
SYSTEMS
THINKING

CONTINUING THE SERIES ON THINKING AND DECISION MAKING THAT BEGAN IN THE FEBRUARY/MARCH 2012 ISSUE OF *THE ACTUARY* WITH, "THE EVOLUTION OF THINKING," THIS ARTICLE EXPLORES LOOKING AT RISK MANAGEMENT HOLISTICALLY. BY NEIL CANTLE

WHEN FACED WITH A WALL OF COMPLEXITY, most people have been taught to immediately seek to break the problem into more digestible pieces, study them and then reaggregate to understand the "whole." This approach actually works pretty well if the situation does not change too frequently. Generations of practitioners studying the problem will find increasingly better ways of breaking it up, and reaggregating the solution. But what if things are frequently changing and adapting? In this case the collaboration over time no longer yields the improving accuracy you would hope for.

The reductionist approach is so ingrained in our training that the idea of looking at the full holistic picture as a first step nearly always sounds like a daunting and fruitless route to take. As it happens, this is exactly what we need to do.

MORE THAN THE SUM OF THE PARTS

The problems we typically study in enterprise risk management are framed at the level of a whole business. At this level it is nearly always the case that the uncertainties in the company's performance arise from a multitude of linked factors. These types of systems are complex (they have many components interacting in a non-linear way) and adaptive (the nature of the components and their interactions change over time). Decades of study by many academics tell us that such systems resist simple reductionist techniques of analysis because the interconnections and feedback loops preclude holding some subsystems constant in order to study the others in isolation. It is therefore necessary to describe such systems at multiple scales in order to identify how emergent properties are produced—reductionism and holism are needed as complementary strategies. Complex adaptive systems differ from chaotic ones by virtue of their history. They evolve over time through a series of irreversible events, and, whilst they retain structure, they have the capacity to produce quite exotic behaviors.

So, the classical reductionist approach is simply not going to work when faced with such a complex system. The emergent nature of the outputs being studied means that they cannot be understood simply by studying the contributing parts—it is the interactions between the parts that determine the outcome. Clearly reductionist models have value in some situations, so the addition of systems thinking to our tool kit is to help us work out when the approximations of the simpler models are valid and when they are not.

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The adaptive nature of the system also means that these interactions are changing regularly. Building a model based on historical behaviors, or those at one point in time, will leave the model unlikely of being capable of generating the full range of behaviors of the system as it evolves forward. Risk frameworks therefore tend to lag behind reality, thus the models and tools know about all the risk outcomes that have happened in the past, but are not very good at all at predicting the next one. Consider modeling a new type of pandemic. Early on the data only relates to the initial phases of the contagion's development when things move quite slowly. Later, when other factors have come into play, the disease starts moving much more quickly. Trying to fit a statistical model to these very different modes of behavior is extremely challenging without prior knowledge of the different modes that the system can operate in.

This feature of the reductionist method is fundamentally because the models and analysis are fitting to "outcomes," assuming they follow some kind of repeatable statistical process, without knowing what the mechanism really is and replicating that. Whenever the drivers of the real situation change, we see the models and framework become less useful and declare the event as a "tail" event—in reality it was more likely that we just were not capturing the system behaviors well enough.

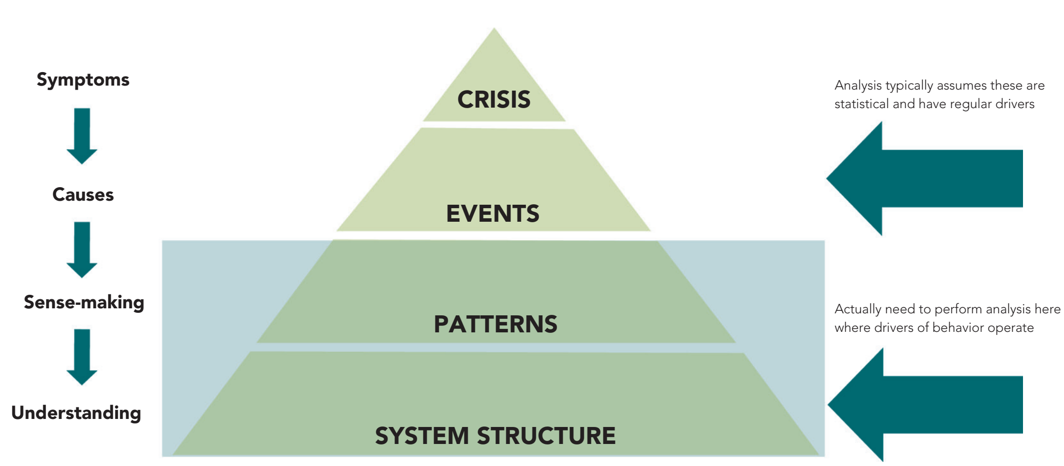
For the study of risk, we typically want to know about less frequent events that require us to know when subtle changes in conditions might lead to unpalatable outcomes. By studying the mechanism of emergence we are able to gain a much better understanding of when those subtle changes matter. Figure 1 shows that we need to gain a deeper understanding of the system if we want to see things early and model unusual behaviors.

Intuitively this feels like a much more realistic view of the risks that we study as professionals in the real world. So, how does one study complex adaptive systems productively to gain these insights?

SYSTEMS THINKING

As discussed earlier, a systems approach seeks to elicit an understanding of how the overall behaviors of the system are produced. Since the behaviors are emergent, this has to start by considering the whole, and expressed in terms of all the interacting factors that contribute to the observed behaviors. It is important that all of the non-linear relationships are retained in the explanation as they often generate some of the more "unusual" or "surpris-

Figure 1: Spotting the Emergent Behaviors of Complex Systems Means Going Below the Surface



ing" behaviors. In this way, systems thinking helps us to see both the forest and the trees.

Earlier in the study of systems, many techniques were focused on so-called "hard" systems. Checkland (1993) describes these systems as being "characterized by the ability to define purpose, goals and missions that can be addressed via engineering methodologies in attempting to, in some sense, 'optimize' a solution." However, the concept of "soft" systems was added slightly later, being those "characterized by extremely complex, problematical and often mysterious phenomena for which concrete goals cannot be established and which require learning in order to make improvement. Such systems are not limited to the social and political areas and also exist within and amongst enterprises where complex, often ill-defined patterns of behavior are observed that are limiting the enterprise's ability to improve." Risk management often involves dealing with hard systems embedded within soft systems, but many of the tools used by risk managers are designed for hard systems. So, it is the tool kit for the soft system elements that typically requires enhancement, and this brings the appropriate context for the other tools.

To understand how the system of risk works in an enterprise, we therefore need to look at the company as a whole—comprising people, cultures, agendas, processes, and technology all interacting with an environment of macroeconomics, competitors, etc. Mitleton-Kelly (2003) describes complexity as the inter-relationship, inter-action and inter-connectivity of elements within a system and between the system and its environment. It does not take too long to realize that much of this system is soft.

Extra Info

FOR MORE INFORMATION ON THIS TOPIC, VISIT THE WEBSITES LISTED BELOW.

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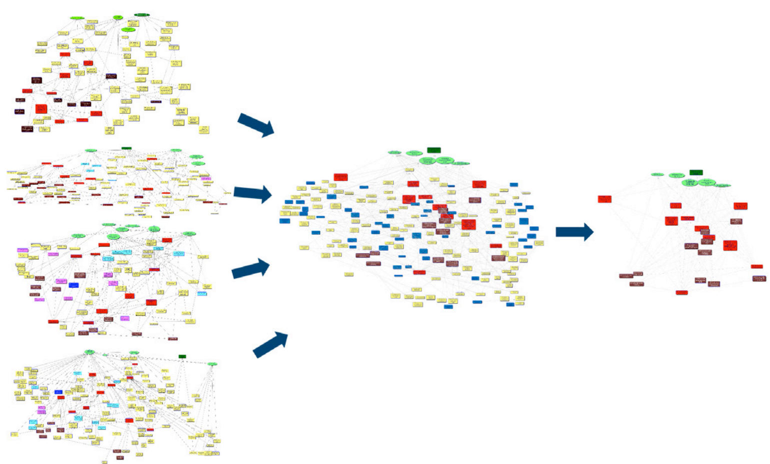
APPLYING SYSTEMS THINKING IN PRACTICE

One of the best sources of information about this complex system is the people in your business. They see the system operating every day and have a good understanding of all the peculiar things it does, and have probably spent time thinking about things it has not done yet, but might do in the future. A challenge, however, is to find a way for these experts to tell the part of the story that they know, in a manner that permits their piece to be combined with those of others. If we had a way to combine and study their collective knowledge of this complex system we would be well on the way to a proper understanding of the system structure that produces the outcomes of our organization.

We know that a feature of complex adaptive systems is that they are highly nonlinear and often give rise to non-intended consequences. This makes it hard for people to see how their actions and those of others interact to produce the observed outcomes. Even where someone has devoted time to understanding the many subtle dynamics of the system, it can be hard to express that to others. This lack of understanding is often then translated into a deficient model—one that captures the obvious behaviors but is not capable of producing the more unusual ones. The use of stress tests or scenarios does not always uncover the relevant unusual behaviors as cognitive biases frequently prevent people from imagining the right things to investigate. How do you model something you haven't considered?

If we pause to consider the financial crisis, which is still playing out, we can see how a systems approach might have helped to prompt action earlier. Before the crisis broke, there were a number of experts who claimed to have spotted a buildup of pressure in various parts of the financial markets. The problem was that, despite communicating this to others, the connection between these early warning signals and the final crisis seemed so far apart that most people thought the warnings were either too early, or incorrect, and there was insufficient sense of urgency about the situation. If more risk frameworks (particularly those in the regulators) had been using systems approaches to visualize the manner in which these warning signals were dangerously connected, it would have been evident that this set of circumstances could unravel very quickly. A systems approach could not have forced people to listen but it would have made the point of the message much clearer to more people.

Figure 2: Cognitive Mapping Can Be Used To Combine Perspectives and Distill Key Features



One tool from the soft systems tool kit that helps us here is "cognitive mapping" (Eden, 1988). This is a technique to visualize the complex and non-linear relationships between different concepts or cognitive constructs and it provides the framework for us to recombine the different perspectives from our experts into a cohesive view of the system (see Figure 2 above).

Once we have a structured understanding of how the various factors interact to produce the final impacts on business performance, there are some special features we particularly want to understand:

- Accepting that all of the factors somehow contribute to the system's behavior, which ones are particularly important?
- Which factors are especially important in the sense that they ultimately trigger significant outcomes?
- Which combinations of factors are preventing the system from entering an unstable state?
- Which combinations of factors are particularly inflammatory and could lead to highly undesirable outcomes?

This information gives us a deep insight into the dynamics of the sources of uncertainty in our business performance and provides a solid platform upon which to build strategies for: how we might identify emerging areas of risk or uncertainty; or, how we might allocate resources to achieve a resilient and robust organization. By using soft systems tools at this stage we explicitly recognize that different people in the business will potentially perceive the situation differently, and our assessment of their input is not pejorative—we simply use our tools to understand the context and likely consequences of their view of the world. Faced with these differing views we are now able to study the consequences in terms of risk outcomes and make a rational choice about how best to respond.

Note that this is very different from a reductionist approach. We have not yet sought to study pieces of the system out of the context of the whole. We have remained focused on the whole at all times and have only tried to identify which parts of it are particularly significant to the overall behavior. Also note that it is quite different to assume that behaviors average out to permit statistical approaches when we consider sufficient numbers of people—e.g., a whole market. Understanding the mechanism at work we know that rapid shifts in underlying behaviors can take place, which statistical models would not anticipate.

Once we have a solid understanding of the dynamics we can revisit our existing models and frameworks to ask whether they cater for all the behaviors we now know to be possible. It is likely that they will cover some subset at least. If we can now see behaviors that it cannot reproduce, we can consider whether these can be illustrated using a scenario or whether new functionality is required.

Humans have evolved a good ability to spot patterns, and it is one of our favorite problem-solving tools. We can use this skill without having a full set of data about a problem and yet still make reasonable judgments about how things are related just from the patterns we see. Making sense of complex systems is partly about spotting the patterns in events that give us clues about the underlying system mechanism. We therefore need to be able to spot the patterns in company performance drivers that will tell us about the underlying system behavior creating our organization's outputs. Many risk systems classify data at the point of capture by applying a reductionist hierarchy of labels (e.g., credit, fraud, IT, people, etc.). This destroys much of the non-linear connectivity information needed to spot the patterns as it is implicitly assuming that items under each label are homogeneous. Many risk registers are therefore highly unlikely to tell you

Complex Systems for Risk Appetite

THE U.K. ACTUARIAL PROFESSION commissioned research in June 2011 relating to risk appetite and emerging risk. The study applied a complex systems approach to the two problems—they are both hard to resolve using traditional methods due to the complex interactions of the parts they are trying to make sense of, and the fact that the interactions change. The science behind this article and the case studies of the research is discussed in the final paper which can be accessed at http://bit.ly/yaJBRo. The project, led by Neil Cantle, was carried out by Milliman and the Universities of Bristol and Bath. A

about emerging risks because their ability to do so has been removed when the risk was coded into the register.

Another common problem is that people often make a prior judgment about what they expect to see in the risk information being studied and then apply tests that really only work well for linear phenomena to see if they were correct. A systems approach requires an open mind when looking at the risk information to spot patterns that we were not previously expecting, and we need to use tools that are designed for non-linear behaviors (e.g., mutual information measures) when we test for relationships between factors.

SUMMARY

There is no argument that the modern world is growing in complexity and the firms we work in are anything but simple. Yet we study these systems with tools at a first step that should often be used later, after the system has been understood and the appropriateness of any approximations confirmed. The reductionist approach used too early risks missing vital information about non-linear adaptive behaviors that we need to see as risk professionals. We also see that a systems approach can help to put expert views into context so that their insights can be leveraged across a wider audience. This article has introduced some of the ways you can look at the world holistically, but rapidly get to an understanding of which tools can be used to model and manage risk appropriately. A

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