Thinking Ahead Institute
An innovation network founded by WTW

Fresh snow | risk management for investment systems

The time for new risk lenses

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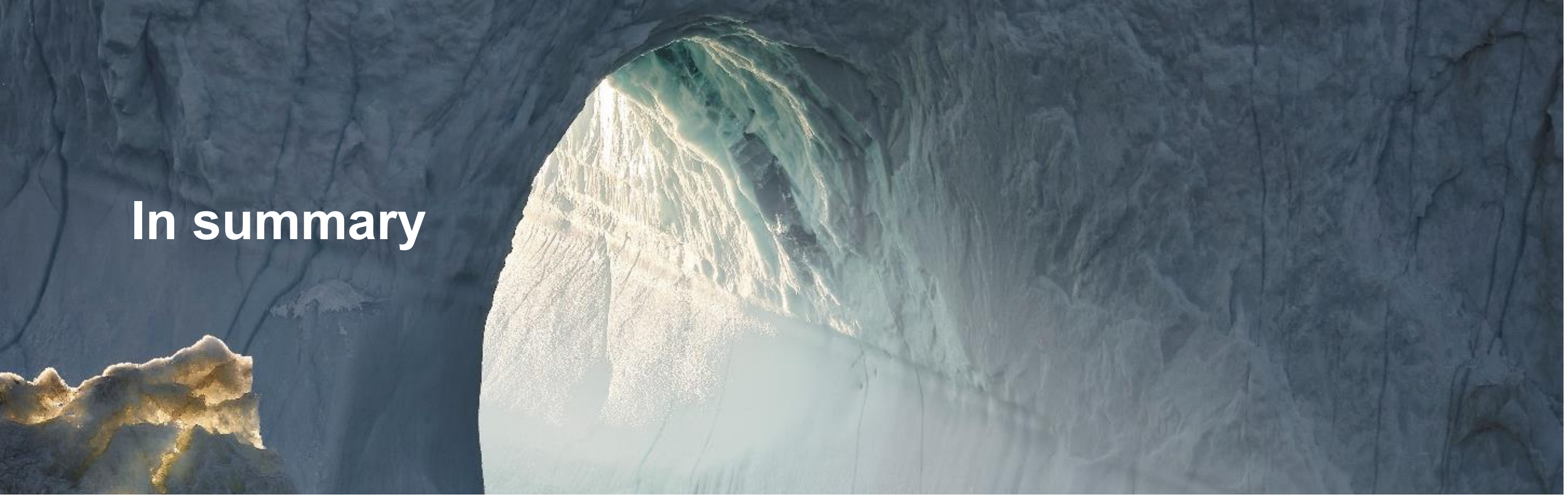

In summary

In 2012, Thinking Ahead published a paper with the title *The wrong type of snow*. It was a paper about risk, one of the most studied and written about subjects in our investment world. We saw the parallel between trains that couldn't run because it was the wrong type of snow[1] (ie lame excuse) and portfolios that didn't perform because it was the wrong type of risk. Historically, risk was mostly considered at a point of time and looking backwards, not over time and looking forwards. Our paper argued for an intertemporal perspective – we defined risk mostly as impairment to mission, which necessarily involves a journey through time.

In our opinion the paper has aged well, and is still a good read. But we now feel we have something new to say about risk – hence 'fresh snow' as the title for this paper.

As we have continued to learn about, and think about, systems, we have increasingly come to see current risk management practice within the investment industry as not paying enough attention to the bigger picture, the narrative along with the numbers, and the more distant future. Too much attention is given to the design, construction and positioning of the deck chair, and not enough to the waters ahead and what might be in them.

After a brief review of what risk is in section 2, we introduce the core idea of this paper in section 3 – risk 1.0 and risk 2.0 are different because they are built on different (mental) models of reality. In section 4 we describe the movement from 1.0 to 2.0. Most of the movement so far has been to add increasing sophistication to 1.0. We already have the mental model for 2.0, but getting our measurement, modelling and narrative to join us is non-trivial. We offer some suggestions. In section 5 we set out the case for why we believe that risk has an 'upward-sloping term structure' – in plainer words, why the future is likely to be a riskier place than the present. Section 6 looks backwards and attempts to answer the question "does a risk 2.0 mindset, applied to historic market drawdowns, help us understand our investment world?". While section 7 attempts to look forward and anticipate two unwelcome developments – the withdrawal of insurance and a food crisis. Do we see different things through the 1.0 and 2.0 lenses? We argue 'yes'. Section 8 concludes this paper by reviewing the benefits of adopting a risk 2.0 mindset and developing the associated practice. In short, it is better. Risk 1.0 will always underestimate risk, because it doesn't give the system an explicit place in the model – and the system always has feedback loops.

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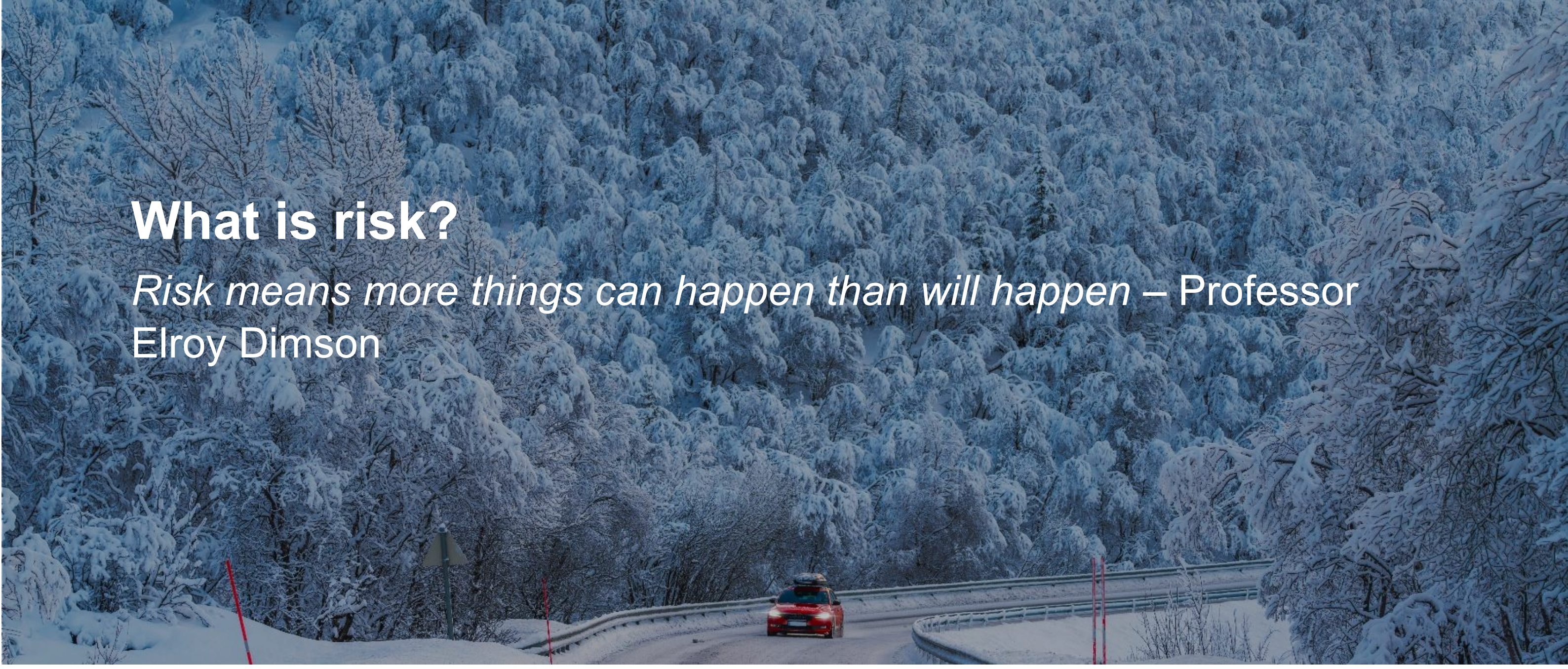
[1] A phrase invented by the British media in 1991. See https://en.wikipedia.org/wiki/The_wrong_type_of_snow



What is risk?

Risk means more things can happen than will happen – Professor Elroy Dimson

A lot of words have been written to explore what risk is and we are responsible for some of them[2]. Here we make the case that risk looks different to different models of reality. Sometimes understanding is illuminated by considering what something is *not*. So, risk is *not* historic volatility, and it's about *not* knowing. The future is fundamentally hidden – we just don't know.

Turning to what risk is, for us it is mostly about a permanent impairment to mission. If an outcome has the potential to compromise our ability to meet our mission, then we are facing considerable risk. If, instead, it is merely unwelcome, uncomfortable and stressful then either we have enormous buffers, or our risk management is excellent. When thinking about risk, context matters.

Models of reality

All models are wrong, but some are useful – George Box

We have previously written about the need to build models of reality[3]. Reality is too big and too complex to understand, and so we build models – simplifications. As simplifications these models will be wrong, but many of them are useful. Once upon a time we modelled the solar system with the Earth at the centre. This was wrong but useful enough for its time. However, if we had failed to update this model our subsequent attempts at space exploration would have been far less successful. By analogy, we are arguing that we need to update from risk 1.0 to risk 2.0. These are built on different models of reality, as we explore below.

3.1 Risk 1.0

The origin story of risk 1.0 starts with Harry Markowitz in 1952[4]. From this point flows the tools (eg mean-variance optimisation, capital asset pricing model etc) and theories (eg modern

[2] See *The wrong type of snow: risk revisited*
[3] See *Systemic risk | deepening our understanding*, Thinking Ahead Institute, 2023
[4] *Portfolio Selection*, Harry Markowitz, The Journal of Finance, 1952

portfolio theory, separation theorem etc)[5]. However, all of it is based on a particular model of reality which is no longer fit for purpose.

Classic economics built a model of reality, and derived laws to explain the behaviour of that model. Within the model we could perform calculations and make predictions, while deviations of the model from observed reality could be explained as 'exogenous shocks' (originating outside the system). Risk model 1.1 was essentially a Gaussian log-normal distribution combined with the knowledge that we would be hit from time to time by unknowable and unquantifiable shocks. We have now risen up the rungs of this ladder to risk model 1.x, which is 'Gaussian with very sophisticated modifiers'. The modifiers can change the shape of the tails of the distribution, and seek to bring in to the model as much of the external shocks as possible. In truth, leading edge risk management under risk 1.0 is genuinely impressive. However, it has been unable to address one problem – namely that the ladder is leaning against the wrong wall.

3.2 Risk 2.0

If you will forgive us the conceit, we will suggest that the origin story of risk 2.0 starts in 2012. In *The wrong type of snow* (see footnote 1) figure 02 compares 'risk 1' with 'risk 2'. Back then we already believed that the world was best understood as a complex adaptive system. Since then we have observed:

- continued growth in complexity, with its associated demands for greater information processing (part of the 'great acceleration'[6])
- a dramatic rise in concern over, and attention given to, climate change
- an adverse shift by climate scientists in terms of their expectations of where climate tipping points lie (ie at lower levels of temperature increase than previously anticipated)
- that we are now in breach of seven of the nine planetary boundaries[7]
- growing geo-political risks.

In addition, our thinking on systemic risk has developed considerably[8].

Again, for the sake of brevity, we will here only address two concepts relating to complex systems. The concepts are endogeneity (originating inside the system) and emergence, and both are important to understand the difference between risk 1.0 and 2.0.

Endogeneity

Risk 2.0, in contrast to 1.0, accepts that risk can arise from within the system, precisely because risk 2.0 assumes a system, and a system has feedback loops. These loops can have physical properties and obey physical laws, such as increasing greenhouse gas concentrations, which trap heat, which changes the risk of hurricane damage for real estate in Florida (and elsewhere). Or they can be more metaphysical, an idea best expressed by George Soros' 'reflexivity'. For example, if investors believe that markets are efficient then that will change how they invest,

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[5] The interested reader may like to refer to our *Stronger investment theory* paper (Thinking Ahead Institute, 2016)
[6] See the Wikipedia entry here
[7] See https://www.planetaryhealthcheck.org/
[8] See our papers *Systemic risk | deepening our understanding*, and *Systemic risk | adapting our practices*, Thinking Ahead Institute, 2024

which in turn will change the nature of the markets (but not necessarily make them more efficient). A reinforcing feedback loop, insufficiently constrained by a balancing loop, can quickly cause a system to exhibit extreme behaviour and trigger tipping points.

Emergence

The second concept, emergence, requires the abandonment of reductionist cause-and-effect thinking, and the embrace of holistic systems thinking where we can observe the effect but will never know the exact cause. Emergence is a characteristic of any complex system where there is a sufficient number interacting entities. Classic examples are termite mounds and ant colonies.

We can use this idea to consider the global economy. There are billions of us interacting continually, so perhaps the global economy is an emergent phenomenon. We can observe that global economy consumes energy and produces and distributes goods. Is it controllable? Well, 196 countries signed up to the Paris Agreement (many put it into national law), produced commitments to reduce greenhouse gases (nationally determined contributions), and… At the time of writing, the annual production of greenhouse gases is still rising, despite the most powerful actors decreeing that they must fall[9][10]. We know we need to transition away from fossil fuels, so we build renewable energy generation. But the transition doesn't happen, because the emergent global economy will happily use all the energy it is offered (AI and crypto, anyone?). Perhaps the global economy is not controllable.

Therefore, the main difference between risk 1.0 and risk 2.0 is the underlying model of reality. Newtonian physics for 1.0, and complexity science for 2.0. We are in no doubt that risk 2.0 is conceptually superior, but we acknowledge that it is far, far less mathematically tractable and, for the foreseeable feature, harder to engage with. Building a new risk model, and a new risk management process will be very difficult. It will require us to think wider (to address endogeneity, among other things), and softer (to cope with emergence, among other things) and longer (see later in series).

We now turn from theory towards practice. In the next section we show worldviews of increasing sophistication and suggest the modelling approaches and investment tools associated with each.

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[9] The majority of government targets and actions are insufficient, and in many cases highly or critically insufficient to achieve the goals of the Paris Agreement, see for example https://climateactiontracker.org/countries/

[10] In addition, existing Nationally Determined Contributions fall far short of the amount of emission reduction required to achieve a WB2C outcome, see for example https://www.climatewatchdata.org/ndc-tracker

Moving from risk 1.0 to risk 2.0

He never suspected that in so doing,
he was crossing his Rubicon
– Jon Krakauer

4.1 Preamble

From the outset of risk 1.0 it was recognised that models are simplifications of reality and that it is important to recognise their limitations and to apply judgment when using them in risk management and other investment activities. In addition, the recorded history of data on the major financial markets is relatively short (~ 125 years), so we are simplifying a small subset of reality. Not to mention that the conditions prevailing in that 125 years have cycled through multiple changes.

This said, there are limits to human ability to qualitatively determine the impact of model limitations on model outcomes and as a result there has been significant academic and practitioner effort expended over time to improve the extent to which various features of the real world are captured in quantitative models.

It is therefore useful and instructive to explore the spectrum of “world views” that could be embedded in an investor’s risk mindset and the associated risk practice that would be consistent with each world view with the aim of identifying where the “jump” from risk 1.0 to risk 2.0 occurs.

4.2 Asset returns are random – risk 1.0

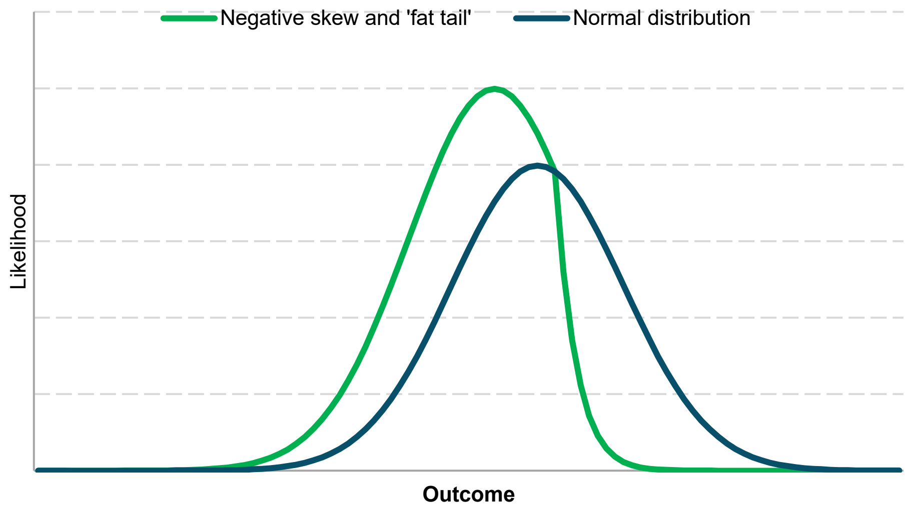
The simplest world view that is of some practical use would be that the returns on all asset classes are a random walk (ie independent through time) and drawn from normal or lognormal distributions that are correlated with each other in a given time period.

This formulation is aligned with the mindset of Markowitz (1952) from which the risk practice including mean-variance optimization and Capital Asset Pricing Model emerged.

4.3 Asset returns are negatively skewed and “fat tailed” – risk 1.1

Most undergraduate finance courses teach that asset returns are typically negatively skewed and “fat tailed”. This means:

- adverse outcomes are more extreme than positive outcomes; and
- extreme market movements are more likely than is predicted by a normal distribution.



There are a number of potential explanations for this outcome including:

- negative skew is a natural feature of certain asset classes (eg corporate bonds, insurance linked securities) and trading strategies (eg carry strategies, short volatility)
- market responses to bad news (fear) tend to be more significant than to positive news, ie "the market goes up by the escalator but down by the elevator shaft".

The corresponding risk practice could include:

- adopting non-normal (but still smooth/continuous) distributions to represent asset return outcomes to better reflect likely downside risk outcomes (eg CVaR)
- greater focus on risks that actually matter (ie mission impairment) and less focus on short-term volatility

incorporating higher moments into optimisation processes, eg defining a utility function that factors skew and kurtosis into portfolio evaluation.

4.4 Economies and markets exhibit different regimes – risk 1.x?

A further evolution of the risk mindset would be to recognise that economies and asset markets move through regimes which have materially different risk and return implications. This could, for example, be expressed via a "good" environment (high return, low volatility, diversification works) and a "bad" environment (negative return, high volatility, diversification fails).

Additional enhancements to risk practice that would be consistent with this include:

- allowing for characteristics of asset returns to be time varying rather than stationary
- allowing for economies and markets to "switch" between two or more regimes with pre-determined probabilities
- creating dependencies between asset classes that reflect real world economic relationships in these regimes (eg property returns should reflect changes in bond yields as the latter are an input to valuation processes)
- assuming asset returns are autocorrelated/mean reverting (vs assuming independence through time).

Beyond modelling aspects, other areas of risk practice that have evolved over time include:

- development of forward-looking scenarios to define regimes and stress test portfolios
- use of risk factors or return drivers to understand portfolio diversity and likely robustness to different economic regimes
- use of multiple lenses/dashboards and qualitative considerations to inform investment decisions with less reliance on quantitative optimisation.

4.5 Regime changes can be triggered by the financial system itself – risk 1.9x/risk 2.0?

What has been described up to this point represents best-in-class current risk practice which embeds an important underlying assumption – that "shocks" to economies and markets are exogenous (externally driven). However, as was observed in the Global Financial Crisis, shocks causing system wide effects can originate from within the financial system (ie shocks can be endogenous as well as exogenous).

A first important step towards a risk 2.0 mindset is therefore to recognize that regime changes can be triggered by the financial system itself due to the behaviour of agents within the system.

In addition, these regime changes are usually "accumulating in the background". This adds a belief that economies and markets are complex adaptive systems, which should lead to more significant changes in risk practice than described previously. In particular:

- switching probabilities are partially uncertain at the outset and respond to the prevailing regime
- more sophisticated representations of interconnectedness within the financial system than correlation matrices
- incorporation of path dependency – if regime changes are accumulating in the background this means that Markovian models that only "look at" the current state of the system are insufficient
- widening the distribution of 10/20 year outcomes beyond conventional models that assume risk on an annualised basis reduces with the square root of time.

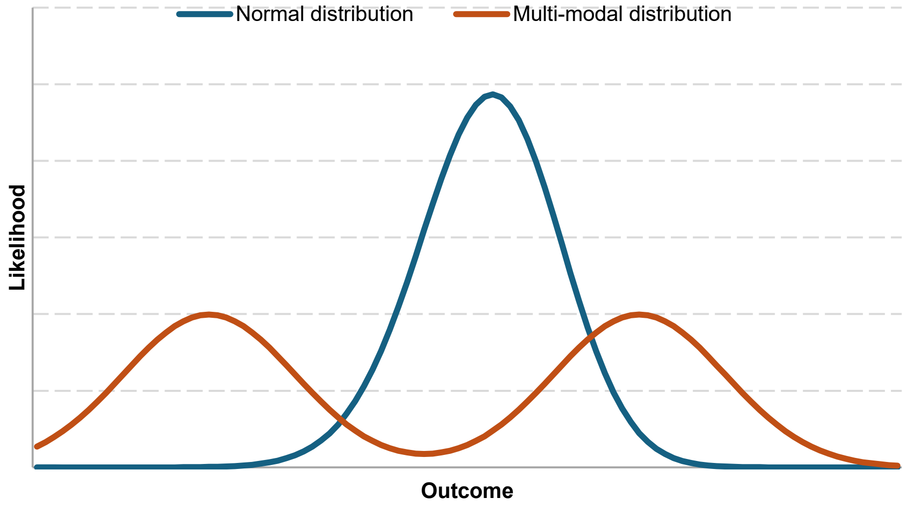
4.6 The financial system is part of a broader System – risk 2.0

An important limitation of the risk mindset described above is the focus on the financial system in isolation. In reality, the financial system is a part of the broader (capital-S) System which has "nested" boundaries around society, the human environment and then the planet itself. Importantly, actions of agents in the financial system can impact the broader System (eg climate change, inequality) which in turn can have impacts on the financial system (this is commonly referred to as "double materiality").

A second related evolution is incorporating "tipping points" which once crossed are very difficult, or impossible, to reverse, ie these can result in permanent transitions of economies, society and environment. Crossing tipping points can trigger systemic risks which result in permanent impairment or stranding of certain sectors of the economy. This is very different to a large fall in markets due to (for example) an economic shock, as these losses are permanent and not subsequently made up.

This suggests that further significant shifts in risk practice are required including:

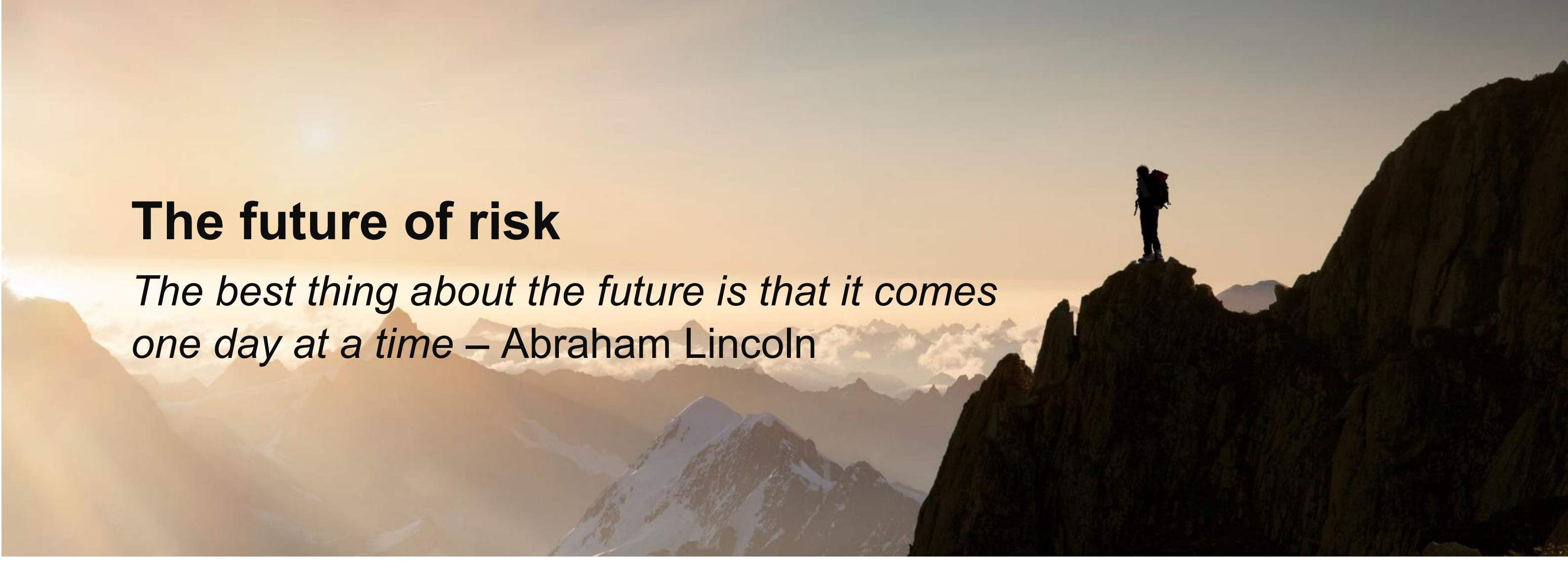
- greater use of qualitative risk measures as there is a natural limit to the usefulness of quantitative models in the measurement and management of systemic risks which are highly non-linear and largely irreducible
- the use of multi-modal or discontinuous distributions, as the outputs from different systemic risk scenarios are likely to be very differentiated in terms of economic, social and environmental (and therefore financial asset return) outcomes.



- incorporation of "one way" transitions and absorbing states into risk models to represent tipping points can cause mission impairment – this increases the importance of thinking about risk in time series rather than cross section due to the "irreversibility of time".
- shifting focus from portfolio-level risk management to system-level risk mitigation, as it is highly unlikely that:
  - the impact of systemic risk on portfolios can be reduced through asset allocation as systemic risks are pervasive; and/or
  - that a portfolio can be constructed that is robust to a range of systemic risk scenarios as systemic risks are generally highly non-linear
- development of dashboards to monitor the accumulation of systemic risks to allow strategic adaptation of the portfolio as the probability of different scenarios and crossing of tipping points changes over time.

The table below summarises the journey from risk 1.0 to risk 2.0 in terms of changes in world view and the resulting investment toolkit. We conclude that the shift from risk 1.0 (or risk 1.x) to risk 2.0 is both transformational (rather than incremental) and can only be partially achieved by the use of quantitative models.

Worldview	Modelling approach	Investment toolkit
Asset returns are random	Normal/lognormal random walk	SAA thinking Mean-variance optimisation
Asset returns are negatively skewed and “fat tailed”	Skewed and fat tailed but still “smooth” distributions	MVO with penalties for left tail risks
Economies and asset returns move through regimes which have fundamentally different risk/return implications	Two-way switching, exogenous transition probabilities; different means/vols, Gaussian copula	TPA thinking with PQS Macro resilience framework
Regime changes can be triggered by the financial system itself	Switching probabilities become partially endogenous Non-Gaussian copula	Systemic risk (system = financial system) Path-dependency, wider range of 10-20yr outcomes
The financial system impacts the broader System which can impact the financial system	Switching mostly driven by factors endogenous to the financial system One-way transitions Multi-modal distributions Agent-based modelling	VUCA Systemic risk (system = System) Asset classes of the future Systemic resilience framework



The future of risk

The best thing about the future is that it comes one day at a time – Abraham Lincoln

5.1 Preamble

An alternative, more technical, title for this section would be ‘risk has an upward-sloping term premium’. We will argue that the future is riskier not (only) because it is uncertain, but because the quantum of risk increases with time. We start by asserting that the future is unknowable[11]. Talking about the term premium of risk will therefore be tricky. Risk 1.0 gets around the problem by assuming an unchanging world so that, in each future period, we will get a new pick from the same underlying distribution. In this framing risk does not have a term structure or, at least, not one of any interest. Once we ‘know’ (have made our assumption about) the distribution, risk through time is easy to derive mathematically. We could then push harder and talk about ‘time diversification’, which is spreading our risk budget more evenly across our investing lifetime. If there is no term structure to risk, this makes perfect sense.

Risk 2.0 assumes a complex adaptive system, and therefore we know that the underlying distribution is changing and will continue to change. Therefore, if we use a risk 1.0 model, we should introduce error bands around the output to reflect the mismatch between the assumed distribution and reality. The further into the future we wish to make projections, the wider these error bands should be, as there is more time for reality to diverge from the starting assumptions. It is also important to recognise that the increased uncertainty around the shape of the distribution as the projection horizon increases is additional to, and different from, the “widening funnel of doubt” (which is generated by “known” parameters and is part of risk 1.0 mindset).

In addition, a complex adaptive system will exhibit ‘path dependency’. The state it goes to in the next time step is not a random and independent pick from the distribution, as per risk 1.0. Instead, the pick is from a constrained subset of the distribution, because the next possible state is dependent on the path taken through the previous states. Now this could be interpreted as increasing the accuracy of our risk forecasting (reducing the variance of possible outcomes in the next period). However, first, we would need to be confident in our ability to determine the strength of the path dependency and to isolate the appropriate subset. And, second, we would need to be confident that the system was not about to enter a phase transition[12] and jump to another new distribution. Finally, the transition probabilities themselves are dependent on the previous path of the system (not just the current state) and as the projection horizon increases the number of potential paths increases and therefore the degree of predictability of the system decreases. On balance, we would suggest that a further widening of the error bands is probably appropriate.

[11] The technical description would be ‘radical uncertainty’, a term popularised by John Kay and Mervyn King in their 2020 book *Radical Uncertainty: Decision-Making for an Unknowable Future.* Radical uncertainty differs from Knightian uncertainty as it is unresolvable – no amount of new information makes the uncertainty go away

[12] An alternative term is ‘punctuated equilibria’, yet another characteristic of complex adaptive systems. A ‘Minsky moment’ is a prime example of a phase transition / punctuated equilibrium

5.2 What we can know about the future

We know that systems grow in size and/or complexity unless actively constrained[13]. Bigger and more complex systems require greater amounts of energy and resources for information processing, maintenance and growth. They are also more likely to exceed carrying capacity thresholds, making them unsustainable over the longer term. In short, systemic risk rises as systems get bigger – particularly so when the system approaches resource or energy limits.

We also know that almost all politicians are committed to finding policies to promote economic growth. And we know that asset prices are underpinned by an assumption of continued growth. We further know that we face a number of problems that could affect future growth prospects:

- Falling fertility rates
- Toxicity
- Deforestation
- Biodiversity loss
- Climate change
- Planetary boundaries
- Carrying capacity.

So, if growth continues into the future we can posit that systemic risk will rise exponentially alongside it. If growth stops (or at least slows significantly), we should expect a downward repricing of risky assets. In either case, therefore, we can expect an upward sloping term structure for risk. Risk in the future is very likely to be higher than it is today.

5.3 Investment time horizon

The extent to which a rising term structure for risk matters will depend on the investment time horizon. The longer the horizon, the more it matters. This is partly due to the upward slope, and partly due to the higher chance of occurrence (noting that these are not independent). To illustrate, consider a 20-year-old starting a defined contribution pension account. The 'pensions deal', historically, has been to double the real purchasing power of contributions. Early contributions are small and late contributions tend to be large, so the average contribution is invested for about 20 years, and we can double it if we earn an average annual return of 3.5% above inflation. But note that we need to earn that return for 40 years, over the whole period of contributions.

Now, a doubling through investment returns implies a close-to-doubling in the size of the economy[14]. And we need to do this twice for the 20-year-old's investment journey[15]. So, by the year 2065 we would need a global economy 3- to 3.5-times bigger than our current economy. If our current size of economy has produced the list of issues noted above, and breached 7 of the 9 planetary boundaries, how likely is it that we can continue to grow without triggering systemic risk? We are back to the unknowability of the future (in terms of details, timings and possible surprises).

What we have sought to do here is to set the global economy within and dependent on functioning planetary systems, and to explore the need for investment returns, the dependence on growth to achieve them, and the limits to growth on a finite planet. It is our conclusion that the term structure of risk is upward sloping into the future.

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[13] See Systemic risk | deepening our understanding, Thinking Ahead Institute, July 2023

[14] From Thomas Piketty's *Capital in the Twenty-First Century*, 2013, we learn that investment returns (r) are higher than economic growth (g), so the economy does not need to double to support a doubling in investment value

[15] More likely three times, as the trend is to maintain a reasonable weighting in growth assets during the retirement phase

The past inadequacies of risk 1.0

D'oh – Homer Simpson

We now turn back in time – not to imagine how outcomes might have been different under a risk 2.0 framework, but to deepen our understanding of what this new mindset reveals. Because of path dependency, it is likely that a world trained in risk 2.0 would have even evolved along entirely different trajectories. So, rather than asking "what if?", we ask "what can we learn?"

Our inquiry is guided by two questions:

- What new insights emerge when past crises are reinterpreted through the risk 2.0 mindset?
- How do these insights help us recognise the limitations of risk 1.0 and better prepare for the risks of the present and future?

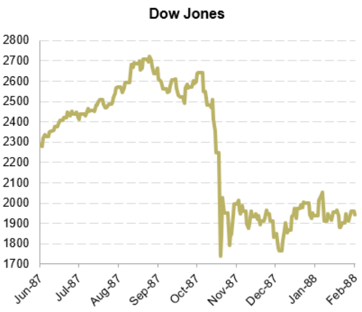
Historical examples of significant market falls allow us to consider whether there are flaws in risk 1.0 thinking that resulted in the nature, likelihood and/or severity of these events being underestimated.

We applied a set of diagnostic criteria that expose where traditional frameworks systematically fell short. These criteria were chosen because they highlight distinct but interlinked failures across assumptions, models, and system-level understanding:

- Crash recorded – describes the event which provides context for the testing framework that follows
- Risk 1.0 assumption violated – identifies the core theoretical assumptions that failed under stress (eg normal distributions, stable correlations, etc). It also highlights how simplifications embedded in risk 1.0 created blind spots under extreme conditions
- Unexplained by risk 1.0 – captures dynamics that risk 1.0 models could not account for (eg nonlinear feedback loops or contagion effects)
- Model blindness – reflects the inability of risk 1.0 models to adapt to emergent realities, leading to misplaced confidence in flawed measures. Demonstrates the disconnect between reductionist models and complex adaptive market behaviour
- VaR inadequacy – shows how VaR underestimated clustering, fat-tailed events, and compounding systemic pressures
- Neglect of systemic risk – exposes the absence of system-wide awareness in risk 1.0 (inter-market connectivity, liquidity spirals, contagion, etc)

6.1 Black Monday (19 Oct 1987)

Crash recorded	Dow Jones dropped 22.6% in one day
R1.0 assumption violated	Normal distribution of returns (20+ σ event) Stable correlations across markets
Unexplained by R1.0	Flash crash via portfolio insurance and dynamic hedging feedback Cross-market and cross-border contagion
Model blindness	Gaussian-based VaR underestimated extreme tail risk Dynamic hedging ignored endogenous feedback loops
VaR inadequacy	Underestimated clustering of volatility & fat-tailed risk
Neglect of systemic risk	Inter-market connectivity Liquidity meltdown Margin spirals



Seen through a risk 2.0 lens, Black Monday exposed the fragility of risk 1.0 foundations. The Dow Jones fell 22.6% in a single day – a 20-plus-sigma event that defied assumptions of normality and stable correlations. What appeared as an isolated market shock was in fact a system-wide feedback loop: portfolio insurance and dynamic hedging amplified losses as automated selling cascaded across markets and borders.

Gaussian-based VaR models failed to anticipate extreme tail risks or the clustering of volatility that followed. Model blindness was exposed by confidence in reductionist models that ignored how collective actions could drive instability. Beneath it all lay a neglect of systemic risk: liquidity vanished, margin calls spiralled, and inter-market connectivity turned local stress into global contagion. Black Monday stands as an early warning of how complex dynamics can overwhelm static models – and why risk 2.0 demands adaptive, system-aware thinking.

6.2 Dot.com bubble (2000-2002)

Crash recorded	Nasdaq ~–77% by Oct 2002
R1.0 assumption violated	Rational pricing: extreme overvaluation; low beta ≠ low risk
Unexplained by R1.0	Tech stock exuberance disconnected from fundamentals Momentum & narrative-driven behaviour
Model blindness	Mean-variance ignoring valuation extremes Dynamic beta shifts
VaR inadequacy	Vol profiles shifted dramatically Tail risks unmodelled
Neglect of systemic risk	Widespread capital loss Investor behaviour feedback loops underappreciated

Through a risk 2.0 lens, the dot-com collapse reveals how belief in rational pricing masked deep behavioural and systemic distortions. By October 2002, the Nasdaq had fallen around 77%, exposing how risk 1.0 models equated low beta with low risk and ignored valuation extremes. Market exuberance became self-reinforcing, driven by momentum, narratives, and a collective faith in technological transformation.

Traditional mean-variance frameworks failed to capture how capital concentrated in overvalued assets, nor how investor behaviour amplified instability. Volatility regimes shifted abruptly, invalidating assumptions of stable risk premia, while VaR models ignored emerging tail risks.

The crash revealed feedback loops between capital loss, investor sentiment, and liquidity withdrawal – dynamics under-appreciated by risk 1.0.

6.3 Great financial crisis (2007-2009)

Crash recorded	DJIA fell ~53% from Oct 2007 to Mar 2009
R1.0 assumption violated	Stable correlations Independence of credit risks Bonds = risk-free
Unexplained by R1.0	Collapse of securitised credit Frozen credit markets Contagion via counterparty risk
Model blindness	Credit models (Gaussian copula) failed to reflect correlation spikes
VaR inadequacy	Historic windows excluded tail events leading to dramatic underestimation
Neglect of systemic risk	Institutions deemed "too big to fail" Liquidity crisis Regulatory failure

Viewed through a risk 2.0 lens, the Global Financial Crisis epitomises the collapse of risk 1.0 assumptions. Between October 2007 and March 2009, the Dow Jones fell roughly 53%, as beliefs in stable correlations and the independence of credit risks unravelled. Bonds once deemed risk-free became central nodes of systemic contagion.

Traditional models could not explain the freezing of credit markets or the cascading counterparty failures. The Gaussian copula framework missed correlation spikes and nonlinear stress dynamics. VaR, built on historical data, underestimated the magnitude and persistence of losses.

At the system level, "too big to fail" institutions turned from stabilisers to amplifiers, exposing the fragility of tightly coupled markets. Liquidity spirals and regulatory blind spots deepened contagion. The GFC became the germinal moment for the modern notion of systemic risk.

6.4 COVID-19 crash (March 2020)

Crash recorded	Dow lost ~26% in 4 trading days; –13% single day (March 16)
R1.0 assumption violated	No pandemic or exogenous risk in historic data Stable asset correlations
Unexplained by R1.0	Simultaneous asset declines Global shutdown reflected in financial markets
Model blindness	Sector-specific shocks Asymmetric liquidity Correlation with epidemiological models
VaR inadequacy	Jump risk and flash-crash dynamics overlooked
Neglect of systemic risk	Liquidity freeze Central banks had to intervene aggressively

The COVID-19 shock was unlike anything risk 1.0 could imagine. In just four trading days, the Dow fell around 26% – including a 13% single-day drop on 16 March. No model built on historical financial data contained a pandemic scenario, and assumptions of stable correlations and sector diversification collapsed.

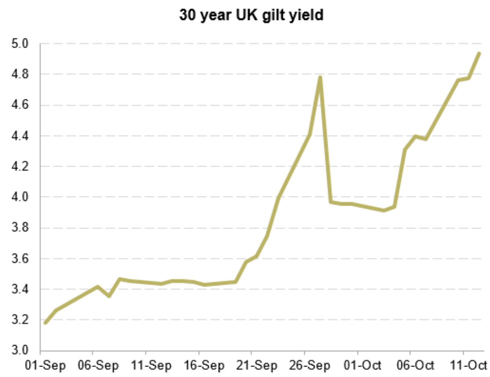
The simultaneous decline of risk assets worldwide reflected an economy in sudden global shutdown. Risk 1.0 models could not link epidemiological dynamics to market stress, nor capture the speed at which liquidity evaporated. Jump risk, flash-crash behaviour and asymmetric liquidity were all overlooked.

Like in other events considered, VaR frameworks underestimated both the magnitude and clustering of volatility, while systemic blind spots emerged as liquidity froze. Only massive central bank intervention prevented a broader financial seizure.

Seen through a risk 2.0 lens, the COVID crisis highlights how financial systems are deeply entangled with environmental, social, and real-world shocks

6.5 UK LDI/gilt crisis (Sept-Oct 2022)

Crash recorded	Gilt yields rose ~1.5 pct in 6 days leading to margin calls
R1.0 assumption violated	Gilts as safe assets Stable rates Low volatility
Unexplained by R1.0	Rapid fire-sales of prolonged-duration bonds Collateral spiral
Model blindness	Ignored extreme rate shock scenarios Inadequate stress parameterisation
VaR inadequacy	Historical rate vol ignored 2022 rate volatility
Neglect of systemic risk	Pension/LDI sector interconnectedness Bank intervened with gilt purchases



The UK gilt crisis of 2022 revealed how even safe assets can become sources of systemic instability. Within six days, long-dated gilt yields rose about 1.5 percentage points, triggering margin calls and forced selling across LDI portfolios. Assumptions of stable rates, low volatility, and gilts as inherently low-risk assets collapsed almost overnight.

Traditional risk models failed to capture how rapid yield spikes could trigger collateral spirals and feedback loops between leveraged pension funds and the broader gilt market. Stress tests were anchored in mild historical scenarios, overlooking the extreme rate shocks of 2022.

The episode exposed the deep interconnections within the pension and LDI ecosystem – linkages under-recognised by risk 1.0. Only the Bank of England's emergency gilt purchases prevented a full-scale liquidity crisis.

What can we learn?

Revisiting these crises through a risk 2.0 lens is not about judging the past, but about refreshing our field of vision. Each episode exposes how risk 1.0's linear, model-centric view missed the adaptive, interconnected nature of real markets.

Risk 2.0 invites us to see and think in systems, shaped by behaviour, feedback, and design. Its strength lies less in prediction and more in awareness – the ability to recognise fragility before it becomes failure.

Potential problems viewed through the two lenses

I can see clearly now, the rain is gone – Johnny Nash

Looking at the past is informative but ultimately what matters is how risk 2.0 mindset and practice might help to address potential future risk events. With this in mind, we explore two potential future risk scenarios and describe how each would be interpreted and managed through a risk 1.0 lens and a risk 2.0 lens.

7.1 Uninsurable future

Risk 1.0 lens	Risk 2.0 lens
The Uninsurable future scenario is driven by an escalation in insurance premiums (in particular home insurance but also commercial insurance) to levels that are unaffordable. The increasing frequency and severity of climate-related disasters – such as floods, wildfires, and storms – are treated as external shocks that disrupt insurance markets. These events lead to higher claims, which in turn drive up premiums and reinsurance costs. As insurers respond by withdrawing coverage from high-risk areas, the market adjusts through price signals and policyholder behaviour. The assumption is that if individuals and governments act rationally – by relocating, investing in mitigation, or subsidising insurance – market equilibrium can be restored. Risk is treated as a technical problem solvable through better modelling, pricing, and regulation.	With a risk 2.0 mindset, the Uninsurable future scenario is driven by a convergence of climate-induced hazards, systemic governance failures, and economic pressures that collectively push regions past a tipping point where insurance becomes unavailable, inaccessible, or unaffordable. Root causes include rising greenhouse gas emissions, sea-level rises, poor land-use planning, and socioeconomic inequality, which increase exposure and vulnerability to extreme weather events. As disasters grow more frequent and severe, traditional insurance models – based on historical data – struggle to price risk accurately. Reinsurance costs surge, data gaps persist, and insurers begin withdrawing from high-risk markets, leaving millions of properties without coverage. In Australia alone, over 520,000 homes are projected to be uninsurable by 2030[16]. The first-order impacts are immediate and severe: households face delayed recovery, rising debt, and mental health challenges. Property markets destabilise as uninsurable homes lose value and become difficult to sell or finance. This directly affects the banking sector, which relies on insured assets to

[16] UNU Institute for Environment and Human Security. 2023. *Uninsurable future*

	secure mortgage lending. Without insurance, banks face increased credit risk, reduced collateral value, and potential defaults – especially in disaster-prone areas. These vulnerabilities can ripple through the broader financial system, undermining investor confidence and asset stability. Governments, meanwhile, are forced to act as insurers of last resort and absorb uninsured losses, straining public budgets and increasing debt burdens. The US National Flood Insurance Program, for example, is already over $20 billion in debt. Second-order impacts include systemic economic and social consequences. Direct GDP losses resulting from under-insurance[17] are projected to reach 3% in the EU and UK by 2050[18], while the global protection gap – uninsured losses – hit $1.8 trillion in 2022[19]. As insurance becomes inaccessible, inequality deepens: wealthier individuals and businesses relocate or self-insure, while vulnerable populations remain exposed. Feedback loops emerge as migration to cheaper, high-risk areas increases exposure, further driving uninsurability. These dynamics link to other systemic tipping points, such as ecosystem degradation and loss of space-based climate monitoring, which further erode resilience and risk modelling capabilities. The scenario underscores the urgent need for transformative approaches to climate adaptation, financial regulation, and collective risk-sharing to prevent cascading failures across social, economic, and ecological systems.

7.2 Food crisis

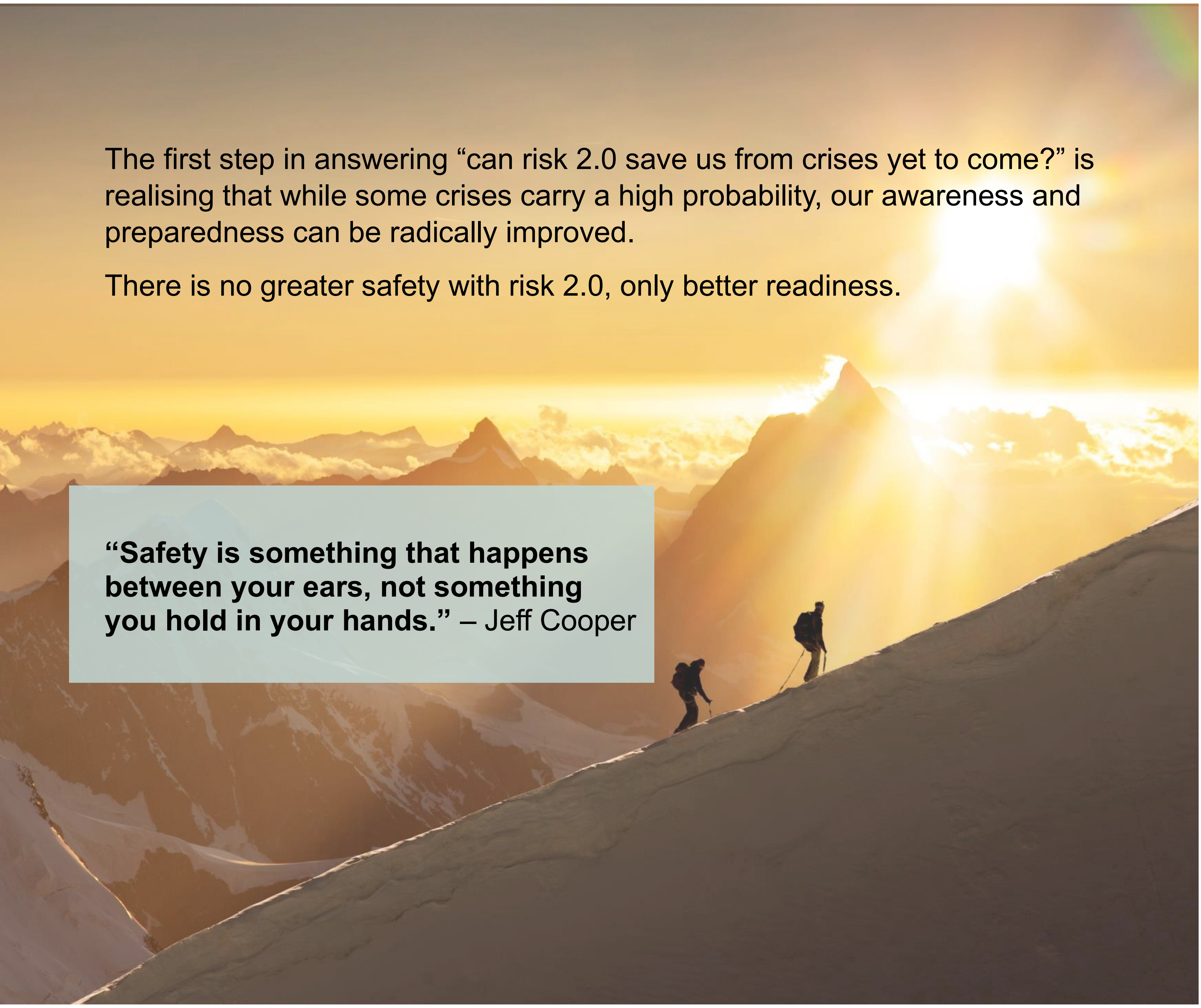
Risk 1.0 lens	Risk 2.0 lens
Scanning historical data suggests local food crises are possible, but tend to be in low-income countries and to follow periods of drought. They are generally addressed by humanitarian relief efforts and have no	The global food system employs complex global supply chains, and "there are unprecedented levels of market concentration throughout global agrifood systems"[20]. A few companies control seeds,

[17] Total GDP losses after taking feedback loops through the financial and social system into account would be expected to be significantly larger (ie multiples of the estimate of direct losses)
[18] European Insurance and Occupational Pensions Authority. 2023. *Policy options to reduce the climate insurance protection gap*
[19] Aggarwal et al. 2023. *Sigma - Restoring resilience: the need to reload shock-absorbing capacity*
[20] IPES-Food (International Panel of Experts on Sustainable Food Systems). 2017. *Too big to feed: Exploring the impacts of mega-mergers, concentration, concentration of power in the agri-food sector*.

discernible impact on asset prices. Food problems have been seen in high income countries during times of war (rationing) or pandemic (temporary unavailability during covid). Looking forward, it would be reasonable to assign a higher probability to a disappointing harvest in a major breadbasket region of the world (eg climate change induced drought, or war continuing in Ukraine). However, expectations would suggest high income countries would be able to afford to import the food they require at the higher prices. There could be a temporary negative impact on asset prices from a temporary spike in inflation (driven by food prices), but significant or lasting economic damage is highly unlikely. We therefore assign a low probability to this scenario, and a low to moderate adverse impact to asset prices.	chemicals, pharmaceuticals, machinery, fertilisers, livestock genetics, food processing and commodity trading, and have potentially gained "market power"[21]. We would describe it as highly efficient but with very low resilience. It is highly dependent on continued availability of fresh water, and continued deforestation (which is likely to disrupt the water cycle, let alone over-drawing from aquifers). Supply assumes, and is dependent on, the independence of weather across the world's breadbasket regions. Climate change challenges this assumption and, we suggest, correlated poor harvests are now possible, if not probable just yet. Climate change also threatens to tip the Amazon from forest to savannah, which would remove a major rainfall source for a large part of South America, and likely interrupt rainfall patterns globally. In turn this could strand existing agricultural infrastructure assets. The system is also exposed to any disruption in global shipping (Suez and Panama canal blockages / droughts, and war). Unlike the GFC, governments will not be able to bail out the food system by issuing "future food". There is likely to be widespread social unrest, and possible direct action against the agri corporates and possibly the financial firms that fund them. Given the lack of resilience in the food system, and the lack of action to address climate change, we are forced to conclude that – in the absence of new action – the probability of a food crisis will rise through time, until it becomes a near-certainty. At that point the risk to financial asset values is very high.

We may be guilty of drawing boundaries around specific sectors in this piece, but the ultimate purpose is to show that a risk 2.0 lens allows those boundaries to dissolve as we recognise our hyper-connected global system.

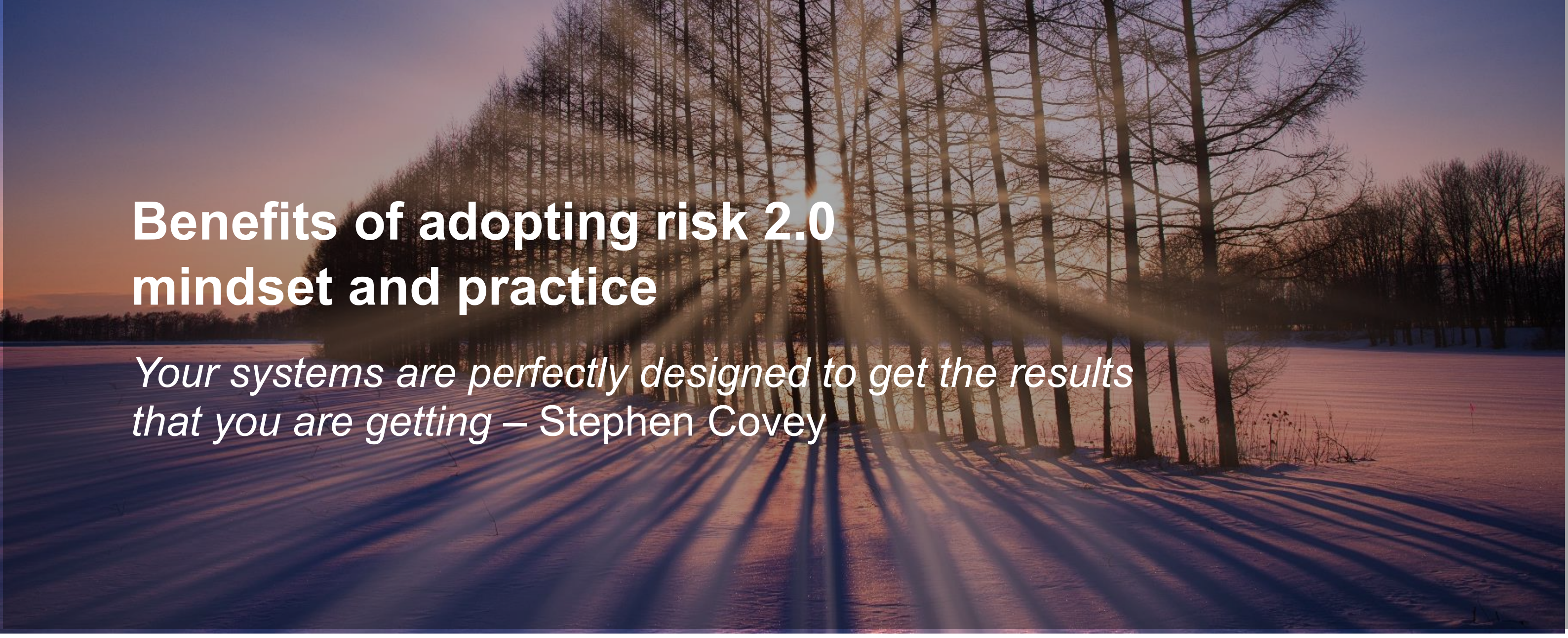
[21] FAO. 2022. *The future of food and agriculture – Drivers and triggers for transformation*. The Future of Food and Agriculture, no. 3. Rome. https://doi.org/10.4060/cc0959en



The first step in answering “can risk 2.0 save us from crises yet to come?” is realising that while some crises carry a high probability, our awareness and preparedness can be radically improved.

There is no greater safety with risk 2.0, only better readiness.

“Safety is something that happens between your ears, not something you hold in your hands.” – Jeff Cooper



Benefits of adopting risk 2.0 mindset and practice

Your systems are perfectly designed to get the results that you are getting – Stephen Covey

8.1 Commonalities across the risk 2.0 view of risk events

Looking across the historical and forward-looking risk events considered above, there are a number of instructive commonalities that can be drawn out.

Primacy of the market is a key driver of risk

Under a risk 1.0 lens the economy/market is assumed to have primacy and all other actions are determined so as to optimise market outcomes. However, one consequence of this from a risk 2.0 perspective, is that the singular focus on economic optimisation can, over time, create fragilities within societal systems. The pursuit of efficiency at the cost of resilience can lead us deeper into systemic risk. In addition, in some cases it is the propagation of risk events through the social system that leads to the financial impact of these events. For example:

- urbanisation has resulted in increased efficiency by concentrating populations in smaller areas but this has also resulted in concentrated exposures to physical climate risks and increased vulnerability to other dangers (eg disease)
- globalisation of food supply chains has allowed significant increase in efficiency and profits but has created significant vulnerability to weather events in the major global bread baskets. Hungry populations are likely to cause financial losses.

An important shift when moving to a risk 2.0 mindset is therefore to move away from the system as a hierarchy with the economy/market at the apex, to a 'flatter' view where the health of all parts of the System needs to be thought about simultaneously when making risk management decisions.

Limits to the power of quantitative analysis / "narratives eat models for breakfast"

Another important observation is that historical data is of relatively little use in pricing/quantifying the risks that materialise(d). As a result, a risk 1.0 mindset assumes the scenarios are technical problems that can be solved with limited long-term adverse impact.

In contrast, a risk 2.0 mindset recognises that these events are the result of the build-up of pressures that are not easily observed in historical data and are triggered by the crossing of key tipping points that are not easily reversed. This said, in most cases the process for understanding the scenarios and the important causes and effects is reasonably intuitive and, in the case of the future scenarios, superior insight is not needed to establish a reasonably vivid narrative for what is likely to happen. This highlights the need for the use of softer/more qualitative measures as part of risk 2.0 practice.

Upward sloping term structure of risk / "inevitability"

A final set of observations particularly in relation to the forward-looking scenarios is that the risk 2.0 mindset highlights that:

- climate change is 'threat multiplier', ie beyond the direct impacts of climate change it can be a key catalyst for other systemic risks that would be expected to materialise over a shorter time horizon than the longer-dated impacts of physical climate risks
- assuming no change to current economic and social probabilities the cumulative probability of any one of these events occurring will continue to increase over time, ie under 'business as usual' some version of these events appears inevitable at some sufficiently-long time horizon.

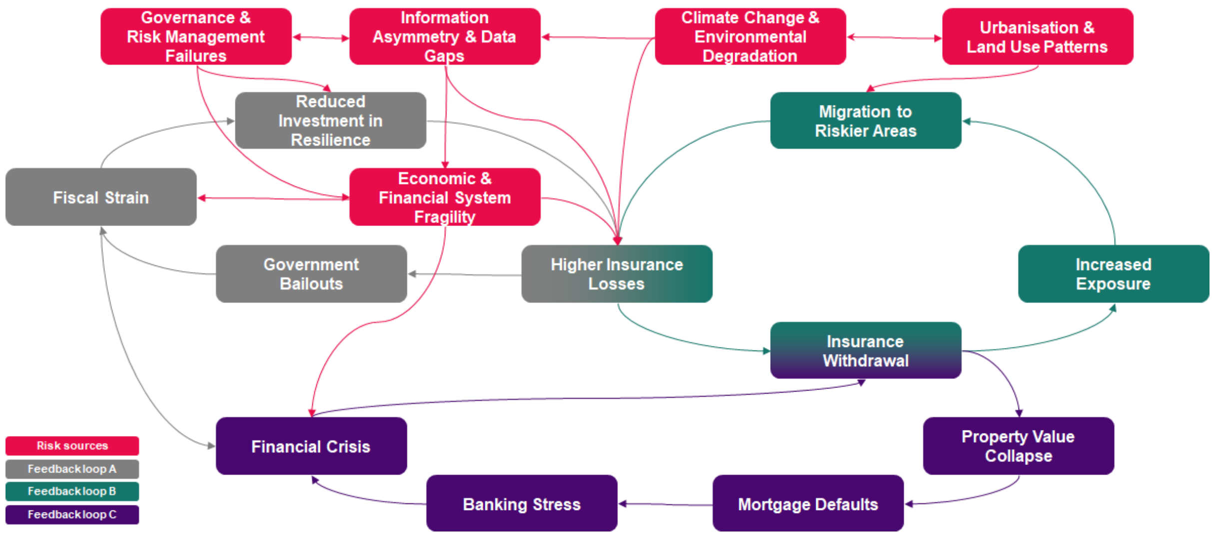
This both supports the upward sloping term structure of risk described earlier as well as challenges the risk 1.0 view that systemic risks like climate change are too distant in nature to be incorporated into the current definition of fiduciary duty.

8.2 Insights gained from adopting risk 2.0 mindset

The benefits to risk management and decision making gained from adopting a risk 2.0 mindset are set out below, using the uninsurable futures scenario as the primary example.

Improved understanding of the drivers and effects of future scenarios

An important result of adopting a risk 2.0 mindset is a better understanding of the key drivers of a given risk event, the broader impacts of these and the associated feedback loops and interaction effects. This is set out at a high level below for the uninsurable futures scenario described earlier:



Source: WTW

Improvements to risk management approaches

Another benefit is a more effective approach to risk management with a focus on transformational approaches that directly address underlying risk drivers rather than the resulting impacts of the risks. This is illustrated below using the ADAT2 framework introduced in the UHU-EHS technical paper[22] on the topic of Uninsurable futures.

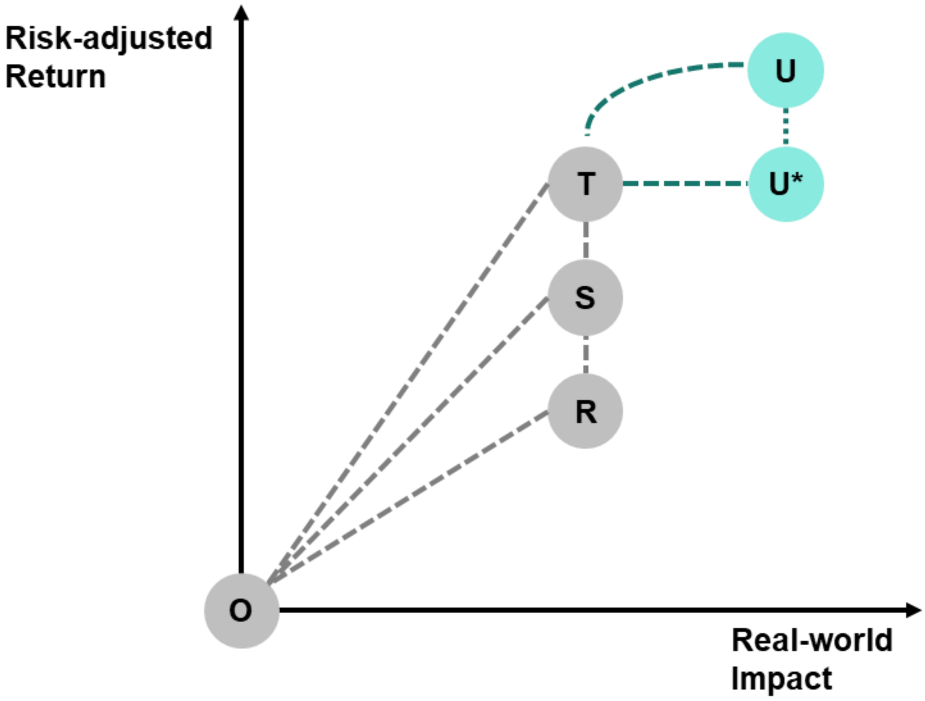
Risk 1.0	Risk 2.0
Adapt–Delay • Focus on coping with impacts after the tipping point has been crossed, eg – Community-Based Catastrophe Insurance: Local schemes that pool risk and reduce administrative costs. – Informal risk-sharing mechanisms: Traditional community-based approaches to managing climate risk. • Limitations: – These approaches do not reduce underlying risk drivers. – They may be overwhelmed by escalating damages due to climate change.	**Adapt–Transform** • Prepare society to live sustainably within a changed risk landscape, eg – Managed relocation: Moving communities from high-risk areas to safer zones. – Inclusive planning: Ensuring equitable outcomes for displaced populations, especially Indigenous communities. • Strategic value: – Recognizes that some areas may become permanently uninsurable. – Requires long-term planning, community engagement, and robust governance.
Avoid–Delay • Seek to maintain insurance availability through short-term fixes, eg – Government-backed reinsurance schemes. – Premium subsidies and affordability caps. – Improved data access and modeling using big data and remote sensing. • Limitations: – These measures are reactive and may not be sustainable as climate impacts intensify. – They address symptoms rather than root causes.	**Avoid–Transform** • Target systemic change to prevent crossing tipping points, eg – Nature-based solutions: Restoring ecosystems to reduce hazard exposure. – Climate-resilient infrastructure and building design. – Insurance industry reform: Incentivizing adaptation, increasing transparency, and reducing support for fossil fuel producers. – Forward-planning: Red-zoning, land-use regulation, and climate risk commissions. • Strategic value: – Builds long-term resilience. – Reduces hazard, exposure, and vulnerability simultaneously. – Encourages cross-sector collaboration and innovation.

Source: UHU-EHS, TAI

Recognition of "better beta" as a benefit of true risk management

A third benefit is that a risk 2.0 mindset starts by considering the System and systemic risk which means true risk management must include system stewardship. An investor with this mindset recognises that a current investment in the future public good can result in subsequent private gain and/or that reducing the likelihood or severity of systemic risks increases the value of all financial assets. This takes us from position T to U* or U in the figure below.

[22] UNU Institute for Environment and Human Security. 2023. *Uninsurable future*



Key

R = reference portfolio
S = strategic asset allocation
T = risk 1.0 view
U = risk 2.0 view

8.3 Next steps

This paper has left room for follow-on research in which we will be exploring these two big ‘how’ questions in the sequel paper *Fresh tracks.*

- How risk 2.0 may be able to improve the quality of our responses to the big questions that are challenging investors
- How investment organisations can transition to the risk 2.0 construct with transformational change programs that are effective and economical

In *Fresh snow* we have considered the fresh hazards that we are facing in our risk journey, and the mindset shifts we must make. In *Fresh tracks* we will consider the practical steps that can be taken to arrive in one piece and what success might look like.

The big questions? We have these in our mind:

- **What changes to portfolio construction and governance will risk 2.0 require to be effective?**
  The answers we will be considering will draw from our parallel research into the total portfolio approach (TPA) and the integrated thinking that is needed across asset classes, factors, themes, liquidity, and multiple time horizons. As we have suggested in this paper, an evolved version of governance 2.0 will be needed

- **What cultural and organisational shifts are needed to support risk 2.0?**
  Successful adoption starts with breaking down silos, aligning incentives, and fostering a risk-aware culture. How culturally-prepared are organisations to adapt to these states – all of which are both stretching and energy-sapping

- **How can institutions operationalise risk 2.0 across public and private markets?**
  Investors are exploring how to embed consistent risk metrics, liquidity parameters, stress testing, and scenario analysis across diverse exposures. Solving this integration challenge is extremely high up the wish list

- **How does risk 2.0 help address freshly emerging risks where opportunities to hedge or mitigate seem vexed? We cite in particular geopolitical risk, cyber threats and grey zone activities**
  Investors need frameworks that integrate these risks into strategic planning and capital allocation and risk management. And frameworks to consider the systemic risks that haven’t yet emerged.

And what about the big change? A transformational change process is needed to go from risk 1.0 (or risk 1.n) to risk 2.0. It is clear from the narrative in this paper that this a multi-stage process that will have to operate with governance that is equal parts clear-eyed, well-coordinated, and systemically-savvy.

As this paper describes, there is always large drawdown of energy to address complex change. But the prizes for those making this transition seem more than worthy of the price.

Appendix

Ergodicity

Risk 1.0 assumes that our system is ergodic, which is a rich and complex concept. At the risk of oversimplification, an ergodic system will – given enough time – visit all possible states of the system. The probabilities are given by the assumed distribution. Let's assume a really simple distribution – tossing a fair coin[23]. For a 'head' we will payout $10, and $0 for a 'tail'. The expected payout is $5 per toss. It doesn't matter whether we recruit 1,000 players to toss the coin once (the 'ensemble average'), or 1 player to toss the coin 1,000 times (the 'time average') we would expect to payout $5 per toss. This is because we have set this up as an ergodic system and in such a system the ensemble and time averages are always the same[24]. As an aside, if we asked our 1,000 recruits to each toss the coin 100 times, it is possible that we might 'visit all possible states of the system'. It is possible that 1 recruit might toss 100 heads, and another 100 tails, while most recruits clustered around 50 of each.

We can break the ergodicity by changing the payouts. Each recruit will start with $100, a head will pay a +50% return, and a tail will pay a -40% return. We use our 1,000 recruits to generate the ensemble average. For 500 of them, their $100 grows to $150, while the others see theirs fall to $60. On average, we pay out $5 per player. This makes sense, as the expected return (50-40 / 2) is 5%.

For the time average, our single player tosses their coin 1,000 times. We expect them to toss 500 heads and 500 tails. If they toss a head first ($150) and a tail second, they end up at $90 after 2 tosses (150 x 0.6 = 90). If they toss a tail first ($60) and a head second, they also end up at $90 (60 x 1.5 = 90). The time average is very different to the ensemble average, and is (approximately) -5% per toss. The difference between the averages is a defining feature of non-ergodic systems.

We created this non-ergodic system by switching to a 'multiplicative dynamic'. Our payout was calculated by multiplying our starting 'wealth' by the growth rate (either +50% or -40%). Hopefully the read across to our real world is now obvious. Economics and GDP growth is all about multiplicative dynamics, as is investment. We need to lean our ladder against the non-ergodic wall.

To be fair to risk 1.0, it originated when investment was a very small part of a small economy, that was some way off breaching planetary boundaries. So perhaps ergodicity was an OK simplifying assumption (but still technically wrong). Now, however, investment is a much bigger part of a significantly larger economy, that is significantly more complex, and that has already breached several planetary boundaries. And we may also be approaching several climate tipping points. Risk 1.0 is no longer fit for our time.

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[23] For the definitive treatment of the 'Peter's coin toss', please see *The infamous coin toss* by Ole Peters

[24] We have created ergodicity by using an 'additive dynamic'. The payout from my next toss ($0 or $10) is added to the sum of my previous payouts.

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