

**The Actuarial Profession**  
making financial sense of the future

Risk management in life insurance – current hot topics  
Neil Cattle, Milliman



## Emerging Risk Spotting it early

23 March 2011

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## Agenda

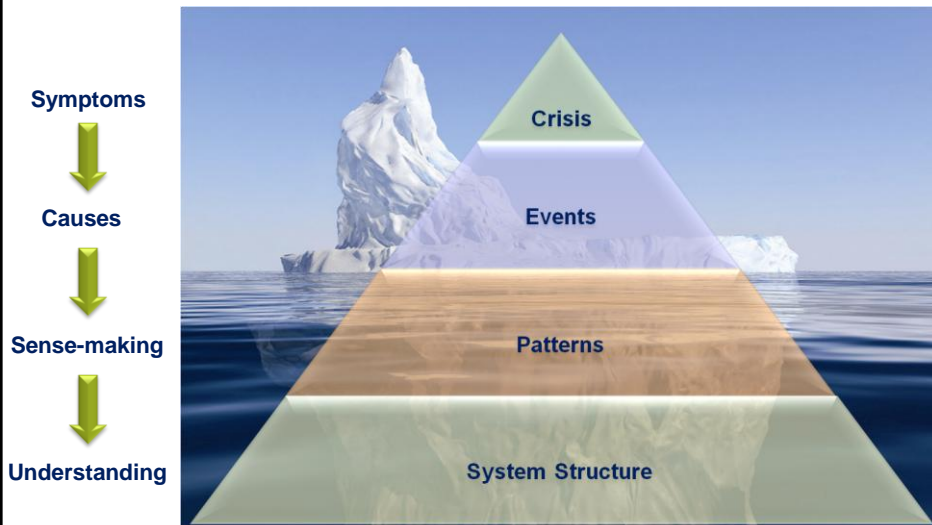
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- What is emerging risk?
- How to spot it early
- Making sense of early signals
- Modelling emerging risks

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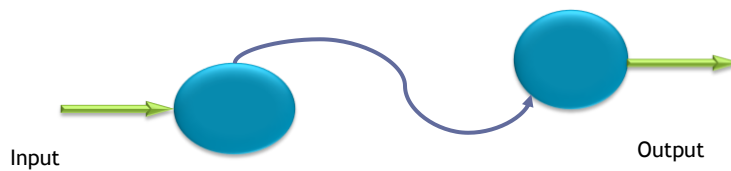
## Understanding a crisis



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## What is a system ?

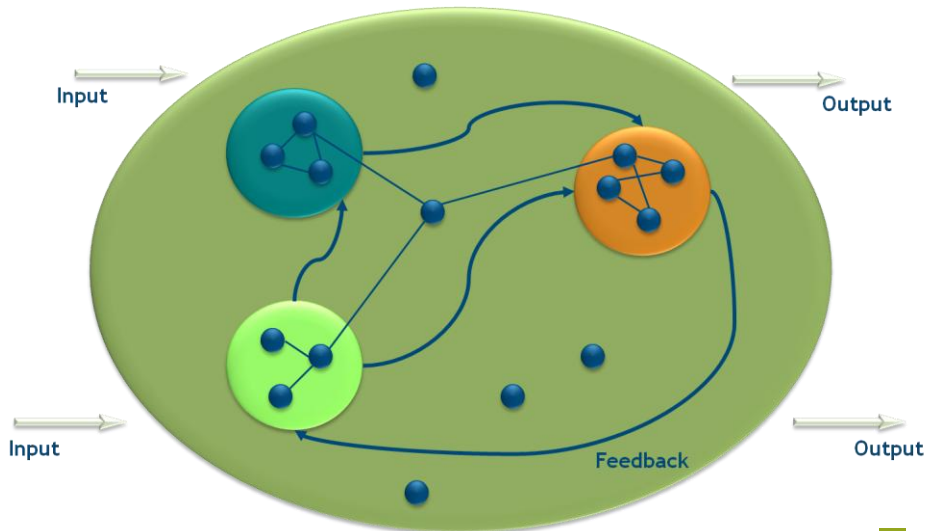


*"a set of components interconnected for a purpose."*

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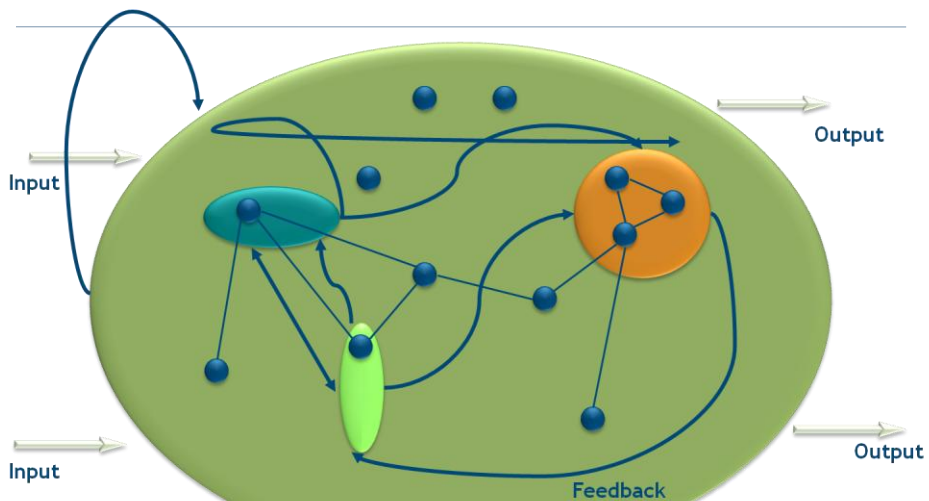
## What is a *complex* system ?



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## What is a complex *adaptive* system ?



**Elements can change**

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## Complex Adaptive Systems

- Basic properties:
  - Has a purpose
  - Emergence – the whole has properties not held by sub components
  - Self Organisation – structure and hierarchy but few leverage points
  - Interacting feedback loops – causing highly non-linear behaviour
  - Counter-intuitive and non-intended consequences
  - Has tipping point or critical complexity limit before collapse
  - Evolves and history is important
  - Cause and symptom separated in time and space
- Risk is the unintended emergent property of a company (which is a complex adaptive system)

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## So...What is Emerging Risk?

- An emergent property of a complex adaptive system (company / industry)



- ...which is great news because now we know how to spot it

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## How to spot emerging risk early

- Pattern spotting is what humans do best
- ...and is the thing typical risk frameworks do least
- Need to know which data is relevant
- Need to retain “information” in the data you store
- Need to remain open-minded about what you will find
- You probably already have most of what you need – just look at it differently



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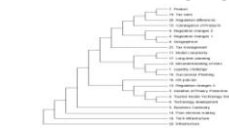
## The key to spotting the patterns

### 1. Understand how the system works



### 2. Anticipate potential areas of emerging risk

*Under-developed stories*



*Evolutionary patterns*

### 3. Identify unusual performance signatures



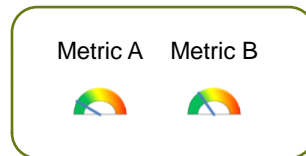
*Which factors are driving behaviour?*

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## A Scenario

- Consider part of a typical risk dashboard



- Suppose the metrics relate to different business areas
- There is no reason to think they are connected
- Consider how this might evolve

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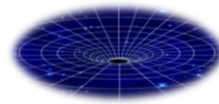
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## A Scenario

- Suppose that A and B actually both depend on a common factor, C
- The influence of C is greater on B than on A
- Over time our dashboard shows a pattern that we need to be able to spot
- Here we see a trend which is hard to spot until it is too late

t	Metric A	Metric B
1		
2		
3		
4		

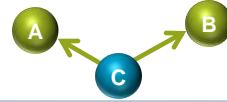
*Like detecting a Black Hole by virtue of gravitational impact on nearby stars*



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## Scenario Lessons



- The point of the simple example:
  - Monitoring only the components without looking for interactions won't tell you much until it is too late
  - Complex adaptive systems change their structures, by definition, so static reporting can't work for long
- This tells us:
  - Holistic views are needed first, then reductionist ones
  - We need a dynamic, but structured approach
  - We must not lose information upfront
  - To keep an open mind about what data says

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## Cognitive Mapping

1. Understand how the system works



- Business experts often already know the signs of emerging risk exist
- Complex interactions between factors and separation of symptoms in time and space make it hard to “connect the dots”
- Cognitive maps facilitate reconstruction of what experts know and make sense of it holistically

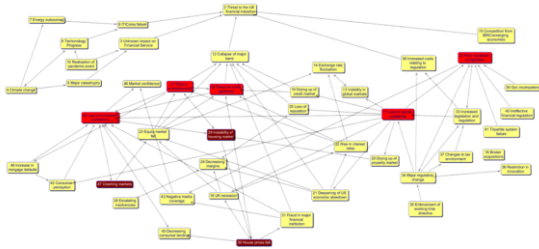


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## It's all in your head

1. Understand how the system works



Source: Milliman

*It is possible to use cognitive mapping techniques to reconstruct the highly complex risk profiles of real business in a robust, repeatable way – simply through dialogue with your own experts*

*Helps make sense of emerging risk factors.*

*Gaps in the story often signify “blind spots” which can become emerging risk.*



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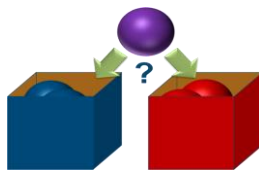
## Evolutionary Patterns

2. Anticipate potential areas of emerging risk

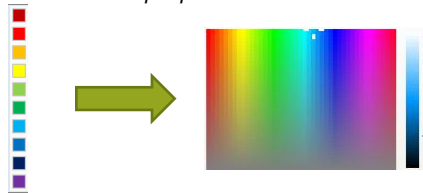
Under-developed stories  
Evolutionary patterns

- New risks tend not to “appear” out of thin air
- Their characteristics are an evolution of previous ones
- Studying the evolutionary signature of your risks gives clues about possible new ones
- Requires a multi-characteristic view of risk

*Don't force monochrome view...*



*...Allow people to “mix” colours*



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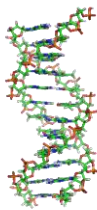
## Analysing Risks Using Multiple Characteristics

2. Anticipate potential areas of emerging risk

Under-developed stories

Evolutionary patterns

Categorise risks according to "all" the characteristics they have - *DNA*



Risk Scenario	Characteristic Number
1. Liquidity challenge	25
2. Regulation changes 1	1, 15, 16, 17, 18, 19, 26, 33, 36
3. Violation of Privacy Protection	9, 10, 12, 14, 17, 20, 21, 31, 34
4. Trusted Insider Technology Risks	10, 31, 34
5. Business Continuity	12, 30, 35
6. Technology development	10, 31, 34, 35
7. Product	26, 36
8. Geographical	1, 2, 8, 18, 19, 26, 36
9. Regulation changes 2	17, 19, 36
10. Succession Planning	33
11. Model complexity	21, 22, 32
12. Convergence of Products	1, 26, 36
13. Regulation changes 3	9, 10, 34, 36
14. Poor decision making	1, 35, 37
15. Misunderstanding of risks	2, 3, 12
16. HR policies	9, 10, 12, 37
17. Long-term planning	1, 32, 33, 36
18. Tech infrastructure	30, 35, 37
19. Tax rules	16, 26, 36
20. Regulation differences	18, 26, 36
21. Tax management	26
22. Infrastructure	30, 35, 37

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## Compute cladistic tree

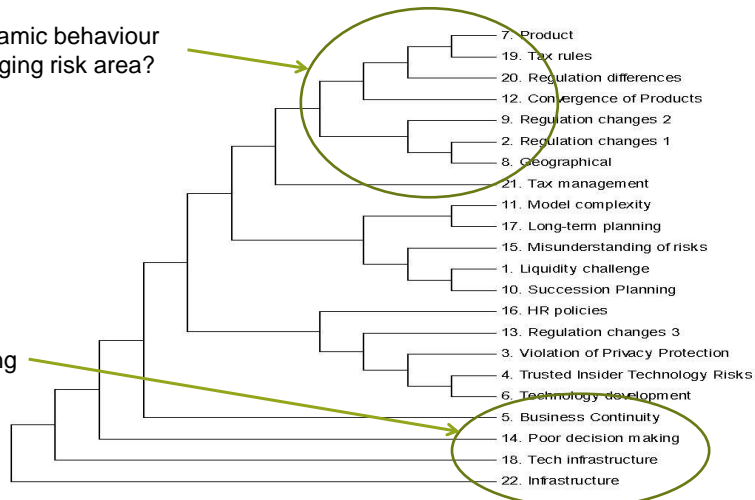
2. Anticipate potential areas of emerging risk

Under-developed stories

Evolutionary patterns

Lots of dynamic behaviour here. Emerging risk area?

"Old" risks, not changing much



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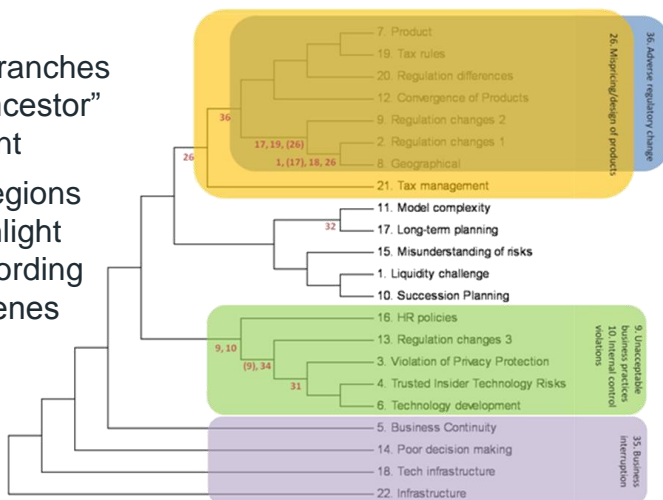
## Interpretation knowing path dependency

2. Anticipate potential areas of emerging risk

Under-developed stories

Evolutionary patterns

- Label the branches to show “ancestor” development
- Coloured regions help to highlight groups according to “early” genes
- Helps us to uncover emerging patterns



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## Looking for Information

3. Identify unusual performance signatures

Which factors are driving behaviour?

- Information Theory says that the information of an event,  $x$ , with probability  $p$  is  $I(x) = -\log p(x)$
- We can average this over a system to find out if its performance “makes sense”
- If it doesn’t then there is something going on we don’t understand – may be an emerging risk?
- Find out which drivers are causing that odd behaviour
- Need to know which factors are connected to each other and overall performance

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## Connectivity

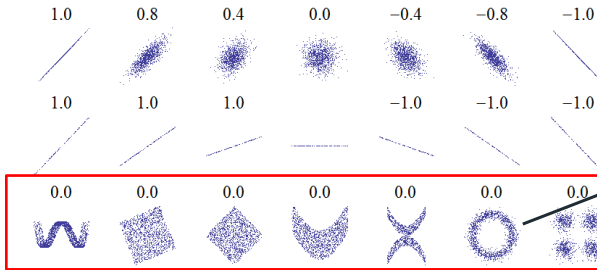
3. Identify unusual performance signatures



Which factors are driving behaviour?

- Typical measures cannot spot non-linear dependency
- ...mutual information sharing can

Different levels of correlation



### Example

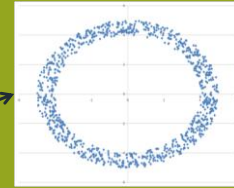
$$\Theta \sim U[0, 2\pi]$$

$$R \sim U[4, 5]$$

$$X = R \cos \Theta$$

$$Y = R \sin \Theta$$

Sample of 1000



Correlation = 0.0  
Mutual Info = 1.0

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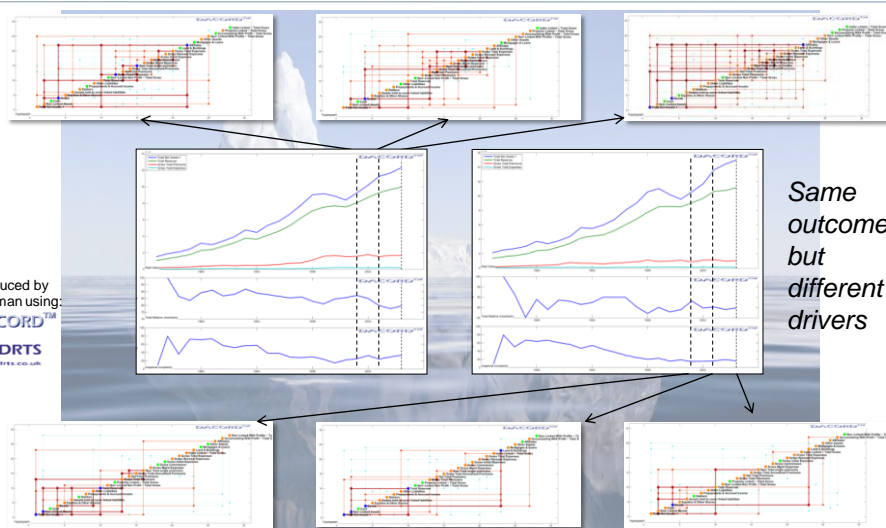
## Looking beneath the headlines

3. Identify unusual performance signatures



Which factors are driving behaviour?

Produced by  
Milliman using:  
DACORD™  
DRTS



Same  
outcome  
but  
different  
drivers

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## Modelling

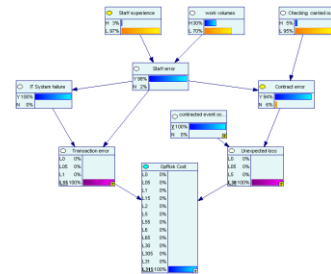
- Different types of modelling:
  - Modelling to understand behaviours
    - Examples:
      - Systems Dynamics
      - Scenarios
      - Agent Based Models
  - Modelling to estimate impact on appetite
    - Examples:
      - Bayesian Networks

## Modelling

- Can check that models match reality – information content
- Use Bayesian process to integrate new evidence (hard and soft)
- Experts know about the dynamics but find it hard to explain
- A model expressed in terms of drivers is easier to validate and update as new evidence emerges

## Quick example

- Suppose we build a simple Bayesian Network model of a particular risk scenario
- Have we captured all the key drivers?
- We can measure the outcome and the drivers of the model and check that they tell the same story
- Cognitive mapping/inference used to identify concerns with model

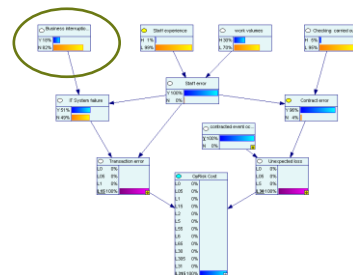


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## Quick example

- Our analysis reveals that an additional factor may be required to explain the behaviour of part of the model
- We add that new node and find that the “information” content of the model has now increased
- This confirms that we have added useful insight



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## Summary

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- Emerging risks are hard because you need to spot patterns
- Patterns are hard because of complex adaptive nature of system
- Typical tools are not powerful enough to spot subtle patterns
- Data often has information removed before storage
- But, small changes to existing framework can help:
  - See signatures of unusual behaviour early and explain it
  - Prevent you from seeing only what you are looking for
  - Leverage your knowledge better

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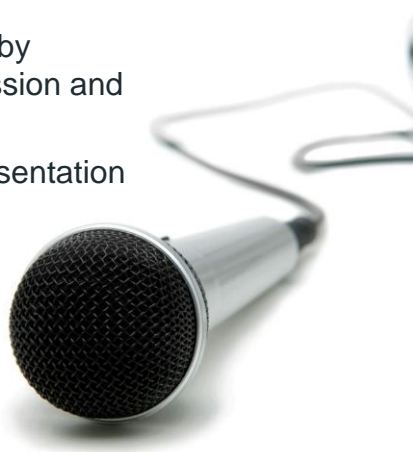
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## Questions or comments?

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The views expressed in this presentation are those of the presenter.



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