SOCIETY OF ACTUARIES

Article from:

Risk Management

September 2009 – Issue 17

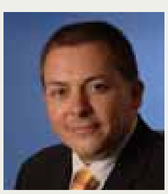
Emerging Risk—The Signs Are There

By Neil Cantle and Neil Allan

INTRODUCTION

AS THE WORLD STEADIES itself after one of the biggest economic shocks on record, there has naturally been considerable reflection in the risk community over where it all went wrong. A common theme is that some people were able to piece together parts of the story, some even raised warning flags. However, very few organizations were able to substantiate their concerns with evidence from risk management systems, let alone have the conviction to act upon the evidence. By the time most traditional risk systems did start to notice problems, it was far too late to avoid the inevitable fallout.

We began our research into emerging risk more than six years before the recent crash. Even then we had a sense of discomfort with the rather simplistic framework used to conceptualize and model "risk," particularly for the types of risk that emerge at the enterprise level. Essentially risk was framed as some sort of event, which threatened an enterprise's ability to achieve its objectives. Risk management has therefore developed a deductive approach to searching for the events comprising the risk occurrence and aims to avoid those precursory events.



Neil Cantle, ASA, FIA, is a principal & consulting actuary at Milliman in London, United Kingdom. He can be reached at *neil.cantle@milliman.com*.

NOT THE SUM OF THE PARTS

Despite the evolution of "risk management" into "enterprise risk management" the tools for managing and quantifying risk are still essentially focused on individual types of risk which are then "added up" to achieve the "enterprise" aspect. It is this focus on enterprise risk as being an aggregation of risk types which causes difficulty when trying to make sense of complex integrated and interconnected risks.

We know that the financial services sector is essentially service-based and relies heavily upon people to achieve its outputs. It is very far from the equilibrium and optimized world with which most risk management tools were designed to cope. Our insights from complexity science bring the bad news that the old approach to assessing and analyzing risk is flawed and is fundamentally not capable of achieving the holistic perspective that is needed.

Our research suggested we should start by framing risk in a different way. At the enterprise level we observe that risks are not "events" but tend to emerge continuously over time through a process of complex interactions of multiple factors. When people refer to "a risk event" we translate this to mean that the emerging risk process has pushed the organization over some tipping point where a sort of unstoppable cascade has begun. However, the risk will continue to evolve even after this point. This framing creates a more realistic perspective of enterprise risk.

Enterprise risks are rarely, if ever, the same twice and they seem to emerge rapidly and chaotically in the later stages. With this new paradigm for risk we can look to the science of complex systems to provide some of the tools we need to start making sense of what is going on.

ON THE EDGE

The study of "systems theory and systems thinking" has evolved rapidly, particularly as computing power has become more accessible at reasonable cost, and this has enabled some of nature's most impenetrable secrets to be, at least partially, understood. Weather prediction is an example where the insights gained by scientists into how weather systems work enables them to make relatively reliable predictions – although they occasionally get it wrong, it is surely more incredible that they are able to ever get it right when you think about the complexity of the globe's weather!

For our risk study we are interested in a particular class of systems, known as "complex adaptive systems," and particularly those which fall into the category of being "self-organized." Complex adaptive systems are characterized by having components interconnected in such a way as to create feedback loops, and where the components themselves can change. These systems exhibit the following basic properties:

- A purpose – they have evolved to fill a niche in their given environment.

> "Systems which operate in a mode that is close to the maximum threshold they can tolerate are highly fragile and prone to collapse…"

- Emergence – the system overall exhibits properties not held by the components.
- Self-organization – it has structure and hierarchy which can form and change spontaneously.
- Interacting feedback loops creating highly non-linear behavior.
- A critical complexity limit beyond which it collapses or goes chaotic.

Systems which involve people are nearly always in this category due to the way they interact and adapt.

Each system will have a maximum level of complexity it is able to handle. This limit will be a function of its structure and operating capabilities, for example, as well as the environment it operates in. Systems which operate in a mode that is close to the maximum threshold they can tolerate are highly fragile and prone to collapse if the operating environment changes by even a relatively small amount.

In the context of risk management we are seeking to examine the limits of complexity that an operation can tolerate, and to assess how close that operation is to the limit. Further, we want to understand why the business is operating at the levels of complexity that it does. To do this requires a number of different tools in combination.

MANAGING RISK

If we consider the tasks that are needed in a well-formed risk management process, we can represent those tasks in the following way:

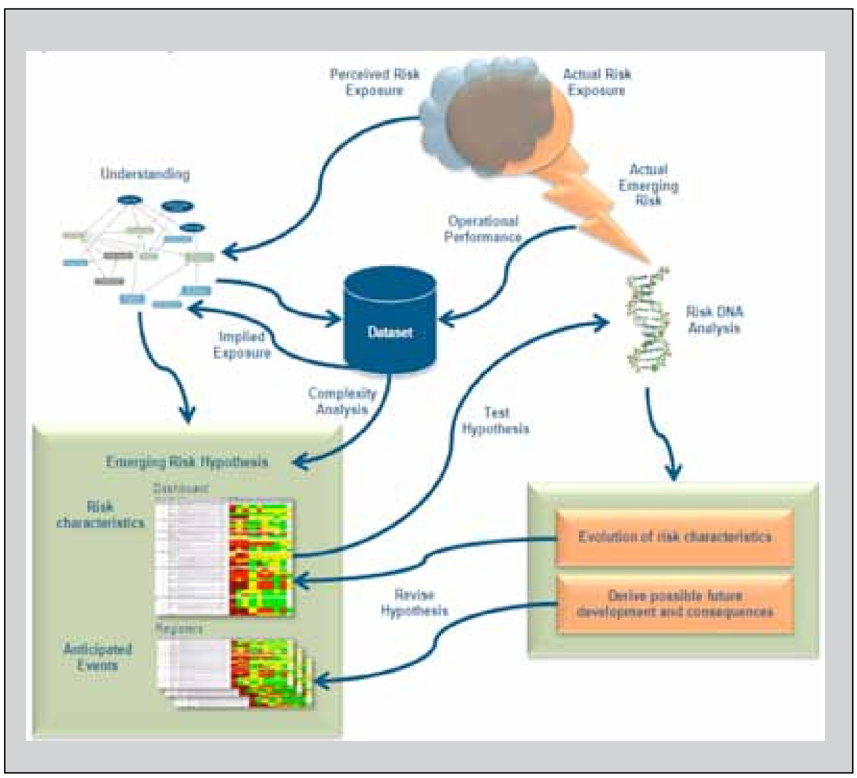
Management's job is to identify, as accurately as possible, the risk exposure that the enterprise faces as a consequence of executing the business plan. From this they form a hypothesis about which risks may emerge over time and produce a summary of this that they can monitor against. They evaluate key indicators relating to risk and operating performance, and also look for signs of emerging risk so that the hypothesis can be tested and updated. This learning cycle should be at the heart of every enterprise risk framework.

The difficulty starts right upfront in knowing what the risk exposure is. We have developed techniques based around cognitive mapping to capture the knowledge of the firm and structure it in such a way as to make visible the interconnected features and dynamics of the risk exposure. This technique very quickly and successfully documents how the strategy translates into risk exposure.

From this solid base we can explore and model the dynamics of the risk exposure to determine a core dataset which is needed to describe the behavior of the organization's performance. The risk exposure analysis also provides a robust platform for creating the scenarios needed to complete the hypothesis about where and how risks may emerge.

Neil Allan, is a Fellow of the Bristol Systems Centre at the University of Bristol in Bristol, United Kingdom. He can be reached at *N.D.Allan@bath.ac.uk.*

Figure 1: Risk Management Process



CONTINUED ON **PAGE 10**

Emerging Risk … | from Page 9

In preparing the hypothesis it is important to formulate a relatively static baseline. A "Top 10" list of concerns as the top level reporting device simply will not do. The top level reporting is best achieved as a manageable list of risk characteristics, which can be used to classify risk scenarios. For example, it is common to start from very broad headings which are now in common use, such as: strategic; market; credit; insurance; operational; etc. These can be customized one stage further to generate more detailed characteristics such as: fraud; business discontinuity; adverse regulatory changes; etc. This list of around 20 to 30 items essentially forms the list of risk "DNA" for an enterprise.

A series of risk registers are then used to construct plausible risk scenarios, which may combine certain of these characteristics into real-world situations that could lead to harm. The choice of scenarios is made easier by having a good understanding of the risk exposure in the first instance. By capturing the connections between different scenarios in the risk registers we can also work out which scenarios seem to be the most important overall.

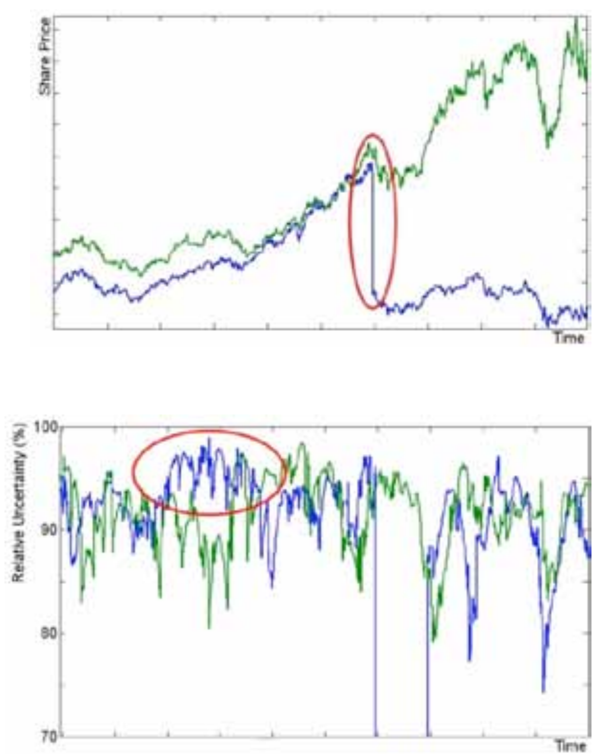
Having defined the core dataset, management can look for evidence that their organization's performance is either robust or fragile. Initially we can use a simplified complexity measure, "system uncertainty." According to Information Theory, the amount of information in an observation x is –log p(x) where p is the probability of x being the information we want. We look at the average amount of information in the organization's performance variables and this is then equivalent to looking at the uncertainty removed after seeing the actual performance of the organization. So, if we are perfectly certain about what will happen next, then we learn nothing by watching the actual performance and our "uncertainty" is zero. When it is perfectly unclear to us what will happen next our "uncertainty" is 1.

An organization needs a certain level of complexity in order to be capable of generating a good level of performance, but we need to avoid it becoming too high and hence unstable. Complex systems have a critical maximum amount of complexity that they can handle before becoming unstable, so we are particularly interested in looking at the current amount of uncertainty in an organization's performance relative to this maximum. Management is therefore interested in maintaining their performance such that the level of uncertainty is sufficient to permit good operational performance, but which is below the maximum.

ECHOES OF RISK

The following simple example (Figure 2) shows two banks whose share prices follow broadly similar paths until one suddenly collapses. Even by looking only at the share price data in terms of uncertainty, we can see that the evidence for collapse was visible some time before. The bank which collapsed suddenly starts to operate around 95 percent, at which level the organization must be highly fragile and sensitive to perturbations, and remains operating at this high level for some time. In contrast, the other bank occasionally operates briefly at high levels of uncertainty but its management seems able to take action to reduce it before the organization becomes unstable.

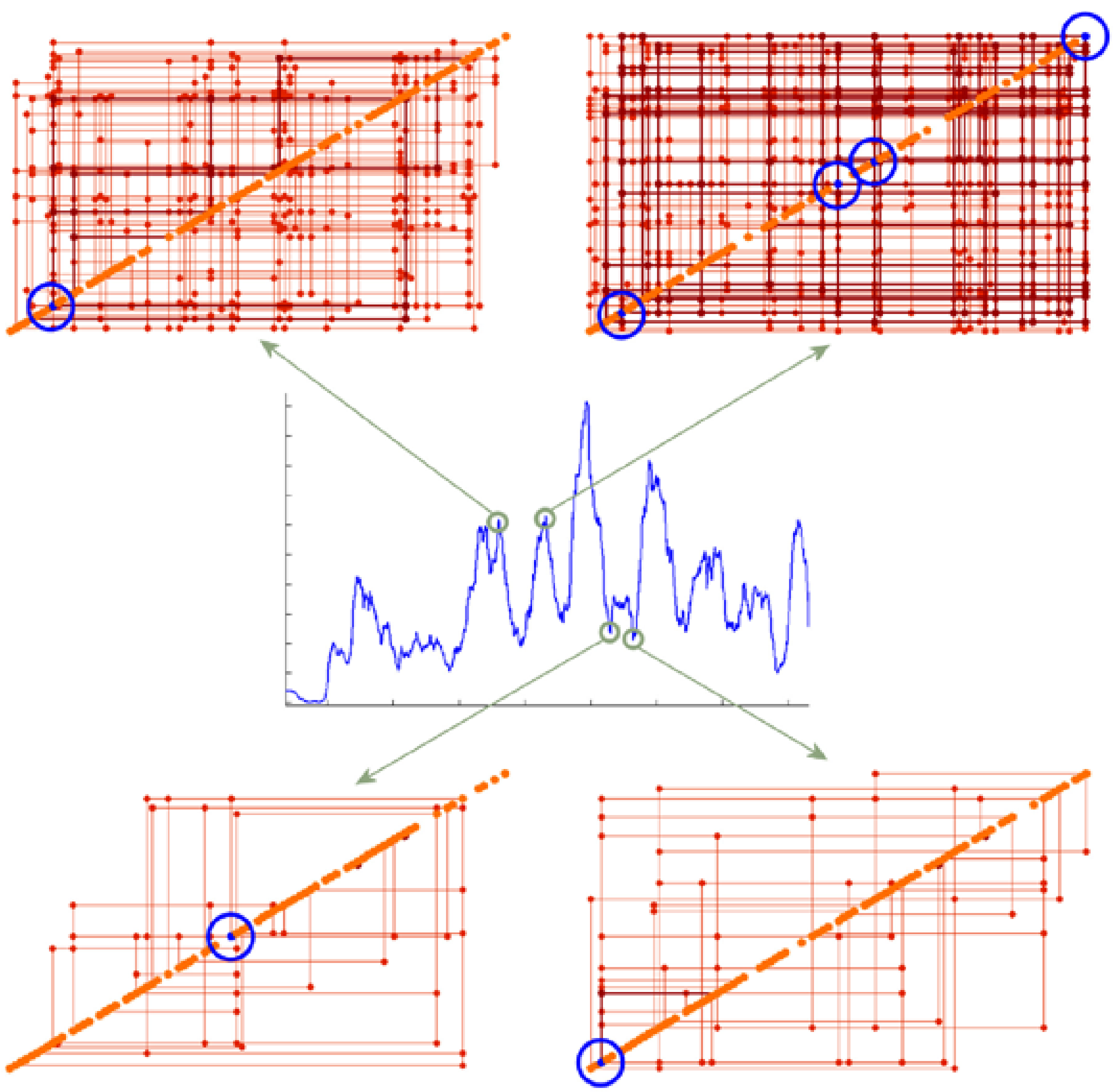
Figure 2: Using "Uncertainty" to Identify Building Trouble



> "...through complexity-based approaches we are able to better understand and articulate risk exposure..."

Management will typically have much more than one variable to look at, and so they have the possibility to use more sophisticated measures of complexity and try to understand where this build-up is coming from. The following chart (Figure 3) shows the complexity of a particular system taking into account uncertainty and the manner in which the variables are connected. Note that these "connections" are not correlations. They represent actual information sharing and are therefore much more profound than correlation since they tell us about how the connections of the organization are actually working, thereby giving insights into its structure and performance. The calculation was carried out using DACORD™, a proprietary development of DRTS Limited.

Figure 3: Analyzing System Structure to Understand Complexity



CONTINUED ON PAGE 12

Emerging Risk … | from Page 11

We can examine the structure and connectivity of the system at key variables (these are shown along the diagonal with the connections drawn between them to indicate the information sharing taking place) and see that the variables which drive the system (shown in blue) change with time, and the way they connect with other variables also changes. This is very significant in the context of trying to understand emerging risk. Traditional approaches to risk analysis use qualitative and/or quantitative models as a way of understanding the behavior of the organization. Our insight here shows that these models may need to change quite frequently if they are to represent what is actually going on. This lack of correspondence between the traditional models and reality explains the "surprises" that people have when apparently new risks appear – in truth they were often simply looking at the wrong things.

So, through the use of complexity-based approaches, we are able to better understand and articulate risk exposure, making full recognition of the interconnected nature of its dynamics. We are also able to more intelligently find out what our data is telling us.

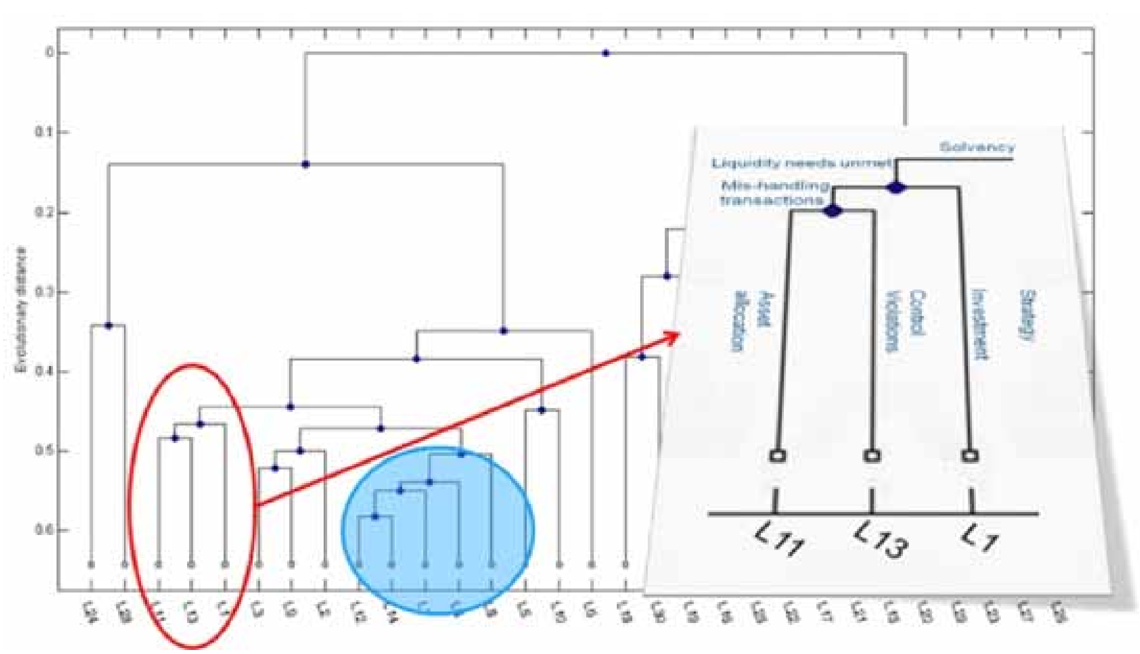
RISK DNA

The next area where we can gain insight is in the analysis of actual emerging risks. Even if we successfully avoid the risk it is valuable to learn about which risks we actually faced and test to see if our hypothesis is correct.

We gather information about emerging risks in a log which contains a description of the risk, a time reference and an assessment of whichever combination of risk characteristics seems most appropriate to each risk. We then conduct a Risk DNA Analysis on this information to gain insight into how the risks are evolving in the business and which characteristics are more prone to combining to create new risks to the business. The analysis is carried out using cladistic algorithms, which group the risks according to their characteristics, searching for the simplest representation. In practice the calculation is not trivial and is a proprietary process developed by the authors.

The following example (Figure 4) shows the cladistic system of 30 entries from an emerging risk log that were analyzed.

Figure 4: Analysis of Emerging Risk in Terms of Risk Characteristics



> "By measuring the effort involved in different combinations, we provide insight into which new combinations of risk characteristics are most possible …"

As you work down the diagram from the top, each bifurcation point represents an important evolutionary phase when characteristics are either lost from, or added to, the risk branch to the right but not those to the left. For example, risk L11 and L13 still have "Liquidity Needs Unmet" whereas L1 does not.

We can investigate the analysis and look for areas of rapid evolution, for example, which suggests that certain characteristics are not being held in check and are combining freely. In the above, the blue shaded area shows such a group. Alternatively we might look for areas of more stable evolution to understand some of the root characteristics that exist almost in the culture of the organization.
Just as in biological evolution, there is an "effort" associated with characteristics trying to recombine in different ways. This is represented by the length of each branch leg. By measuring the effort involved in different combinations we are able to provide insight into which new combinations of risk characteristics are most possible, given the current state. This information helps to reassess the risk hypothesis and also to explore the possibility of different risk scenarios.

CONCLUSION

In summary, we know that risk, as a human construct emerging from predominately people-based organizations, is going to behave like a complex adaptive system. Hence there are some important messages from complex system theory that help us understand and manage risks more effectively. First, complex systems have special properties such as hierarchy, emergence, self-organization and connectivity; but importantly, they also follow the laws of entropy. Applying these concepts to risk management we get new insights such as:

1. Emerging risks are essentially the emergent property from a complex system.

2. History is important. We already know this in the insurance industry, but including an evolutionary approach provides us with a unique understanding of the connectivity between elements of an enterprise's risk system. It shapes what happens next and unlocks a new way to identify how and where risks emerge.

3. The critical limit of complexity, sometimes called the "edge of chaos," is real. The techniques above provide a rigorous approach to determining when an enterprise or sub-system is close to this threshold and subsequent collapse.

4. Understanding the connectivity of a risk system is fundamental to understanding the dynamics, structure and hierarchy of the system. It is important to understand how these connections can be made explicit from qualitative and quantitative data. We have illustrated several proven techniques to enable this.

5. Finally, industry systemic risk is essentially an aggregation of sub-systems behavior, such as enterprises and people. The nature of their interaction can cause self-organization, which can lead to significant non-linear behavior. The tools and techniques we have discussed in this article make it possible to anticipate, and observe, the onset of such systemic risks.

The concepts described above are well researched in the science journals. The techniques we have developed over the last six years are unique to risk management, but are based on physical, psychological and mathematical theories. Framing risk in the right way and using the right tools for the job offers us the chance to see the signs of emerging risk early, and to make better sense of what is happening. ✦