.</p>	<ul style="list-style-type: none"> • The consequence will include more uncertainty in financial markets, greater fragmentation of capital markets and eventually a reversal in globalization • The world economy would likely shrink, as foreign markets became closed to local businesses • Since more goods would need to be produced locally, some domestic businesses would flourish, at least in the short run; however, global efficiency would be lost, which is likely to trigger a wave of inflation. • The potential for a food, water, or energy crisis exists
	<p>Likelihood: Unlikely</p> <p>Uncertainty: Medium</p>	<p>Impact intensity: Endurable</p> <p>Impact scope: Global</p>

Extreme risk: P3 Political extremism

Background and Underlying Factors	Event Description	Potential Consequences
<p>During the twentieth century, many nations suffered under extraordinarily brutal governments, which intended to hold total authority over the society and seek to control all aspects of public and private life (totalitarianism). The Soviet Union and Nazi Germany are the two most-studied totalitarian regimes.</p> <p>The risk of political extremism is defined by the rise to power in a major economy of an oppressive government (including but not limited to totalitarianism). Political extremism typically causes a large number of civilian deaths (by modern calculations, the Soviets killed approximately twenty million civilians, the Nazis twenty-five million) and could become a major threat to global peace (Nazi Germany directly caused World War II).</p> <p>Bryan Caplan from George Mason University speculates that the chance of a world-wide totalitarian government emerging during the next 1,000 years — and lasting for 1,000 years or more — is about five percent (Caplan 2006).</p>	<p>The event would be the rise to power of an oppressive government in a major economy. As was the case in Nazi Germany, the rise could be a take-over and transformation of an existing government, rather than a revolution. In such a scenario, at least a portion of the public would acquiesce to the transformation. Any dissidents in opposition would be crushed by the new regime.</p>	<ul style="list-style-type: none"> • Suppression and murder of the opposition • War, to the extent that other countries were the focus of expansion for the regime; eventually countries that felt threatened might have no choice but to join together and fight • A contemporary totalitarian regime is likely to engage in 'economic' war with the rest of the world, seeking to disrupt foreign businesses and protect domestic businesses; foreign trade is likely to collapse
	<p>Likelihood: Highly unlikely</p> <p>Uncertainty: High</p>	<p>Impact intensity: Crushing</p> <p>Impact scope: Local</p>

Extreme Risk: P4 Terrorism

Background and Underlying Factors	Event Description	Potential Consequences
<p>The September 11 attacks on the World Trade Center and Pentagon caused almost 3,000 deaths, and destroyed several billion dollars of property.</p> <p>In the period of uncertainty that followed, the Dow Jones Industrial Average fell by more than fourteen percent in the week after the New York Stock Exchange reopened. Markets around the world, although not directly affected, also fell.</p> <p>Locally, business interruption were substantial. It is estimated that New York City's GDP lost \$27.3 billion in the ten year period from 2001-2012. More broadly, public uncertainty as to whether there would be more attacks, and what the economic impact of the attack would be caused a pause in purchases, most visibly with new car sales.</p> <p>The impact of 9/11 extended beyond geopolitics into society and culture in general.</p>	<p>The extreme risk event is a major ideologically-driven terrorist attack of a larger scale than 9/11, targeted at a region of global economic and/or political importance and inflicting large-scale human and financial damage. The event would be at a scale sufficient to disrupt daily life for a significant population, and have an impact on the global economy.</p>	<ul style="list-style-type: none"> • The event is likely to be accompanied by some form of infrastructure failure • Financial markets could be disrupted, more significantly than in 9/11 • While the U.S. government succeeded in getting the public to quickly return to 'business as usual', that might not be the case in another event. Unease about the future (the threat of further attacks) could cause a significant drop in consumption, leading to a recession • A migration away from targeted areas could occur, as people might have fears about safety
	<p>Likelihood: Very unlikely</p> <p>Uncertainty: Medium</p>	<p>Impact intensity: Endurable</p> <p>Impact scope: Local</p>

Extreme Risk: *P5 World War III*

Background and Underlying Factors	Event Description	Potential Consequences
<p>One consequence of war is the destruction of capital – both physical and human. War tends to kill those in prime ages (predominantly males), which leaves a reduced younger workforce base and in turn reduces economic output and consumption. World War II caused deaths of between 65 and 75 million, and the total number of deaths in wars and conflicts for the entire 20th century was between 136.5 and 148.5 million (Leitenberg 2006).</p> <p>In addition to the loss of human life, whole cities were destroyed where the campaigns were conducted. Business activity and support systems had to be completely restarted afterward.</p> <p>The availability of weapons of mass destruction means the next world war could destroy an order of magnitude more capital than the previous ones. As Albert Einstein put it ‘I know not with what weapons World War III will be fought, but World War IV will be fought with sticks and stones’. The invention of nuclear and biological weapons raises the possibility that the future war could put much of the human race at risk.</p>	<p>This extreme risk is a military war involving many of the world's most powerful and populous countries causing multiple-millions of deaths, and destruction of property on a massive scale.</p>	<ul style="list-style-type: none"> • Global trade would be significantly disrupted, as would global financial systems; some assets would be frozen, and commodity shortages would likely create additional hardship • In areas directly affected, general economic activity would be disrupted; outside of the campaign theaters, business activity would be diverted to support the war effort
	<p>Likelihood: Highly unlikely</p> <p>Uncertainty: Medium</p>	<p>Impact intensity: Crushing</p> <p>Impact scope: Global</p>

Extreme Risk: e1 Alien Invasion

Background and Underlying Factors	Event Description	Potential Consequences
<p>An alien invasion is a very common theme in science fiction stories and films despite the fact that evidence of extra-terrestrial life has never been documented. NASA's Kepler mission to identify earth-size planets around stars was launched in March 2009 and has already discovered thousands of candidates (2740 planet candidates and 105 confirmed planets as of 11 Feb 2013), including one the size of earth.</p> <p>The closest historical analog to an alien invasion is the arrival of the Europeans in the Americas, intending to colonize the 'New World'. While the extermination of the Native Americans wasn't an explicit part of the colonist's plans, it turns out that this was partly accomplished by inadvertent means. The early explorers brought smallpox and other diseases with them, for which the Native Americans had no immunity. By the time the Pilgrims arrived, it is estimated that roughly 90% of the Native Americans had died. The colonists found whole villages deserted and land cleared but unplanted. In addition the survivors were weakened and afraid, and therefore unable to repel the waves of arriving colonists.</p> <p>The colonial example underscores the uncertainty associated with an alien invasion, illustrating that it can unfold in unforeseen ways.</p>	<p>The extreme risk is an invasion of non-peace-seeking extra-terrestrials that look to either remove the planet's resources, or enslave or exterminate human life.</p>	<ul style="list-style-type: none"> The range of outcomes of an alien life contact can be vast and entirely unpredictable but if the contact is indeed hostile it is more likely that the human race is unable to defend itself due to the potentially overwhelming technological gap.
	<p>Likelihood: Extremely unlikely Uncertainty: High</p>	<p>Impact intensity: Existential Impact scope: Pan-generational</p>

Extreme risk: e2 *Biodiversity collapse*

Background and Underlying Factors	Event Description	Potential Consequences
<p>It is estimated that less than one percent of the species that have existed on earth are extant, and there have been five known mass extinctions since life began on earth that led to large and sudden drops in biodiversity .</p> <p>Human activity has accelerated the species loss and these losses could reach a point beyond which it becomes irreversible.</p> <p>It is believed by some scientists that earth is not far away from its sixth mass extinction. Although about 80 percent of humans' food supply comes from just twenty types of plant, humans use at least 40,000 species. Earth's surviving biodiversity provides resources for increasing the range of food and other products suitable for human use, although the present extinction rate shrinks that potential.</p>	<p>The event would be an collapse in biodiversity, in which an accelerating number of species decline to extinction. The process could be a 'death spiral', in which the disappearance of one species would initiate the decline of others due to their inter-dependency. In essence the earth's ecosystem would be destroyed.</p>	<ul style="list-style-type: none"> • The destruction of the world's ecosystem can cause the loss to humans of ecosystem services: provision (food and clean water), regulation (climate and disease), support (nutrient cycles and crop pollination) and culture (spiritual and recreational benefits). • It is likely that the loss of these services would lead to a broader economic collapse, and either to war or anarchy
	<p>Likelihood: Highly unlikely Uncertainty: Medium</p>	<p>Impact intensity: Crushing/Existential Impact scope: Trans-generational</p>

Extreme risk: e3 Cosmic threats

Background and Underlying Factors	Event Description	Potential Consequences
<p>There are risks arising beyond earth, such as a major meteorite impact, being pulled out of orbit (or the solar system) by a passing asteroid, or a giant solar flare (the effects of which would be compounded if during a reversal of the earth's magnetic field).</p> <p>A ten kilometer wide meteorite (like the one that hit earth around 65 million years ago causing, as widely believed, the extinction of dinosaurs) could release 100 million megatons equivalent of energy. It is estimated that such a meteorite could trigger magnitude 10 earthquakes and a 300-metre high tsunami spreading to all of the earth's coastal regions, costing millions if not billions of human lives. Noxious gases and dust would then accumulate in the atmosphere cutting out sunlight and potentially terminating all lives that survived the direct impact – a mass extinction event.</p>	<p>The event would be an extreme cosmic occurrence, such as a major meteor striking the earth, a significant disturbance to the earth's orbit by a passing asteroid, or a giant solar flare — any of which could have a major impact on the physical aspects of the planet.</p>	<ul style="list-style-type: none"> • The impact of these events could range from severely inconvenient to existential • A big enough solar eruption could trigger a magnetic storm and damage electricity distribution lines or disable critical communication and navigation systems
	<p>Likelihood: Extremely unlikely</p> <p>Uncertainty: Medium</p>	<p>Impact intensity: Existential</p> <p>Impact scope: Pan-generational</p>

Extreme risk: e4 Global temperature change

Background and Underlying Factors	Event Description	Potential Consequences
<p>There is little doubt in science that we are experiencing a period of rising global temperature. Increasingly the scientific community is pointing to rising greenhouse gas emissions from human activities as the root cause.</p> <p>Natural feedbacks (e.g., the ice-albedo feedback, in which melting ice reveals darker land and water surfaces below, which absorb more solar heat, causing more melting and warming) in the system have the potential of amplifying global warming. Global warming is expected to be followed by serious consequences including extreme weather being more frequent, and rising sea levels (of several meters) making much of the current coastal communities uninhabitable.</p> <p>On the other hand, while gaining less support in the science community, earth's surface and atmosphere could experience excessive cold slipping into an ice age. This could be caused by a drop in the sun's emission of energy (for a temporary but prolonged period), or by another extreme event such as a meteorite strike or super-volcano which would spread ash into the atmosphere creating a global winter.</p>	<p>The extreme risk event is that earth's atmosphere passes a point of no-return, and tips into a less-habitable state (either hot or cold), disrupting social and economic systems.</p>	<ul style="list-style-type: none"> • Habitable areas will be significantly reduced, causing large scale migration and reducing the quality of life for most of humankind; economic stagnation is a possible consequence, as is a health progress backfire • Food production will be disrupted, as existing arable land becomes too hot and dry • Rising sea levels will necessitate inland migration • Coastal properties will lose value and become uninsurable; inland properties will rise in value • Extreme weather of all types, and related hazards such as wildfires, will disrupt property insurance markets; rebuilding will become a more significant part of the economy
	<p>Likelihood: Very unlikely Uncertainty: Low</p>	<p>Impact intensity: Crushing Impact scope: Trans-generational</p>

Extreme risk: e5 Natural catastrophe

Background and Underlying Factors	Event Description	Potential Consequences
<p>These are the disasters resulting from natural processes of the earth including earthquakes, tsunamis, hurricanes, flooding (including atmospheric river storms) and volcanic eruptions.</p> <p>The extreme risk would either be a confluence of connected extreme natural catastrophes (e.g., a magnitude 10 earthquake, causing a giant tsunami and triggering volcanic eruptions) or the eruption of a super-volcano. The latter would cause global effects on climate from the ash fallout and aerosol clouds ('volcanic winter').</p> <p>It is believed that a super-volcanic event at Lake Toba around 71,000 years ago led directly to a cooling event that lasted over a thousand years (Zielinski et al 1996).</p> <p>While not yet statistically significant, there is growing evidence that weather phenomena such as hurricanes, windstorms, blizzards, etc. are becoming more severe, and that the frequency of severe events is rising.</p>	<p>The event would be an extreme natural catastrophe event on an unprecedented scale, include a mega-earthquake or a super-volcano; it could also take the form of a season of hurricanes or other weather events at a frequency and severity that is unprecedented — with major impacts.</p>	<ul style="list-style-type: none"> • Massive property losses, on an unprecedented scale; overwhelming property insurers and government disaster relief mechanisms • Going forward, insurance in affected areas would become unavailable or unaffordable • Agriculture collapse as a result of the loss of one or more growing seasons • Decline in health (famine and spread of infectious disease) • Transportation disruption (air travel halted for years) • Utilities (electrical, communication, gas, oil) offline for an extended period, making some areas uninhabitable
	<p>Likelihood: Extremely unlikely</p> <p>Uncertainty: Medium</p>	<p>Impact intensity: Crushing/Existential</p> <p>Impact scope: Trans-generational</p>

Extreme risk: *S1 Extreme longevity*

Background and Underlying Factors	Event Description	Potential Consequences
<p>A major breakthrough in medical or human genome science – it is hoped that the cure for common banes such as heart disease, cancer and stroke may be in the offing – could result in an unanticipated, significant increase in life expectancy for everyone, or the majority of people.</p> <p>In addition, even though life expectancy has increased steadily in recent history, these gains do not necessarily lead to better health in later life. The risk therefore also includes an emergence of a society with a growing number of the elderly who suffer chronic but non-fatal diseases – people live longer but their ‘productive’ years stay more or less the same.</p>	<p>The event would be a significant advance in medicine or genome science that significantly increases life expectancy, either by curing common diseases or reversing the aging process itself.</p>	<ul style="list-style-type: none"> • A direct impact of longer lifespans on defined benefit pensions and annuities is increased liabilities; these systems could be overwhelmed by the additional cost of promised benefits • The economy will struggle to support the needs of a growing mass of the elderly who are in need of long-term health care and other support services • To the extent that governments are involved with pensions, either as payors or guarantors, they could be overwhelmed fiscally, spawning a currency crisis • Intergenerational politics will be stressed, as a smaller workforce will be asked to support a growing retiree group
	<p>Likelihood: Highly unlikely</p> <p>Uncertainty: Low</p>	<p>Impact intensity: Endurable</p> <p>Impact scope: Global</p>

Extreme risk: S2 Food/water/energy crisis

Background and Underlying Factors	Event Description	Potential Consequences
<p>It was estimated in 2010 that 600 million people in 21 countries were facing either cropland or freshwater scarcity, and that number is projected increase to 1.4 billion people in 36 countries by 2025.</p> <p>Over one billion people live in areas where human use of available water supplies exceeds sustainable limits and by 2025 this figure is projected to rise to 1.8 billion, with up to two-thirds of the world's population living in water stressed conditions (NIC and EUISS 2010).</p> <p>On the energy side, the supply of fossil fuels has a known limited time span while no viable alternatives are currently available with comparable energy returns on energy invested (EROEI). There is a risk that the necessary technological breakthrough will not arrive in time to prevent a global economic collapse due to an energy crisis.</p> <p>Consequently, given the current fine balance between supply and demand and the projections of demand growing faster than supply for food, water, and energy, we see this as a particular area of vulnerability.</p>	<p>The extreme risk event is the occurrence of a major shortfall in the supply of, or access to, food, water, or energy for a large proportion of the world's population, causing severe societal issues.</p>	<ul style="list-style-type: none"> • Particularly in the case of food and water, a crisis could lead to widespread death and damage to the quality of life for many survivors; economic stagnation could occur • Nations may go to war to take the resources they need from those who have them; for example OPEC nations could be attacked to gain access to their oil • Energy shortages, and food shortages for workers, could cause a significant decline in output
	<p>Likelihood: Unlikely Uncertainty: Low</p>	<p>Impact intensity: Crushing Impact scope: Local</p>

Extreme risk: S3 Health progress backfire

Background and Underlying Factors	Event Description	Potential Consequences
<p>In the movie <i>I am Legend</i>, a virus originally developed as a cure for cancer turns out to cause mutations (such as the inability to be exposed to sunlight), but the mutations are not discovered until after the virus has been used to inoculate most of the population. Society and the economy collapse, as a few who are immune seek an antidote.</p> <p>Modern medicine has been consistently meeting existing and new diseases with new treatments, giving rise to improved human health. There is no guarantee that the rate of medical advancement can always outpace the rate of pathogen evolution and a catastrophic event could emerge should biological mutation eventually outpace human innovation. This could result from the unintended consequences of current healthcare practices such as antibiotic resistance.</p> <p>The World Economic Forum warns (WEF 2013) that we are decades behind in comparison with the historical rate at which we have discovered and developed new antibiotics and none of the drugs currently in the development pipeline would be effective against certain killer bacteria.</p> <p>Social trends such as widespread mental health problems and obesity are additive to the problem. Stephen Petranek, then editor-in-chief of Discover magazine, points out in a TED talk that despite improved physical health, the human race is mentally falling apart – one in five people in the West is believed to be clinically depressed.</p>	<p>The event would be a massive rise in morbidity or mental ill-health for a large proportion of the population, perhaps due to an unintended consequence of a new health practice.</p>	<ul style="list-style-type: none"> • Both the quality of life and economic output would be degraded • Health-care costs would rise dramatically • There may or may not be a reduction in longevity; lifespans could be unaffected
	<p>Likelihood: Very unlikely</p> <p>Uncertainty: Medium</p>	<p>Impact intensity: Endurable/Crushing</p> <p>Impact scope: Trans-generational</p>

Extreme risk: S4 Organized crime

Background and Underlying Factors	Event Description	Potential Consequences
<p>Organized crime is a common reality for most if not all countries.</p> <p>The UK Home Office suggests that organized crime costs the UK between £20 and £40 billion each year and its impact is felt by the state, businesses, communities, families and individuals.</p> <p>Organized crime was very strong in the U.S. during Prohibition in the 1930s, providing a substantial business opportunity to which the general public did not object. When Prohibition was repealed the government was able to exert better control over the reach and influence of organized crime.</p> <p>The drug cartels in parts of Latin America where cocaine is produced are a modern-day example of the extent to which organized crime can become ingrained into the fabric of society.</p>	<p>The extreme event is a significant increase in the scale of illegal operations by organized crime in a major economy, to the extent that legitimate economic activity becomes non-viable.</p>	<ul style="list-style-type: none"> • Extreme form organized crime could bring severe disruptions to normal activities in affected areas, typically associated with high homicide rates, wide use of illegal drugs and the collapse of legal business activity potentially followed by social unrest.
	<p>Likelihood: Highly unlikely</p> <p>Uncertainty: Medium</p>	<p>Impact intensity: Endurable</p> <p>Impact scope: Local</p>

Extreme risk: *S5 pandemic*

Background and Underlying Factors	Event Description	Potential Consequences
<p>Recent pandemics (e.g., SARS, avian flu and swine flu), despite being successfully contained (for now?), demonstrate how easily deadly viruses can mutate.</p> <p>History is full of significant pandemics with an extremely high number of casualties. For example, it is believed that Plague of Justinian in AD 541-542 killed 50 percent of the world's population; the Black Death in the 13th century caused the death of one-third of the population of Europe, and 'Spanish flu' during 1918-1919 killed 20-50 million people (Kilbourne 2006).</p> <p>Of course, many of the above pandemics occurred before the advent of modern medicine. For example, the Black Death is believed to have been a bacterial infection which would, today, be treated with antibiotics. However, the current threat of antibiotic resistance suggests that we should not be too complacent about the ability of medical solutions to respond quickly to new strains of bacteria and viruses.</p> <p>Pandemics can be attended by high morbidity within a very short period of time (e.g., influenza), increasing the difficulty for effective vaccines to develop in time. Modern travelling patterns make it almost impossible to contain a contagious disease within a specific region.</p> <p>While we have relatively more knowledge about human disease pandemics than other events, there is still the possibility of surprises.</p> <p>Pandemics among animal or plants are also a reality. The most recent instance is the precipitous drop in the bee population, which is believe to be due to a virus.</p>	<p>The extreme event is a pandemic of a new, highly infectious and fatal disease that spreads quickly through human, animal or plant populations worldwide, with catastrophic consequences.</p>	<ul style="list-style-type: none"> • A substantial spike in mortality • Rather than being fatal, the disease could be permanently injurious (like polio), creating a whole class of people with higher morbidity • If it were necessary to restrict travel, business activity could be affected • Absenteeism could adversely affect core services, like hospitals, air traffic control, etc. • Animal or plant pandemics could adversely affect food supplies
	<p>Likelihood: Highly unlikely Uncertainty: High</p>	<p>Impact intensity: Crushing Impact scope: Global</p>

Extreme risk: *T1 Biotech catastrophe*

Background and Underlying Factors	Event Description	Potential Consequences
<p>DNA sequencing and synthesizing machines are available to anyone with enough money to afford a used car. Nasty nucleotide sequences such as the Ebola virus and the 1918 influenza virus are accessible online and genetic engineering of viruses is much less complex and far less expensive than sequencing human DNA. This makes it a lot easier to apply this technology to destructive uses than constructive ones.</p> <p>Adding to the problem is the fact that the biotech industry is highly unregulated. Regulating and controlling current and new developments would require strong global governance which the world currently lacks. British cosmologist and astronomer Martin Rees speculates that by the year 2020, an instance of bio-error or bio-terror will have killed a million people (Rees 2003), which is the extreme risk considered here.</p>	<p>The event would be an instance where biological technology (genome, nano-technology, viruses, etc.) is applied in a destructive way, either intentionally or inadvertently, with catastrophic consequences.</p> <p>(This risk overlaps somewhat with <i>S3 Health progress backfire</i>, due to the convergence between biology and technology.)</p>	<ul style="list-style-type: none"> • Consequences could range from disruption to extinction, and are uncertain • Could be similar to <i>S3 Health progress backfire</i> or <i>S5 Pandemic</i>
	<p>Likelihood: Highly unlikely</p> <p>Uncertainty: High</p>	<p>Impact intensity: Crushing/Existential</p> <p>Impact scope: Global</p>

Extreme risk: T2 Cyber warfare

Background and Underlying Factors	Event Description	Potential Consequences
<p>In the movie <i>Live Free or Die Hard</i>, cyber terrorists hack into government and commercial computers across the United States with the goal to start a "fire-sale" of financial assets. Electricity grids, traffic control systems, natural gas pipelines, communication networks and television are all disrupted via their computer networks. The film was based on the 1997 article "A Farewell to Arms" published in <i>Wired</i> magazine.</p> <p>This extreme risk refers to politically-sponsored computer hacking to conduct sabotage and espionage on a national or global-power scale.</p> <p>It is reported that a series of cyber-attacks on businesses and institutions in the United States have prompted fears of a looming 'cyber cold war'. Outgoing United States Defense Secretary Leon Panetta recently predicted a cyber-version of Pearl Harbor might soon take the United States by surprise.</p> <p>Social security, financial and medical systems connected to the internet could all become the target of cyber-attacks.</p> <p>A cyber-attack on the defense system can be expected to precede a military attack in all future wars.</p>	<p>The event would be computer sabotage or espionage on a major scale, with severe damage to hard infrastructure, financial services systems and networks, communications networks, corporate systems, medical support systems, or defense systems.</p>	<ul style="list-style-type: none"> • Cyber war could cause severe damage to physical infrastructure – bridges, tunnels, air traffic control, electricity grids and energy pipelines; this damage could easily be of a scale to disrupt business and economic activity • Financial records could be altered or destroyed on a massive scale, essentially wrecking the financial system • Ground traffic in major cities could be put into sustained gridlock, disrupting all aspects of life
	<p>Likelihood: Very unlikely Uncertainty: High</p>	<p>Impact intensity: Endurable Impact scope: Global</p>

Extreme risk: T3 Infrastructure failure

Background and Underlying Factors	Event Description	Potential Consequences
<p>This extreme risk refers to an interruption (prolonged but not permanent) of a major infrastructure network due to either human activity (e.g., cyber-attack), natural disasters (e.g., earthquake or flooding), or even cosmic threats (e.g., giant solar flare).</p> <p>The eastern US has been subjected to an electricity blackout twice since the 1970s. While the blackouts lasted only overnight, they unnerved the public, as they were unaccustomed to such events.</p> <p>We saw a glimpse of the potential impact of infrastructure failure after Storm Sandy hit metropolitan New York. Subways and power in lower Manhattan were out for over a week, power outages in the suburbs lasted a month or more, spot-shortages of gasoline were prevalent, and utility services for the most-affected areas took more than six months to be restored. The affected citizens were very angry that “no one was coming to help them” with these infrastructure problems.</p> <p>In most situations, the impact of an infrastructure failure can be expected to increase exponentially with the length of the ensuing disruption.</p>	<p>The event is an extreme interruption of a major infrastructure network, disrupting business activities or impacting basic needs of a large population for a period sufficiently long to be disruptive.</p> <p>An example would be the loss of the electricity grid in a population center for an extended period, particularly during the winter in colder climates.</p>	<ul style="list-style-type: none"> • An extended shut-down of a critical network or electricity grid would bring increasing disruption to economies within the geographical area of impact. • People’s basic needs would be threatened in such circumstances raising the possibility of social unrest and law-breaking behaviors for survival • A food, water or energy crisis could be spawned by an infrastructure failure
	<p>Likelihood: Very unlikely</p> <p>Uncertainty: Medium</p>	<p>Impact intensity: Endurable</p> <p>Impact scope: Local</p>

Extreme risk: T4 Nuclear contamination

Background and Underlying Factors	Event Description	Potential Consequences
<p>It is reported that worldwide there have been 99 accidents at nuclear power plants from 1952 to 2009 (defined as incidents that either resulted in the loss of human life or more than US\$50,000 of property damage), totaling US\$20.5 billion in property damages (Sovacool 2010).</p> <p>One of the worst nuclear contamination events to date is the Chernobyl disaster which occurred in 1986 in Ukraine, killing 30 people directly, causing thousands of indirect deaths due to radiation-induced cancer, as well as damaging approximately \$7 billion of property .</p> <p>Even the threat of contamination can be disastrous, as shown in Japan following their earthquake and tsunami. While some radiation was apparently released, the larger effects have been the shutdown of Japan's entire nuclear generation system. This decision will have far-reaching economic repercussions, for example it is likely to make Japan's semiconductor production business uncompetitive, which would be a major loss economically.</p> <p>Nuclear contamination can also be a direct consequence of a nuclear terrorist attack or a full-blown nuclear war among nations.</p>	<p>The event is a major nuclear accident or attack, more significant than Chernobyl, that leads to lethal effects on a large population of individuals and a major radioactivity release to the environment.</p>	<ul style="list-style-type: none"> • Fatalities and high morbidity for those directly affected • A food, water or energy crisis could be spawned by a nuclear contamination event • Loss of property value in the affected area, as residents migrate away • Disruption in electricity generation, as plants are shut down for safety checks; potential for a permanent loss of nuclear electric generation capacity
	<p>Likelihood: Very unlikely Uncertainty: Medium</p>	<p>Impact intensity: Crushing Impact scope: Local</p>

Extreme risk: T5 Technological singularity

Background and Underlying Factors	Event Description	Potential Consequences
<p>It is possible that the creation of a computer more powerful than the human brain, which can then design and build an even more advanced machine, would create an environment where human survival is at risk.</p> <p>In the <i>Terminator</i> movies, Skynet achieves self-awareness, correctly perceives humans as a threat, and attempts to exterminate the human race.</p> <p>Ray Kurzweil, a leading futurist believes that the “singularity”, in which a computer will be constructed that is capable of intelligent thought at the level of humans, is likely to occur in the next twenty years (Kurzweil 2005). A key premise is that technology is expanding exponentially, while people typically extrapolate linearly.</p> <p>However, while Kurzweil views the event optimistically, Bill Joy, former Chief Scientist at Sun Microsystems, has argued that “21st century technologies – robotics, genetic engineering, and nanotech – are threatening to make humans an endangered species” because “they share a dangerous amplifying factor: they can self-replicate’ (Joy 2000).</p> <p>Another possibility is a so-called nanotechnology ‘grey goo’ scenario, in which nano-robots self-replicate in an uncontrolled manner and eventually consume everything on the earth . The University of Cambridge has recently established a research Centre named ‘The Centre for the Study of Existential Risk’, devoted to studying possible catastrophic threats posed by present or future technology.</p>	<p>The event is a technological advancement that extends beyond the point of human understanding or control, including a computer capable of independent intelligent human thought, the development and deployment of self-replicating nanotechnology, a breakthrough in advanced robotics or a substantial step forward in genetic engineering.</p>	<ul style="list-style-type: none"> Consequences are highly uncertain
	<p>Likelihood: Highly unlikely</p> <p>Uncertainty: High</p>	<p>Impact intensity: Existential</p> <p>Impact scope: Pan-generational</p>