# Extreme risks

## 2013

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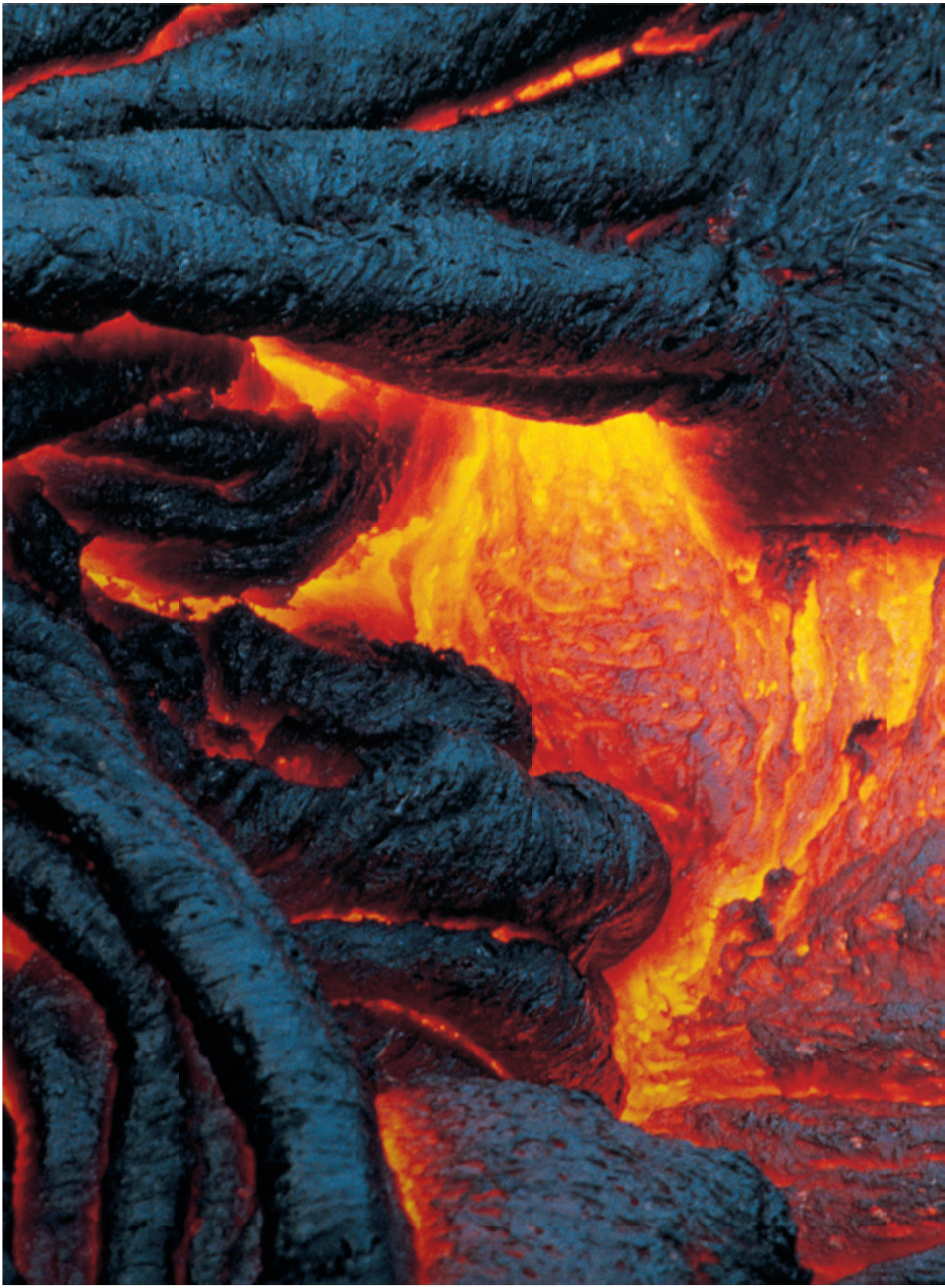


Extreme risks are potential events that are very unlikely to occur (and therefore infrequent) but that could have a significant impact on economic growth and asset returns, should they happen. We argue that a robust risk management approach should not stop at a particular percentile (whether $VaR_{95}$ or $VaR_{99.5}$) and a holistic risk management framework should include very unlikely, but potentially high impact, events.

# Why care?

We would like to argue that extreme risks matter and they deserve more attention than they have been given thus far for the following reasons:

- We believe that the world is a complex adaptive system where sudden and violent regime change is possible. In this description of the world, the tails of the 'complexity distribution' are considerably fatter than those of a normal distribution. That means extreme events are much more likely than we previously thought. Readers looking for a more detailed tour of this subject could refer to our long white paper.[2]
- We all only live once, in a single universe, and we face problems in series, not parallel. This seemingly naive statement, as we argued in a recent paper[3], is in fact often overlooked in the area of finance and economics when thinking about the 'average'. This type of thinking has a profound impact on how an extreme risk event should be considered. The very unlucky person who was hit by a lightning strike does not take any comfort from knowing that this is extremely unlikely to happen to anyone. When confronted with an extreme event, there is no going back in time and 'diluting' the impact with other less negative outcomes in parallel universes. One must deal with its consequences.
- Last but not least is that when it comes to assessing risks, particularly low-probability, high-impact events, our limited understanding of the world can have a material impact. In fact the uncertainty and our proneness to error can dominate when the extreme events involve poorly understood natural phenomena, complex social dynamics such as financial markets, or new technology.[4] For example, suppose that our body of knowledge indicates that some catastrophic event X has an extremely low probability Pr(X) of occurring. The margin of error associated with this estimate, resulting from flaws in our body of knowledge, could be significant. If this seems a strange concept at first, consider that our body of knowledge once thought the solar system was geocentric. In fact the whole history of scientific progress is one of correcting flaws in the previous body of knowledge. Extreme events might be much less extreme than we thought after all.

# Previous papers

By way of context, in 2009 we identified and then in 2011 provided an update of 15 extreme risks which were categorised into three groups: financial, economic and 'other'.

"'Other' extreme risks related to environmental and political themes... Climate change, major war, Euro break-up, political crisis, infrastructure failure, protectionism and killer pandemic were included in this group."

The **Financial** category of extreme risks concerned an inability to meet liabilities. This could occur as a liquidity event, such as a banking crisis, where an institution has insufficient cash or other liquid assets to meet a current demand for payment, even if the institution has more assets than liabilities. Failure to make that payment could cascade rapidly through the financial system, with further institutions then unable, or unwilling due to a collapse in trust, to meet their own payment demands. The alternative mechanism for a financial extreme risk was a solvency-driven crisis, such as an insurance crisis or sovereign default, where there are insufficient assets to meet the liabilities irrespective of how liquid the assets are. This does not preclude the possibility that a solvency crisis could lead to a liquidity crisis or vice versa.

**Economic** extreme risks were less homogenous, ranging from a deflationary depression to hyperinflation and end of fiat money. These risks would have their genesis in imbalances, which create instability. Imbalances could be seen all around us – household debt relative to income, government debt relative to GDP, government revenue relative to expenditures, imports relative to exports, foreign reserves and, perhaps, the size of the financial sector relative to the economy in certain countries. While the correction of imbalances can occur smoothly there is plenty of potential for non-linear, and therefore painful, jumps, including a currency crisis or resource scarcity.

**'Other'** extreme risks related to environmental and political themes. If we considered the way we were treating the environment, and the political structures we had (or more importantly, did not have) for dealing with it, as well as with the financial and economic issues, we ended up with wide scope for nasty surprises. Climate change, major war, Euro break-up, political crisis, infrastructure failure, protectionism and killer pandemic were included in this group.

# New list of 30 risks

In this new update, we have significantly extended our thinking in the 'other' group, breaking it down into four categories: political, environmental, social and technological. As a result, the total number of extreme risks we have identified has increased to 30, although most of the analysis hereafter is centred on the top 15 risks ranked by their importance as per an algorithm which we describe later in this paper.

**There are no changes made to the Financial category, which includes the same three risks of banking crisis (F1)[5], insurance crisis (F2) and sovereign default (F3).**

**Economic:** these risks are now described as arising from a shock to growth, a shock to price levels, or a collapse in trust (which is essential for the efficient working of any economic system). Growth shocks can take the form of a depression (E5) or stagnation (E7). The former has a painful contraction phase but then relatively swift recovery, compared to stagnation where growth is weak for an extended period. Price level shocks can occur in opposite directions: rapid rises in hyperinflation (E6) and falling prices in deflation (E4). 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 (abandonment of fiat money, E1), in the value of a major currency (currency crisis, E3), or in the economic system as a whole (break-down of capitalism, E2).

**Political:** This category of extreme risks comprises those which derive from policy decisions. In two of the cases the link is direct and obvious. Global trade collapse (P2) follows policy decisions to favour protectionism over openness and globalisation, and World War III (P5) follows an active decision to declare war. For anarchy (P1) and political extremism (P3) the link is less direct but in both cases poor prior policy decisions are likely to be a necessary, if not sufficient, condition for these risks to foment. Terrorism (P4) is included in the political category due to its ideological foundation, and as the target chosen for the act of terrorism is likely to have political ramifications. Please note that we are considering extreme manifestations in this paper. Terrorism is a weekly, if not daily, occurrence somewhere around the world and so the extreme risk would be a terrorist act comparable to, or worse than, 9/11.

**Environmental:** The risks in this category are threats to human safety and well-being arising from a disruption to planet earth's environment. If we draw the boundary of the system around the earth and its atmosphere then two of these risks – alien invasion (e1) and cosmic threats (e3) – would be exogenous. Is an alien invasion too extreme to spend any time seriously considering? Quite possibly. After all, both the probability of the event and the consequences are unknowable. However, risk management is about taking action in advance to prepare for possible future consequences and the value of the exercise is in scanning the horizon with an open mind. We can always apply further filters at a later stage to protect our finite risk management resources (in fact alien invasion is not included in the top 15 risks we focus on in this paper). Two of the environmental risks, biodiversity collapse (e2) and global temperature change (e4), could be caused by humanity, and would thus represent serious own-goals. The final risk in this category is natural catastrophe (e5). As earthquakes, for example, happen every day the extreme version of this risk is either a confluence of extreme natural catastrophes (think magnitude 10 earthquake, combined with 25 metre tsunami, helped along by a category five windstorm) or the eruption of a supervolcano. This is the downside of living on a planet that regularly brings to the surface useful and valuable minerals.

**Social:** The social extreme risks are those threats that could adversely affect the smooth functioning of society. It should be noted that the categories we are discussing are not independent and it should be clear that the social risks link to policy decisions, the environment, and, in some cases, to technology. This is obvious in the case of food/water/energy crisis (S2) which will have political, environmental and technological drivers as well as offsets. Three of the risks are health related. Pandemics (S5) are a favourite of commentators on extreme risks as in relative terms there is plenty of good data. For our purposes we postulate a new disease agent that hits the 'disease sweet spot' of high infectivity and high mortality (these are typically trade-offs). Health progress backfire (S3) refers to a reversal in the trend of improved health while, in the other direction, extreme longevity (S1) becomes a risk when viewed through the lens of a retirement provider. In most other contexts it would be considered a boon. The final risk in this category is the growth in organised crime (S4) to the extent that legitimate economic activity ceases to be viable in the (major) country or region concerned.

**Technological:** Our final category of extreme risks concerns technology. These risks range from a failure in current technology (nuclear contamination, T4 and infrastructure failure, T3), through the possible consequences of emerging technology (cyber warfare, T2 and biotech catastrophe, T1), to the unknowable future event of the technological singularity (T5). The latter risk refers to the point in time when humans have designed super-intelligence into machines. What happens beyond that point is unknowable and therefore the subject of speculation. The extreme version has already been foreshadowed in various fictional films where the machines replace their human creators.[6]

# Assessment of top 15 risks

For this exercise to be useful we cannot stop at the identification and simple listing of the risks. We need to assess them in order to determine which are more material and which are less.

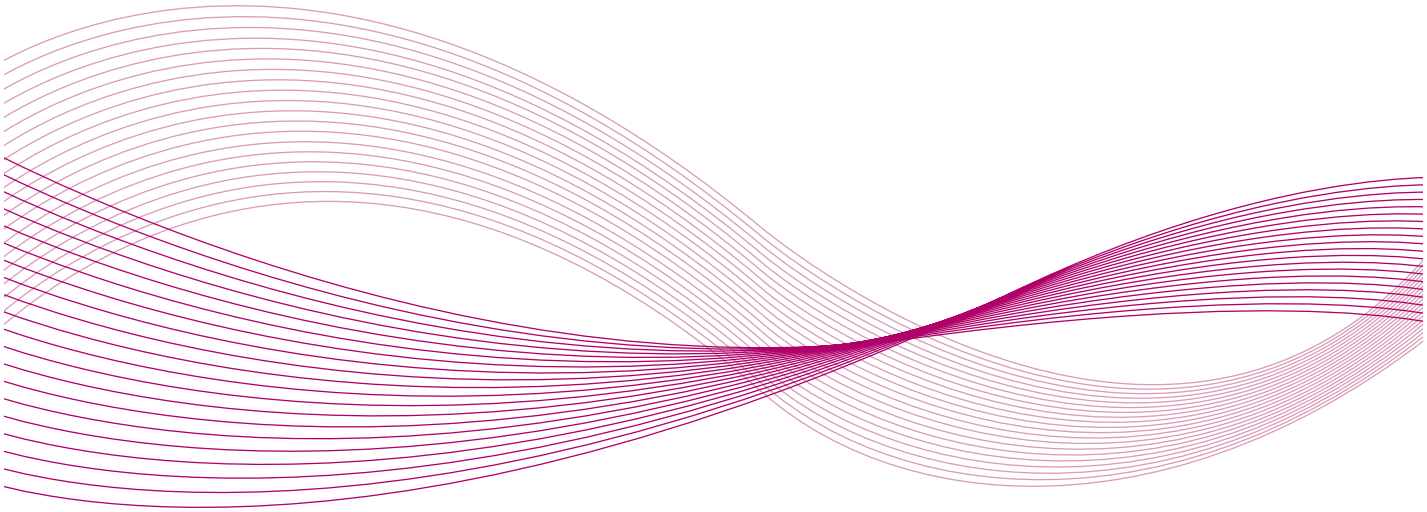
In this update we have 'upgraded' our assessment methodology[7] from the previous two-dimensional likelihood and impact framework and it is shown in **Figure 01** and illustrated graphically in **Figure 02**:

- Starting from likelihood, the new methodology provides a four-point scale representing a likelihood of occurrence of one-in-10 years, one-in-20 years, one-in-100 years, and less likely than one-in-100 years.
- We have split the potential impact of the risk into two separate dimensions, namely the intensity and the scope (or geographical and temporal spread)[8]:
  - The intensity is assigned to one of three states that are labelled 'endurable', 'crushing', and 'existential'. Consider yourself in the three states. An endurable risk could represent a broken leg; crushing might imply the loss of a limb, or paralysis; and existential could refer to the loss of self-awareness or loss of life.
  - The scope of the impact attempts to convey both spatial and temporal information by use of four categories: local, global, trans-generational, and pan-generational. The first two imply a temporary impact while the latter two imply a lasting impact. We use 'trans-generational' to describe an impact that will affect more than one generation but that would then fade or reverse. Pan-generational is used to describe an impact that would affect all subsequent generations, or all previously potential generations (such as extinction of the human species).
- The final score assigned to each risk is uncertainty which is assessed as low, medium, or high. In the graphical representation this is shown as a semi-transparent border around the sphere, with higher uncertainty shown by a larger 'fuzzy' border (or 'location'). As indicated by the shape, the uncertainty is in two dimensions: uncertainty regarding the likelihood and uncertainty regarding the impact.

## Figure 01. Extreme risks assessment table – top 15 risks

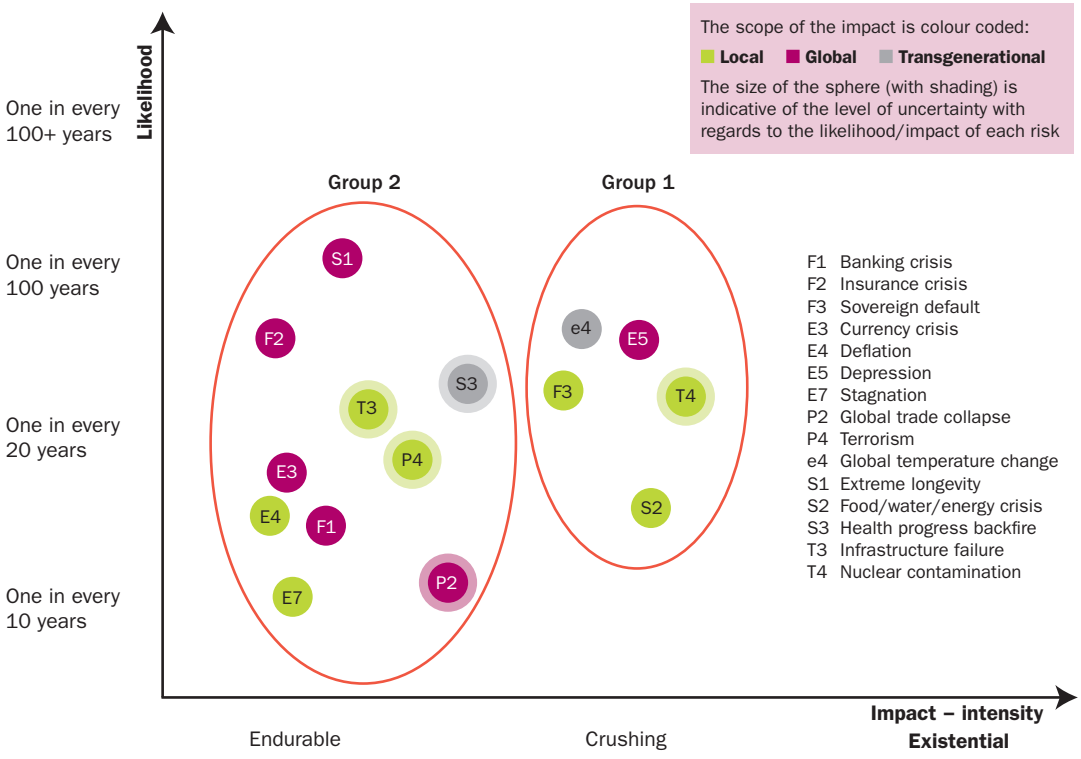
| | **Likelihood**<br>1 – one in 10 years<br>2 – one in 20 years<br>3 – one in 100 years<br>4 – one in 100+ years | **Uncertainty**<br>A degree of High (H), Medium (M) or Low (L) | **Impact – intensity**<br>1 – Endurable<br>2 – Crushing<br>3 – Existential | **Impact – scope**<br>1 – Local<br>2 – Global<br>3 – Trans-generational<br>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 |

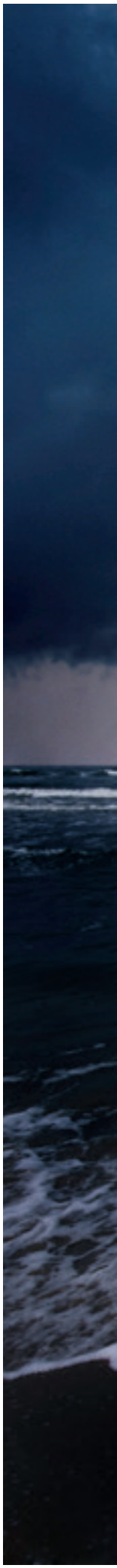
The sharp-eyed readers will have noticed that none of the top 15 extreme risks are assessed as ‘One in every 100+ years’, ‘Existential’, ‘High uncertainty’, or ‘Pan-generational’, which might suggest that these points on the scales are redundant. This is a result of the filtering process applied that excluded the bottom 15 extreme risks which we believe require less attention for the purpose of this paper. For example, we believe that an alien invasion is a potentially existential risk, with high uncertainty, very unlikely (one in every 100+ years) and with impacts affecting all future generations (pan-generational).

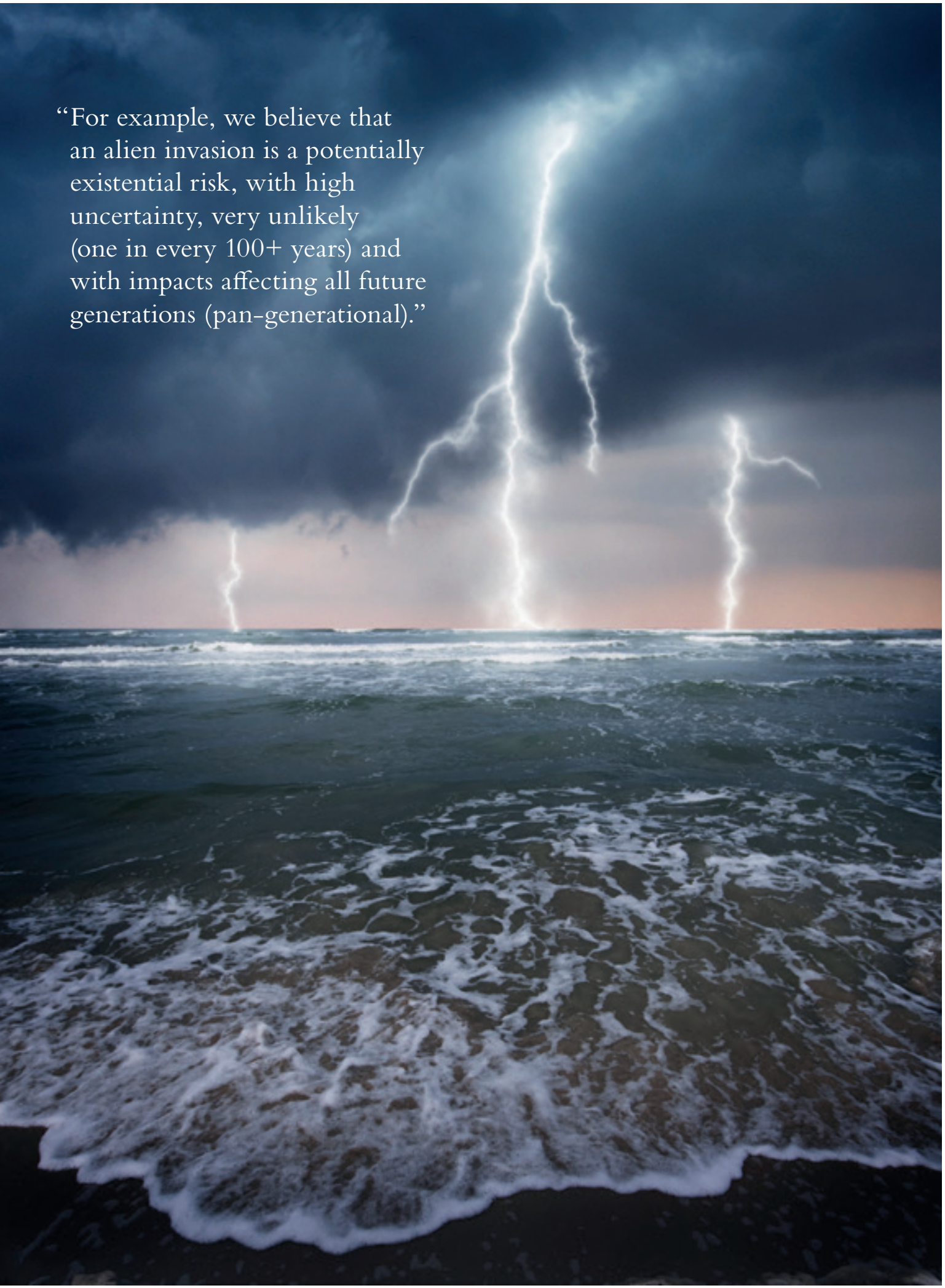


There is a general upwards slope towards top-right, implying that the worst risks are also the least likely, with a couple of exceptions including extreme longevity (S1) and insurance crisis (F2) which are assessed to have both very low likelihood and low impact. For ease of exposition, we can split **Figure 02** into two regions. The first group comprises the five risks with crushing intensity of impact. For these events we expect the effect on assets to be global and materially negative. While the value of liabilities would also generally fall, liabilities tend to be more local than assets and therefore the effect on an entity's balance sheet would be case specific (the exception would be depression, E5, where falling long-term interest rates would drive up the value of liabilities). On balance, therefore, we would expect asset losses to be larger than any reduction in liabilities and so funding levels would deteriorate. The second group is the left ten points (endurable intensity). These are less homogenous but in general we would expect the impact on liabilities to be more muted. The two exceptions in this group are health progress backfire, which would reduce pension fund liabilities but possibly increase insurance liabilities, and extreme longevity which would explicitly increase pension-related liabilities.

## Figure 02. Extreme risks assessment





"For example, we believe that an alien invasion is a potentially existential risk, with high uncertainty, very unlikely (one in every 100+ years) and with impacts affecting all future generations (pan-generational)."

# Association

These extreme risks are not entirely independent. We therefore also show an 'association' matrix in Figure 03. This is not a correlation matrix. Correlations require data to calculate and even then say nothing about causality. Instead we use the term association to communicate that this is a qualitative assessment of whether there is likely to be any causality between the events.

If wanting to consider whether a particular event, X, might cause another event Y, select X in the first column and read across the row. A blank cell means that, in our opinion, X does not cause Y to any material extent. An 'L' for low means that we believe X could cause Y, or is a contributory factor. An 'H' for high means we believe the causality is material, so X is likely to, or will, cause Y. For example, reading across the third row of entries shows that we believe sovereign default (of a major country) (F3) could cause, or contribute to, a banking crisis (F1), a depression (E5) and/or stagnation (E7). A sovereign default is likely to, or will, cause an insurance crisis (F2), and a currency crisis (E3).

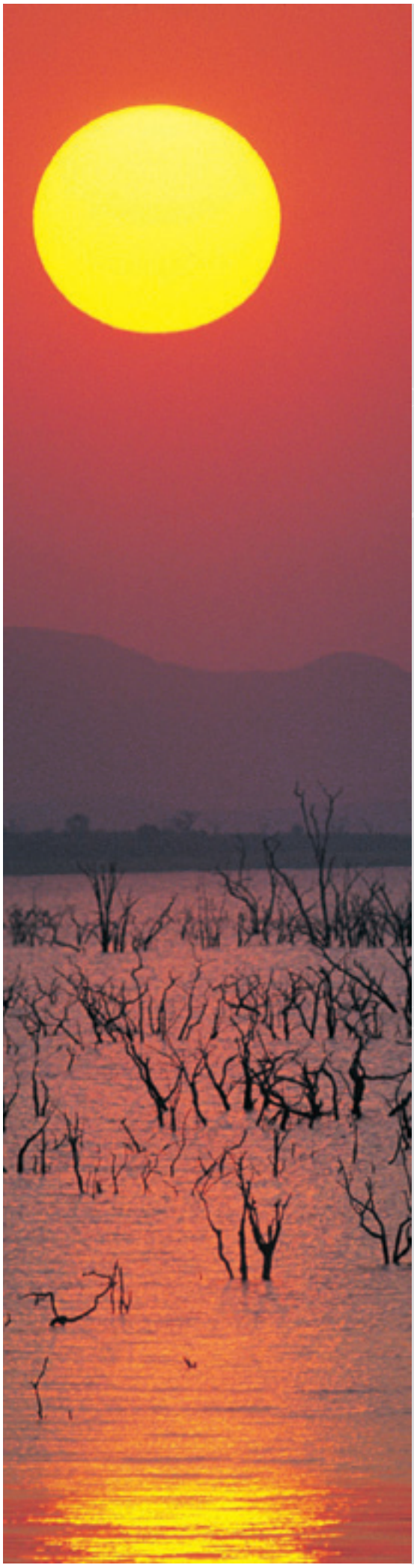
**Figure 03** can also be read down the columns. In this case the column entries mean event Y could or is likely to 'be caused by' events corresponding to the cell entries. As an example, banking crisis (F1) is likely to be caused by depression (E5). It could be caused by a sovereign default (F3) or a currency crisis (E3).

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). 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 depression (E5) and stagnation (E7). 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.

**Figure 03. 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 | | | | | | | | | F1 |
| F2 Insurance crisis | | | | | | | | | | | | | | | | F2 |
| F3 Sovereign default | L | H | | H | | L | L | | | | | | | | | F3 |
| E3 Currency crisis | L | L | L | | | L | L | | | | | L | | | | E3 |
| E4 Deflation | | | L | | | L | H | | | | | | | | | E4 |
| E5 Depression | H | L | H | | H | | L | | | | | L | | L | | E5 |
| E7 Stagnation | | L | L | | H | | | | | | | | | | | E7 |
| P2 Global trade collapse | | | | | | L | L | | | | | H | | L | | P2 |
| P4 Terrorism | | | | | | | | | | | | | | H | L | P4 |
| e4 Global temperature change | | | | | | | L | | | | | H | L | L | | e4 |
| S1 Extreme longevity | | H | L | | | | | | | | | L | | | | S1 |
| S2 Food/water/energy crisis | | | | | | | L | | | | | | | | | S2 |
| S3 Health progress backfire | | | | | | | | | | | | | | | | S3 |
| T3 Infrastructure failure | | | | | | | | | | | | L | | | | T3 |
| T4 Nuclear contamination | | | | | | | | | | | | L | | L | | T3 |
| | F1 | F2 | F3 | E3 | E4 | E5 | E7 | P2 | P4 | e4 | S1 | S2 | S3 | T3 | T4 | |

"There is a significant clustering of associated risks within the financial and economic categories, which should not be surprising."



# Ranking

The final part of our assessment of these risks is to create a ranking of their importance. This introduces no new information but simply combines the four scores for each risk into a single ranking.

The intuition is straightforward. The more likely a risk, the higher up the ranking it should be. Likewise, the less uncertain a risk, the greater the intensity of impact and the larger the scope of the impact, the higher up the ranking a risk should be. Our ranking is shown in **Figure 04**.

At the top of our ranking is food/water/energy crisis (S2). This is primarily driven by our assessment that this is one of the most likely risks and that there is relatively little uncertainty attached to either the likelihood or the consequences. The consequences themselves, locally crushing, are not particularly severe (again in relative terms) and so these are not a driver of the top ranking. The second ranked risk, stagnation (E7), differs only in respect of the intensity of impact which is assessed to be endurable rather than crushing. In contrast the third ranked risk, global temperature change (e4), has much more severe consequences (trans-generationally crushing) but is assessed to have a lower likelihood of occurring.

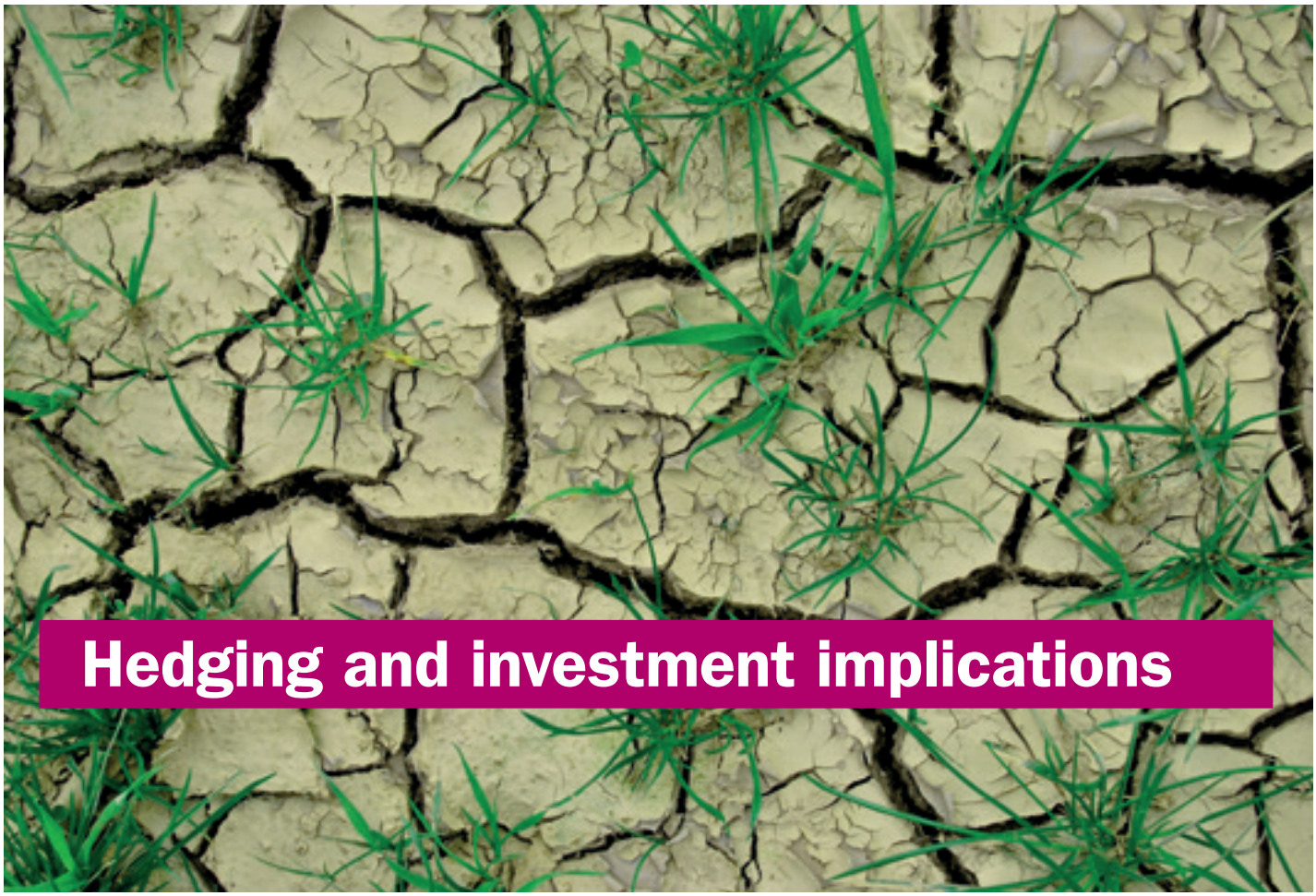
The power of the ranking system is that it combines and trades-off the four risk scores in a consistent manner. Different weights could be applied, but the importance of a ranking system is to challenge pre-conceptions (and mitigate black swan biases). Whatever the weights, the ranking highlights the risks to prioritise when it comes to management actions.

## Figure 04. Extreme risks ranking – top 15 risks

| Risk ranking as at 30 June 2013* | | | |
|---|---|---|---|
| **Rank** | **Risk** | **Description** | **What to invest in** |
| **1** | S2 Food/water/ energy crisis | A major shortfall in the supply of food/water/energy | Securities providing exposure to resource in shortage or beneficiaries of substitution |
| **2** | E7 Stagnation | A prolonged period of little or no economic growth | Globally-diversified long-dated sovereign nominal bonds |
| **3** | e4 Global temperature change | Earth's climate tips into a less-habitable state (hot or cold) | Land (in the 'right' place) |
| **4** | E5 Depression | A deep trough in economic output with massive increase in unemployment | Globally-diversified long-dated sovereign nominal bonds |
| **5** | P2 Global trade collapse | A worldwide protectionist backlash against cross-border trade | Short companies with high reliance on global trade |
| **6** | F1 Banking crisis | Banking activity halts due to lack of liquidity | Short bank equity, long nominal sovereign bonds (medium duration) |
| **7** | F3 Sovereign default | Non-payment by a major sovereign borrower | Country insurance (for example CDS) |
| **8** | E3 Currency crisis | Extreme movement between exchange rates | Foreign assets, currency hedging derivatives, gold |
| **9** | E4 Deflation | Goods and services prices fall for an extended period | Deflation swap, nominal bonds |
| **10** | S3 Health progress backfire | Massive rise in morbidity or mental ill-health, antibiotic resistance | Health care providers |
| **11** | T4 Nuclear contamination | A major nuclear disaster, leading to large radioactivity release and lethal effects | Short uranium |
| **12** | S1 Extreme longevity | Significant increase in life expectancy overwhelms support systems | Longevity swap |
| **13** | F2 Insurance crisis | Insolvency within insurance sector | Short insurance equity, long CDS (with the 'right' counterparty) |
| **14** | P4 Terrorism | A major ideologically-driven attack | Defence companies |
| **15** | T3 Infrastructure failure | An interruption of a major infrastructure network | Tinned food, bottled water, generators |

* Our subjective measure based on the intensity and scope of the impact, the likelihood, and the degree of uncertainty in assessing the risk level

"At the top of our ranking is food/water/energy crisis (S2). This is primarily driven by our assessment that this is one of the most likely risks and that there is relatively little uncertainty attached to either the likelihood or the consequences."



# Hedging and investment implications

While interesting in its own right, we believe the consideration of extreme risks can be useful in helping to design more robust investment portfolios and more robust risk management processes.

The starting point to building a robust investment portfolio and reducing (but not eliminating) tail risks is to introduce greater diversity. It should be noted that diversity is a broader concept than diversification and it refers to having exposure to as broad a number of different risk premia/return drivers as possible, in order to reduce the risk that forecasts about the future are 'wrong'. This is one important element of the world view that we are proposing, and which should lead to more consideration of extreme events.

The next step is to explore some hedging strategies. We present some simple ideas in the **Table 03**, but broadly there are three hedging strategies available to us:

- **Hold cash.** To quote James Montier of GMO, cash is "perhaps the oldest, easiest, and most underrated source of tail risk protection"[9]. Over long historical periods cash has held its real value through both episodes of deflation and inflation but there is no guarantee that this will be the case in the future. If an investor views holding cash as too-high an opportunity cost currently, especially in real terms in Western markets, then this will be a difficult option. However, it is possible to view cash as having a high option value, as some sovereign wealth funds do, with that value increasing non-linearly with the degree of market stress experienced.
- **Derivatives.** As an example, pension funds that worry about extreme longevity can purchase a longevity swap. Or they could buy a Credit Default Swap (CDS) to insure against non-payment by a sovereign borrower. It is worth mentioning that cost and usefulness are often in opposition. The cost of derivatives protection can often be reduced by specifying more precise conditions – but the more precise the conditions, the greater the chance that they are not exactly met and hence the 'insurance' does not pay out.

- **Hold a negatively-correlated asset.** It is clear from **Figure 04** that there is no single asset that will work against all possible bad outcomes. Further, there is no guarantee that the expected performance of the hedge asset will actually transpire in the future event. For example, what hedge can we use against a global temperature change event? The habitable land in the world will be significantly reduced, but assuming that demand for habitable land remains unchanged (that is, population is virtually unaffected by the event), the price of that land will likely go up. However there is tremendous difficulty in discovering the 'right' land beforehand to include in your portfolio which will not only survive from a highly uncertain global temperature change event but also be free of nationalisation or foreign invasion after the catastrophic event occurs.

Of course, hedging comes with its own set of problems as we described in our previous paper.[10] Not all extreme risks can be hedged, and most hedges used are likely to be very imprecise. Even for risks that can be hedged, the carrying cost of the hedge is likely to be high and almost certain to require the use of derivatives. Therefore thought needs to be given to whether the counterparty would be willing and able to pay out if the bad event happened.

In essence the exercise of considering extreme-risks is time spent on 'pre-mortems'. While a post-mortem seeks to establish the cause of death, pre-mortems are about trying to determine in advance what could, colloquially, kill you. We believe that being adept at pre-mortems means you are a better risk manager, and can react more flexibly in the event of an extreme event happening, particularly as the event is unlikely to evolve precisely along the lines predicted.

Consequently, the obvious application of extreme risk thinking is in stress-testing (or reverse stress-testing[11]) or scenario planning, but it is also constructive to consider whether the thinking can be incorporated within the process for managing an investment institution's balance sheet.

One option would be to penalise the existing 'normal state' assumptions by slightly reducing expected returns, or pushing up volatilities, and/or correlations to reflect the impact of infrequent extreme events. A second option is dynamic switching of some sort. We either build two sets of assumptions ('normal' and 'extreme') or we design a second, extreme-risk portfolio directly from first principles. Then 'all' that is left to do is successfully time the switch between the two, not forgetting the need to time the switch back so we can go on harvesting returns when the conditions are conducive.

We would also advocate establishing some sort of early warning system to closely monitor what could develop into extreme events. While this is probably once again one of the areas where things are easier said than done, there has been some interesting research into this area of trying to predict the seemingly 'unpredictable'. For example, Didier Sornette and his Financial Crisis Observatory have plotted a set of early warning signs for unstable, growing systems.[12]

So how should investment institutions actually adapt in recognition of extreme risks? We would suggest a prioritisation exercise: first, worry about the events 'that can kill you', that is permanently impair the investor's mission. This should identify which extreme risks matter and which can be ignored. For the former, the right thing to do is to pay up for the insurance, given that the prioritisation exercise has shown the investor cannot afford to self-insure. Second, an investor should do the simple things. These would include ensuring the portfolio is as diversified across as many return drivers as possible; diversifying within asset classes; and creating a strategic allocation to cash to provide optionality. Finally, greater complexity can be added over time, assuming it passes a considered cost/benefit analysis. This is likely to involve adding long-dated derivative contracts in a contrarian manner, that is, when they are cheap rather than popular.

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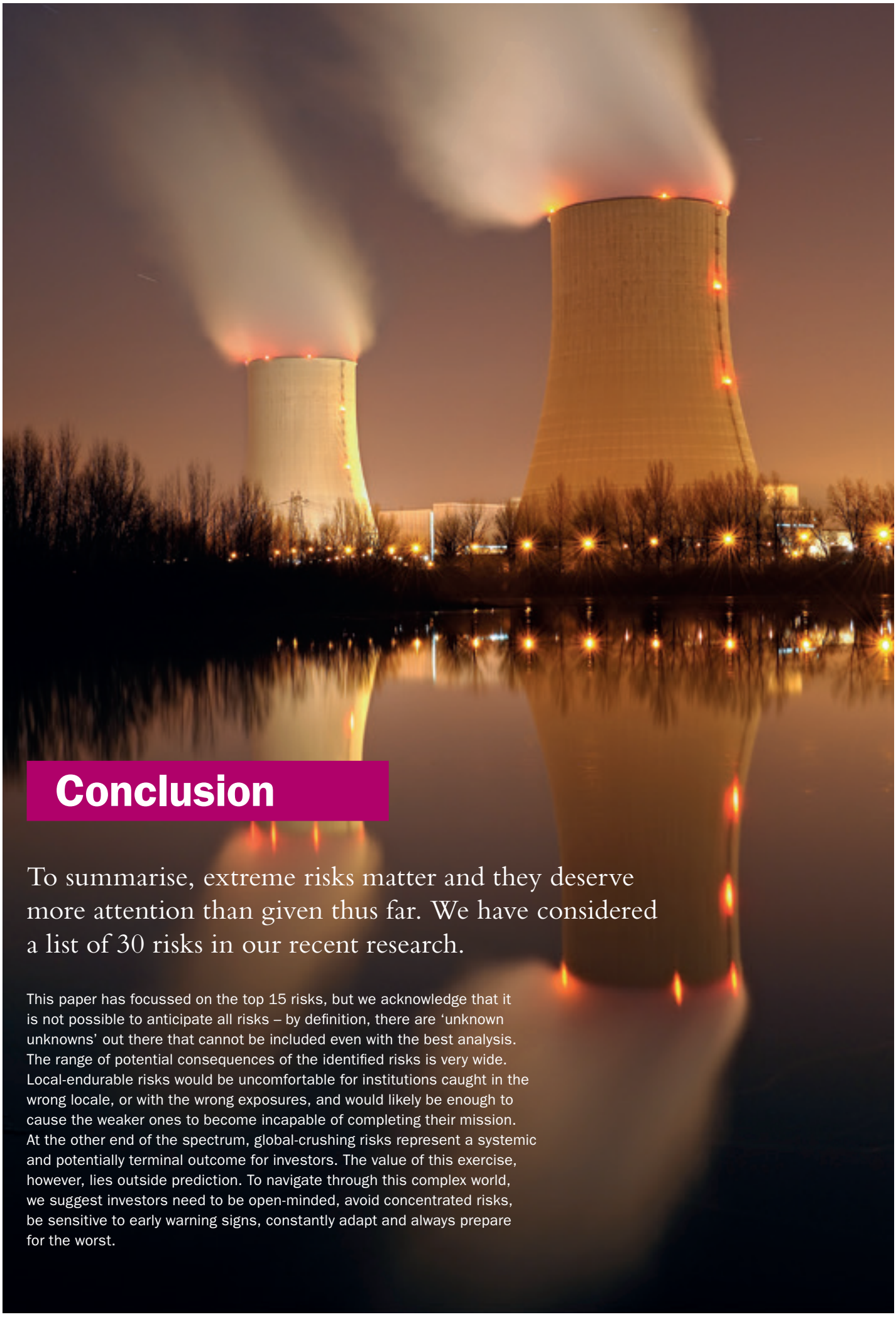

# Conclusion

To summarise, extreme risks matter and they deserve more attention than given thus far. We have considered a list of 30 risks in our recent research.

This paper has focussed on the top 15 risks, but we acknowledge that it is not possible to anticipate all risks – by definition, there are 'unknown unknowns' out there that cannot be included even with the best analysis. The range of potential consequences of the identified risks is very wide. Local-endurable risks would be uncomfortable for institutions caught in the wrong locale, or with the wrong exposures, and would likely be enough to cause the weaker ones to become incapable of completing their mission. At the other end of the spectrum, global-crushing risks represent a systemic and potentially terminal outcome for investors. The value of this exercise, however, lies outside prediction. To navigate through this complex world, we suggest investors need to be open-minded, avoid concentrated risks, be sensitive to early warning signs, constantly adapt and always prepare for the worst.

## Footnotes

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

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

**3** 'The irreversibility of time', Towers Watson, 2012.

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

**5** The labelling of the risks is alphabetical within the categories.

**6** Readers could refer to the long white paper for a more detailed description of each extreme risk (see footnote 2).

**7** We followed a rigorous and robust process to develop our qualitative assessment methodology. In stage one, a team of Towers Watson researchers reviewed the research literature and historical data on past extreme events. The team members then independently generated their scores. In stage two, the independent scores were compared and debated, with a single consolidated scoring approach being the outcome. For stage three, the consolidated scores were sent for peer review by a senior committee, and further refinements were suggested by the committee. Stage four was sign off of the revised scores by the peer review committee.

**8** We have drawn on and adapted the qualitative risk categories of Nick Bostrom mentioned in footnote 4.

**9** 'A value investor's perspective on tail risk protection: an ode to the joy of cash', James Montier, June 2011, GMO white paper.

**10** 'Extreme risks – the 2011 update', Towers Watson, 2011.

**11** Reverse stress testing starts from an outcome of organisational failure and seeks to identify the circumstances where this might occur, thus exposing potential vulnerabilities. Whereas a stress test looks at the impact of a particular adverse scenario, a reverse stress test starts from a negative outcome and seeks to discover the series of events that may lead to this outcome. Reverse stress testing covers plausible scenarios outside the normal stress testing requirements. More details can be found at 'An application of modern social sciences techniques to reverse stress testing at the UK Pension Protection Fund', N. Cantle et al (http://www.ermsymposium.org/2013/pdf/erm-2013-paper-clarke.pdf)

**12** This is explained in a talk given by Didier Sornette, the director of the Financial Crisis Observatory (http://www.ted.com/talks/didier_sornette_how_we_can_predict_the_next_financial_crisis.html)

## Thinking Ahead

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