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Synthetic Risk, Complex Systems and Civilizational Debt

How the transformation of the insurance industry and new approaches to the modelling of risk lie at the heart of macro changes in the world around us.

Synthetic Risk

In May this year, a group of Russian hackers known as DarkSide perpetrated a ransomware attack on the main pipeline that supplies almost half of the fuel to the east coast of the US. Ransomware attacks encrypt data and hold it hostage until a ransom is paid in anonymous cryptocurrency. This was the worst cyber attack to date on US critical infrastructure and highlights a growing problem: the vulnerabilities of human systems are growing exponentially due to their complexity and connectedness.

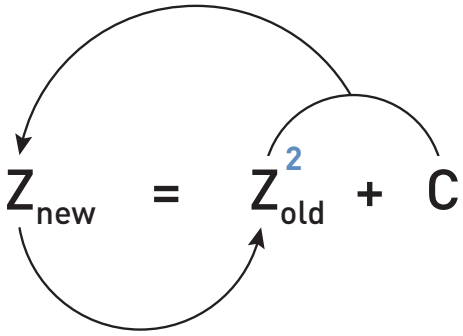
These vulnerabilities and risks are not limited to cyber security but occur in every sector of society. Current climate risk is overwhelmingly a human-created problem. Even the global Coronavirus pandemic is deemed to be an inevitable consequence of rapid global urbanization.

For most of human history, risks to humans have not just been part of the natural environment but part of risk from a natural environment independent of human influence—from wild animals to the weather. Now, even in nature, the majority of risk is created by us. Our environment is post-natural.

What ties these strands of risk together, from weather to disease to hacking is a single term that defines the world we live in. It will dictate the future of human progress and, more specifically, will transform the global insurance industry—synthetic risk.

Complex Systems

In the 1970s, a group of mathematicians showed that iteration of a single, incredibly simple equation, using a feedback loop, where the result was fed back as an input which either ended up producing values that spiralled off into infinity or went nowhere at all, resulted in a boundary between the two that was infinitely complex. The boundary looked the same at any scale, and resembled natural systems closely. We had found the key to creating synthetic, natural systems and, potentially, how to control them and reduce their risks.



This absurdly simple equation produces infinite complexity when the result is fed back in and plotted as an iterated algorithm.

It was computers that allowed us to iterate these equations enough times to reveal this complexity, which lies at the heart of the mathematics that underpins the natural world. Stephen Wolfram suggested that this was a "new kind of science" based on algorithms not equations. (See *A New Kind of Science* by Stephen Wolfram, 2019.)

Today, computers and algorithms are recreating the complex systems of the world around us. It is computers and algorithms—not the single output of mathematical equations—that create the models that allow us to show their future behaviour and mitigate associated risk.

This risk is particularly acute, and growing fastest, where the systems we create are complex. Here, complexity has a specific meaning. It refers to complex outcomes rather than complex components, where the exact future path of a system has to be computed by brute force, algorithmic, iterative computation rather than the solution to an equation. To illustrate this, a complicated mechanical watch is not actually a complex system in these terms, its motions are regular and deterministic, whereas the motion of a seemingly simple system of three planets is - their trajectory can only be predicted by computing it, not by the output of a single equation. In other words, ironically, a complicated watch mechanism is not a complex system, whereas a simple three planet system is —and so is the weather, a pandemic and digital era infrastructure.

We now live in a world of synthetic risk created by complex systems, and the requirements for completely new mathematics to underwrite them is creating a paradigm shift in insurance. This shift is as fundamental as the transition from a world before insurance existed—where outcomes of risks were deemed to be in the lap of the gods—to a post-Enlightenment one, where the mathematics of statistics and probability enabled actuaries to quantify risks, and for these to then be underwritten. Synthetic risk from complex systems does not have probabilistic distributions or outcomes that can be predicted by traditional actuarial methods. It requires iterative computer models and novel sources of data, driven by data scientists and machine learning, rather than actuaries and codified analysis.



This is not a complex system as its output is simple and predictable.

The machine learning revolution is in its infancy, but it is fundamentally different to traditional programming. The model produced by a machine learning-based system is not created by programmers who codify things, but by people who adjust settings on a machine where the inner workings are invisible. There are no algorithms in the traditional sense of human codified logic.

This transforms the way risk can be underwritten. While data scientists will replace actuaries, they will never be able to do what actuaries have traditionally been able to do. They will never be able to understand the 'why' in their models, just know that they produce expected outcomes.

The upside of this will be that complex systems will be more natural and organic, from cities to software. The complex systems we will be able to create will not be like the simple, deterministic, mechanical ones of the Industrial Age—we understood their operations and could predict their trajectories, but they looked sterile and removed from nature.

The downside is that, because we do not really understand the 'why' of these models, we are creating systems that can be used to simulate, and then mitigate, risks from complex systems which, in themselves, create risk due to the vulnerabilities of their own complexity. This is what we are starting to see with cyber risk.

The synthetic complex systems that we are starting to create, which look natural, are combined with natural complex systems—such as the weather and our environment— which we didn't create but are now affecting. These systems are interconnected and part of the overall environment that we have created. The implication is that the natural environment is no longer something separate from our human-created one; it is something that we are part of once again, but that we now have no choice but to try to control.

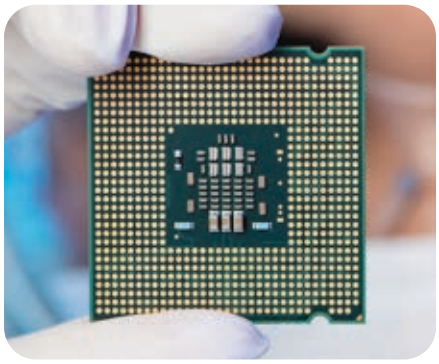
Recently, two of these intertwined systems have collided. The Coronavirus pandemic led to the creation of the data required for a better understanding of climate change—and it was not what we expected. We have just lived through the biggest carbon crash ever recorded, with lockdown measures and trade disruptions that go beyond what we could ever do in the long term if we were to pursue a passive sustainability strategy of cutting back on consumption and emissions. This data shows that cutting back is not enough, we need to fix the damage already done by actively removing CO_2 and harness the weather which is currently out of control.



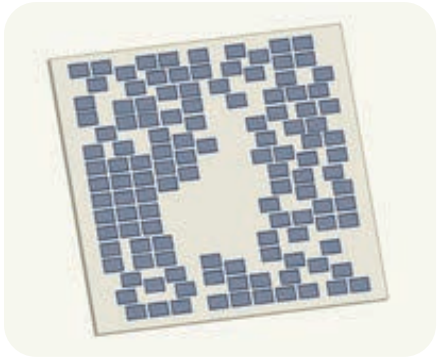
Human-planned city



Algorithm-planned city



Human-designed chip

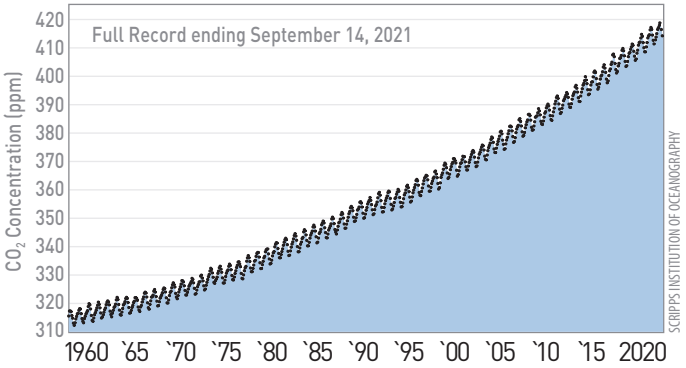


AI-designed chip

Ironically, computer-designed layouts start to look more natural.

A year later, the 2020 lockdowns are barely visible in the CO_2 record and, paradoxically, temperatures may have been increased by the reduction in pollution. The reflection of sunlight by particulates from increased economic activity may have been reducing the effects of greenhouse gases. We now know for sure, from the data from indirect environmental effects of Covid, that temperatures will continue to rise if we cut back. So, we have no option but to pursue the path of technological progress and understanding of complex systems and risks so that we can actively suck carbon out of the atmosphere and control our natural environment globally, just as we do locally within our built environment. We may have no choice but to control the largest complex system we inhabit, and to become 'earth architects'.

Carbon Dioxide Concentration at Mauna Loa Observatory



2020 shutdowns are already invisible in the CO_2 record

Civilizational Debt

In 1992, Ward Cunningham, a computer engineer who co-authored *The Agile Manifesto* and, coincidentally, created the first wiki, coined a term to refer to the extra effort required to deal with the complexity created by bloated software used to build features quickly. He likened this to financial debt and called it technical debt. Years later, it would become the subject of countless academic studies and used as a catch-all term for the latent future cost of dealing with the inefficiencies in almost all areas of software development from bugs, to legacy code, to high level or no code tools, to missing documentation.

This is how he explained the metaphor: "With borrowed money, you can do something sooner than you might otherwise, but then until you pay back that money you'll be paying interest. I thought borrowing money was a good idea. I thought that rushing software out the door to get some experience with it was a good idea, but that, of course, you would eventually go back and as you learned things about that software you would repay that loan by refactoring the program to reflect your experience as you acquired it."

As Cunningham suggested, technical debt, like financial debt, was not necessarily a bad thing if the interest payment was sustainable. But, today, the cost of technical debt is not just in the effort required to refactor software but in the vulnerabilities of the complexity created

by bloated software. Today, these vulnerabilities are more acute as computers are connected to the internet and so they are exposed to hostile actors.

The sum total of these vulnerabilities is called the 'attack surface', but this is a misleading term for a very important reason—surfaces increase less than volumes as something gets bigger but, as software gets bigger, the number of permutations of potential attacks gets much bigger due to complexity. The overall attack surface to lines of code ratio increases with size and technical debt compounds as software becomes more complex and more connected.

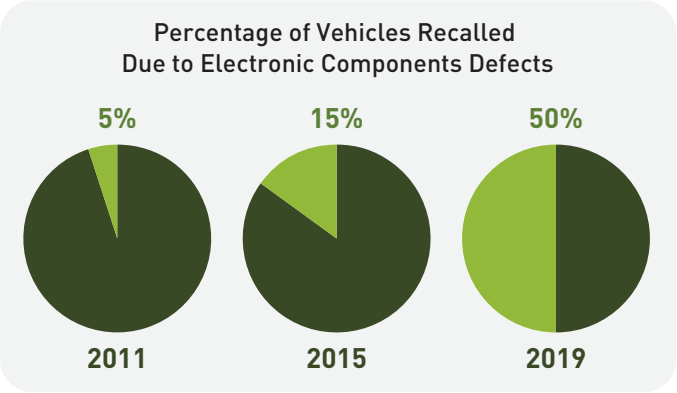


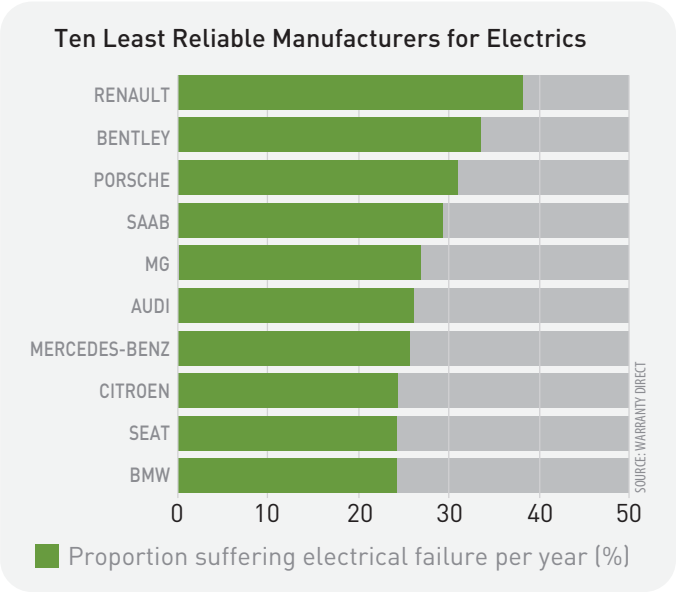
Why the 'attack surface' metaphor is misleading for cyber risk: the surface-to-volume ratio of a bigger thing like an elephant is less than a mouse, but for complex systems, the 'attack surface' is much, much bigger for bigger systems.

Since computers and algorithms are involved in the creation of everything today, from cities to cars to media, technical debt and its runaway effects apply to human culture as a whole. We have created a civilizational debt, which is increasing with human progress and accelerating the production of synthetic risk from complex systems. In addition, as mentioned earlier, the switch to iterative methods of modelling, such as machine learning-based systems, whose inner mechanisms are codified or directly understood by humans, compounds the problem. Effectively, AI systems are weapons of mass technical debt.

An example of the problem is in the complexity of electric cars. By 2030, half the cost of an electric car will be its electronics. Electronic failure is the major reason for recall and several of the top ten most reliable brands of car manufacturer in terms of mechanics are the least reliable in terms of electronics. Today's cars are needlessly overcomplicated in areas where manufacturers have little expertise; by our calculation, some cars will transfer the equivalent of a Library of Congress-worth of data in 'talking' to themselves over an average of 400 hours of driving. An objective measure of complexity derived by measuring this data traffic suggested that a modern car's 'intelligent' lighting system was reaching a level of complexity that put it at risk of systemic failure.

Our ability to survive as a species depends on our ability to reduce this complexity where possible, to model complex systems, understand their risks and underwrite the debt created by these risks. We live in a world of synthetic risk generated by human-created complex systems, where the ability to mitigate this risk is only possible via models that are themselves complex human-created systems and that, in turn, create more risk.





To do this, we need to understand systems as a whole not project the trajectory of individual components, just as a nuclear explosion is a product of a critical mass of a system as a whole not the path of an individual rogue particle. We can do this by eliminating systemic risk through decentralization where possible and focusing on large-scale threats to systems as a whole, versus trying to prevent smallish bad events artificially (similar to allowing lightning strike fires to prevent large-scale deforestation). Small-scale bad events allow for feedback loops that balance risk naturally; complex systems are intertwined intimately with feedback loops that keep things in balance.

Dealing with these synthetic systemic risks will be more profound than the current disruption caused by digital age technologies, from social media-influenced social unrest to changes to trade and capital flows. These require us to understand the risks and underwrite our environment as a whole.

The ability to do this will provide the foundation not just for the future of insurance, built on modelling complex systems rather than traditional mathematics and statistics, but the future of society and our ability to mitigate risk to ensure that it is sustainable.

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