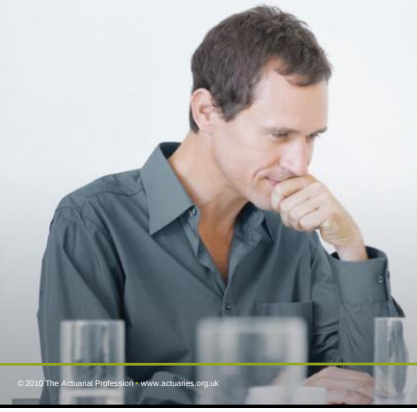
The Actuarial Profession
making financial sense of the future

Financial Crisis Puts Spotlight on ERM
Neil Cantle, Milliman



Unravelling the complexity of risk

Plan for this session

- Introduction to risk appetite and emerging risk
- Overview of systems
- Application to risk appetite
- Application to emerging risk

Introduction – Risk Appetite

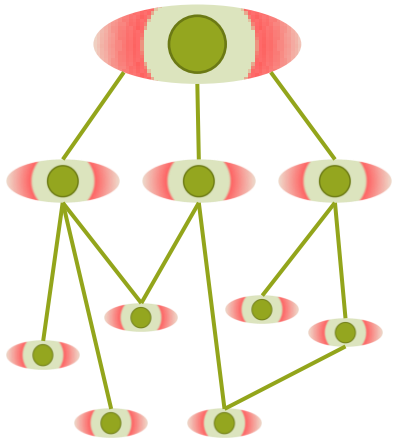
- Intuitively...
  - Looking forward, what types of risk are we prepared to take and how much?
- Practically...
  - Which risks are we prepared to accept in seeking to achieve company goals?
  - How certain do we need to be about meeting those goals?

Risk Appetite – Challenges

- Overall appetite is set
- Now have to explain how everything that happens in the business keeps within that
- ...it is properly complex

Key Question...

- How much can drivers at the bottom vary before we breach overall appetite?



Introduction – Emerging Risk

- Typical risk frameworks list out what we know or suspect
- But how can we know what we don't know...?

- "Black Swans" are metaphors for the unknowable
- However, many situations turn out to be perfectly knowable
- But somehow we miss the signs

- How do we spot the signatures of trouble early?
- ...in a robust and repeatable way?

4

Look beneath the surface

Symptoms

↓

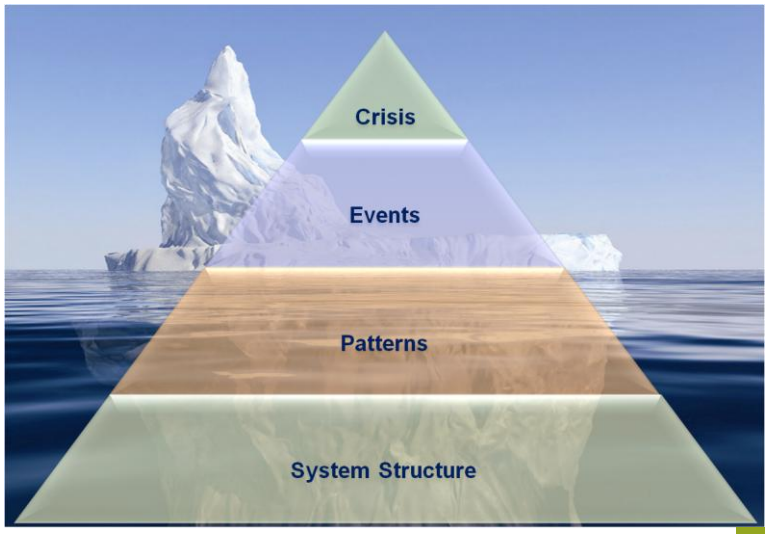
Causes

↓

Sense-making

↓

Understanding



5

Systems Thinking

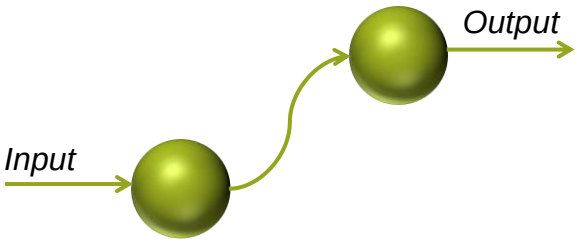
- Systems thinking is both a worldview that:
  - Problems cannot be addressed by reduction of the system
  - System behaviour is about interactions and relationships and
  - Emergent behaviour is a result of those interactions
- And a process or methodology
  - To understanding complex system behaviour
  - To see both the “forest and the trees”
  - Identify possible solutions and system learning
  - Utilises complexity science and other disciplines

Complexity and complex systems

The development of complexity science is a shift in scientific approach towards an interdisciplinary paradigm with the potential to profoundly affect business, organisations and government.

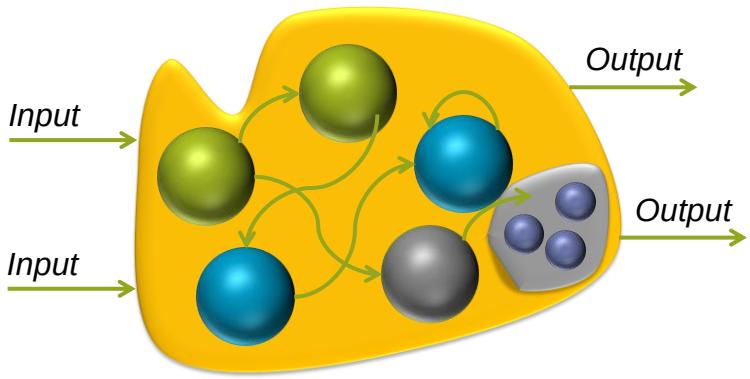
The goal of complexity science is to understand complex systems: what ”rules” govern their behaviour, how they manage change, learn efficiently and optimise their own behaviour.

What is a system ?



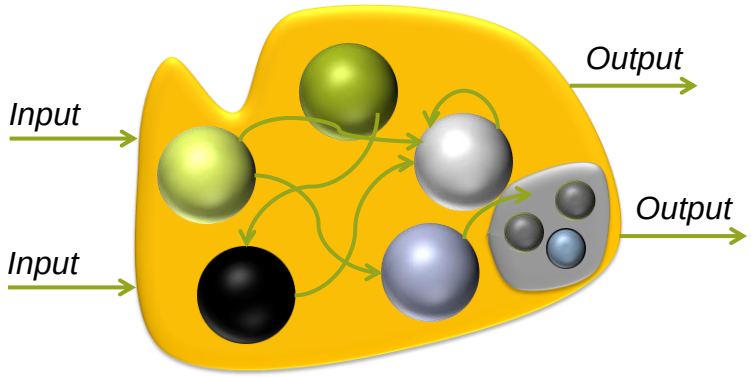
A set of components interconnected for a purpose

What is a *complex* system ?



Complex System – Feedback, subsystems, etc.

What is a complex *adaptive* system ?



Complex Adaptive System – Structure changes

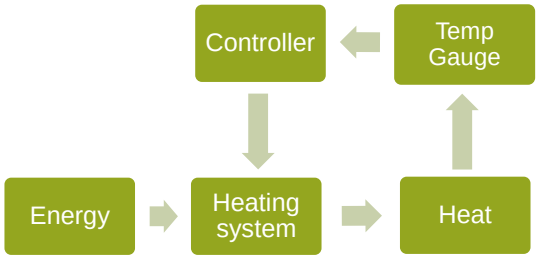
Complex Adaptive System Characteristics

- 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

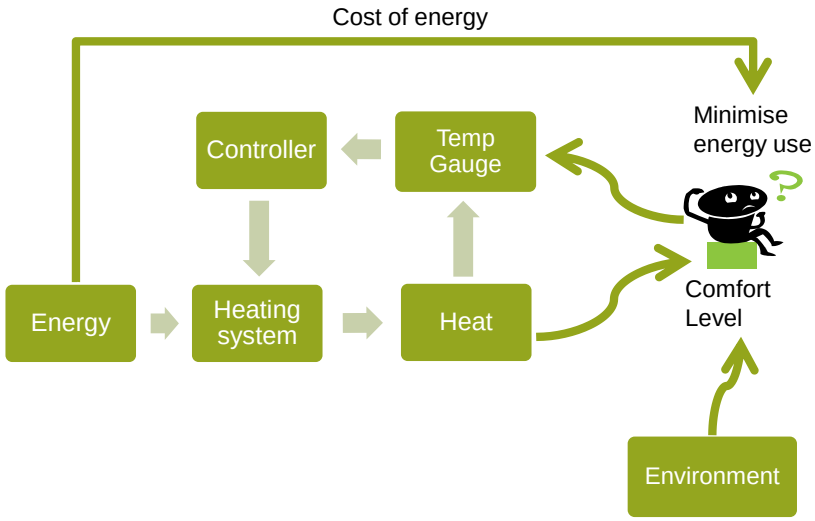
Unintended consequences

- People “understand” bits of risk, not the whole thing

Idealised heating system

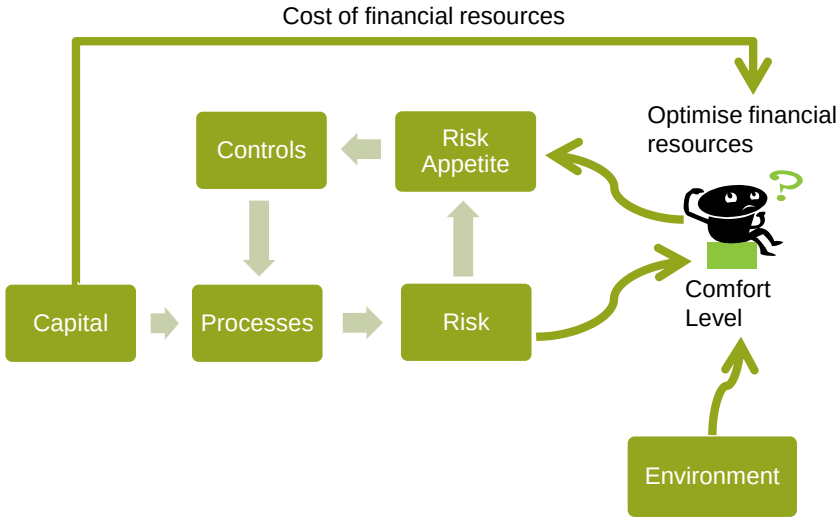


Real world heating system



14

Business as a heating system



15

Recap – Complex Adaptive Systems

- Systems theory is a structured way to describe a set of interacting components which have a purpose
- Complex adaptive systems (CAS) have defined properties
- The study of CAS is interdisciplinary – so are applicable tools
- Complex behaviour can arise from simple rules
- Emergence requires a holistic approach before studying parts
- Important to know a system's critical complexity trajectory

Relevance to Companies

- Companies are CAS because they consist of people who are:
  - Adhering to cultural norms, beliefs, principals
  - Following processes, learning, adapting, interdependent
  - Communicate, use initiative, often irrational, interact
- The industry and related companies are self-organising
- External environment is changing and impacts companies
- Emergent behaviour brings significant new systemic risks
- Evolution and history is important

The human factor

"There can no longer be any doubt that the micro assumptions of [economic] theory – the assumptions of perfect rationality – are contrary to fact. It is not a question of approximation; they do not even remotely describe the process that human beings use for making decisions in complex situations."

Herbert Simon 1979

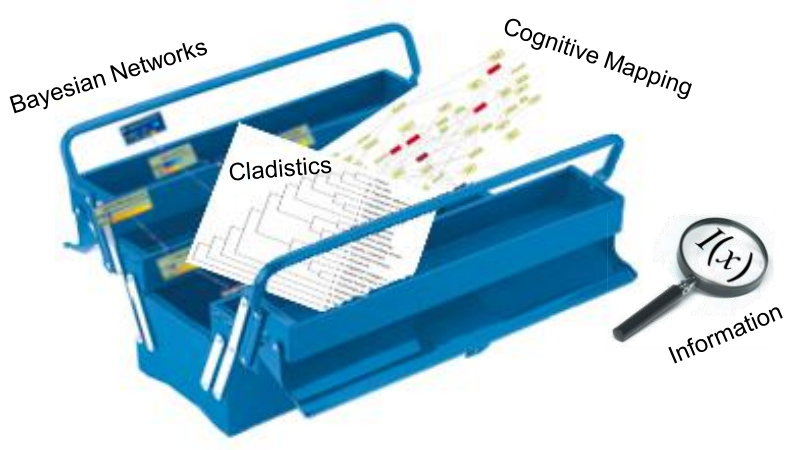
"How do humans reason in situations that are complicated or ill-defined? Modern psychology tells that as humans we are only moderately good at deductive logic, and we make only moderate use of it. But we are superb at seeing or recognising or matching patterns – behaviours that confer obvious evolutionary benefits. In problems of complication, then, we look for patterns."

Brian Arthur "Inductive reasoning and bounded rationality" American Economic Review 84 #2 (1994)

Applied to risk

- Risk is the unintended emergent property of a CAS
- Risk is a process which emerges over time from the complex interactions of many factors
- Risk has multiple-characteristics
- Risk has structure and hierarchy
- Human bias is highly prevalent in assessing risk
- Emerging risk is a function of the past system performance

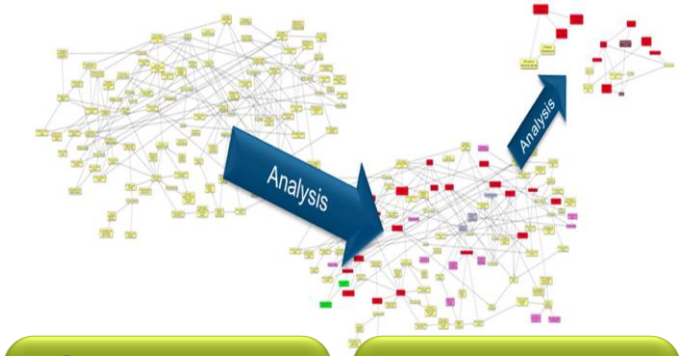
Introducing Some Tools



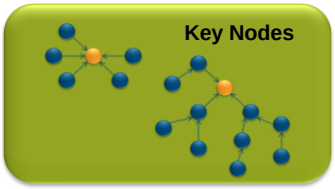
Cognitive Mapping

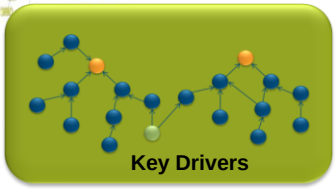
- The theories we use here are based around:
  - Personal Construct Theory (*George Kelly 1955*) – you know your environment
  - Grounded Theory (*Glaser and Strauss 1967*) – generate a theory from the research
  - Cognitive mapping (*Colin Eden, Fran Akermann and Steve Cropper 1990*) – combine multiple “theories” to form single perspective of a problem

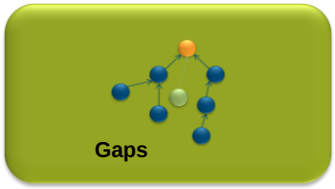
Understanding The System



Rapidly elicit highly detailed description of risk profile and implicit dynamics





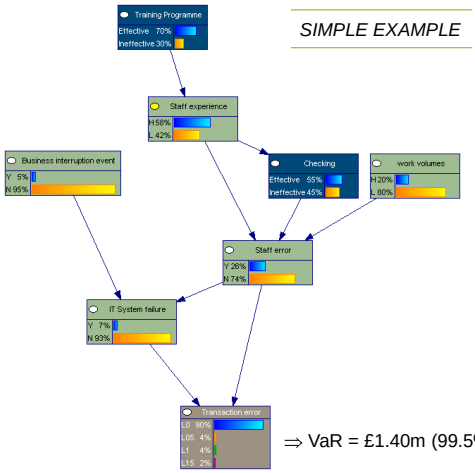


Bayesian Networks

- A visual representation of how outcome is caused
- Conditional probabilities describe state of each node
- Use Bayes' Theorem to propagate evidence
- Combine hard and soft data
- Particularly powerful at "what if" analysis
- Can capture highly non-linear behaviour
- Explicitly capture dependency

Bayesian Networks

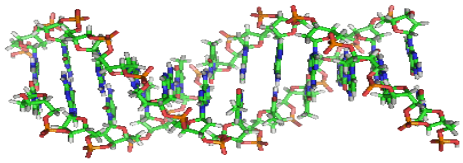
- Permits more transparency and better engagement from business
- Combinations of earlier tools can help to determine relevant key drivers of risk outcome



⇒ VaR = £1.40m (99.5%)

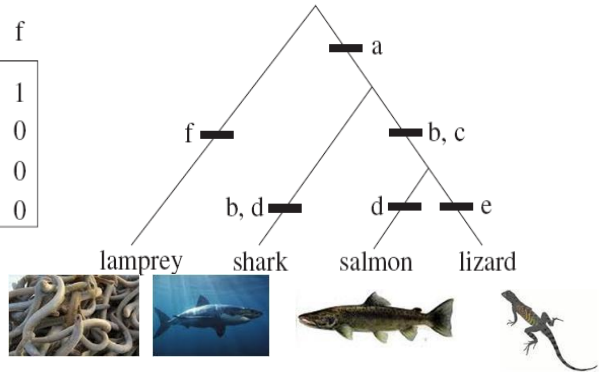
Risk evolution

- Risks have a unique sequence, very much like a DNA
- Collective risk systems evolve and co-evolve
- The path-dependency is an important aspect of a risk
- A risk's evolutionary progression can be analysed
- Predictions made about how risks might develop
- It is a efficient way to classify and manage risks



Cladistics a simple example

	a	b	c	d	e	f
lamprey	0	0	0	0	0	1
shark	1	1	0	1	0	0
salmon	1	1	1	1	0	0
lizard	1	1	1	0	1	0



(a) paired fins, (b) jaws, (c) large dermal bones, (d) fin rays, (e) lungs, and (f) rasping tongue

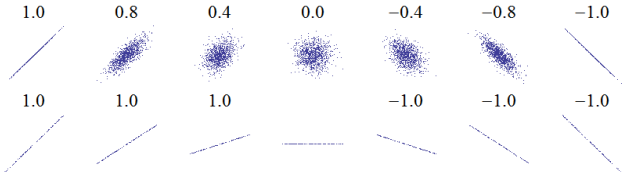
Entropy/Uncertainty

- Measuring the information content (entropy) of system tells us whether performance is making sense
- Information $I(x)$ = - log $p(x)$
- Entropy = average information = -Σ $p(x)$ log $p(x)$
- Intuition – high entropy = high uncertainty:
  - Impossible event ($p(x)$=0) is surprising ($I(x)$ = ∞)
  - Certain event ($p(x)$=1) is not interesting ($I(x)$ = 0)
- Through understanding your “system”, identify relevant variables to monitor
- If their information content is high/volatile you need to know why

Non-linear relationships

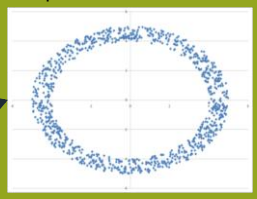
- Are we still talking?

Different levels of correlation



Example
Θ ~ U[0,2π]
R ~ U[4, 5]
X = R cos Θ
Y = R sin Θ

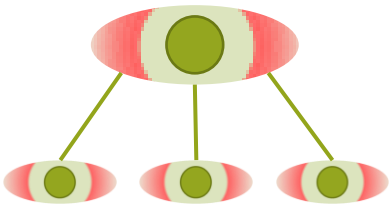
Sample of 1000



Correlation = 0.0
Mutual Info = 1.0

Risk Appetite

- Understand how the risks work in your business
- Use map to decide your high level appetite risk expressed in terms of corporate objectives
- Then explain how these outcomes might occur



Risk Appetite

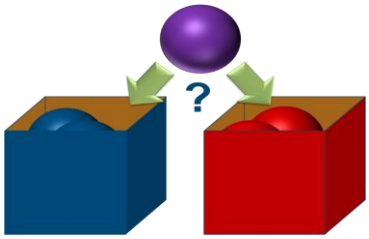
- Propagation of limits through risk appetite framework can be done using Bayesian Networks
- Helps us to understand how to resolve non-linear relationships
- Permits expert views to be slowly replaced by data
- Can validate the likely impact of limit breaches

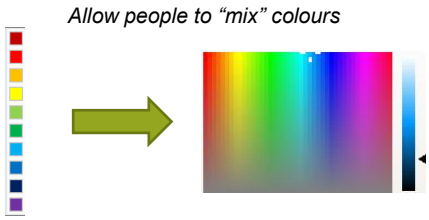
Emerging Risk

- Describe system with Cognitive Maps
- Gaps may signify emerging risks
- Map gives clues about which factors might be related

Don’t oversimplify

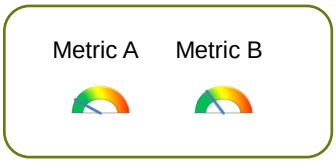
- Looking for patterns needs information
- Many attempts to monitor risk throw that away at outset
- Don’t guess in advance what you expect to see
- Need a “model-free” approach to see emergence





A Scenario

- Consider part of a typical risk dashboard



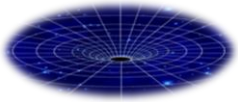
- Suppose the metrics relate to different business areas
- There is no reason to think they are connected
- Consider how this might evolve

A Scenario

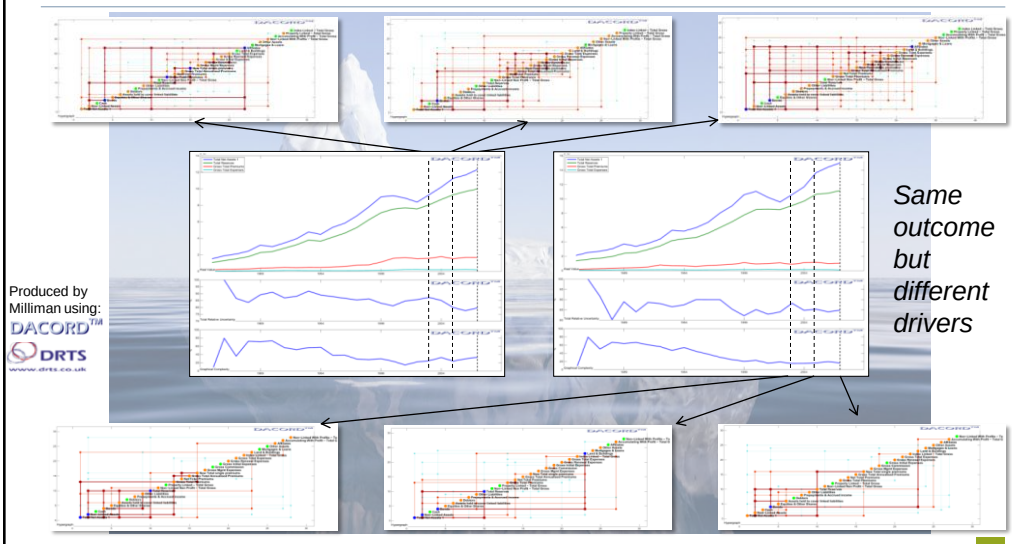
- Suppose that A and B actually both depend on a common factor, C
- The influence of C is greater on B than on A
- Over time our dashboard shows a pattern that we need to be able to spot
- Here we see a trend which is hard to spot until it is too late

t	Metric A	Metric B
1		
2		
3		
4		

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



Looking beneath the surface



Analysing Risks Using Multiple Characteristics

- Determine risk characteristics (example)

Strategic	1	Strategy		
Market	2	Asset allocation	3	Concentration
	4	Other		
Credit	5	Investments	6	Reinsurance
	7	Other		
Insurance	8	Insurance		
Operational	9	Unacceptable business practices	24	Mishandling of investment transactions
	10	Internal control violations	25	Liquidity needs unmet
	11	Project failures	26	Mis-pricing/design of products
	12	Communication failure	27	Mishandling of underwriting
	13	Brand abuse	28	Inadequate reinsurance
	14	Violation of reporting regulations	29	Inadequate claim management
	15	Solvency	30	IT systems failure
	16	Violation of disclosure requirements	31	Unauthorized access to data
	17	Customer due diligence	32	Inadequate functionality
	18	Product compliance	33	Inappropriate skills
	19	Mis-selling	34	Staff act outside authority/competence
	20	Mishandling data	35	Business interruption
	21	Incomplete documentation	36	Adverse legal/regulatory change
	22	Systemic reporting error	37	Other
	23	Mishandling of complaints		

36

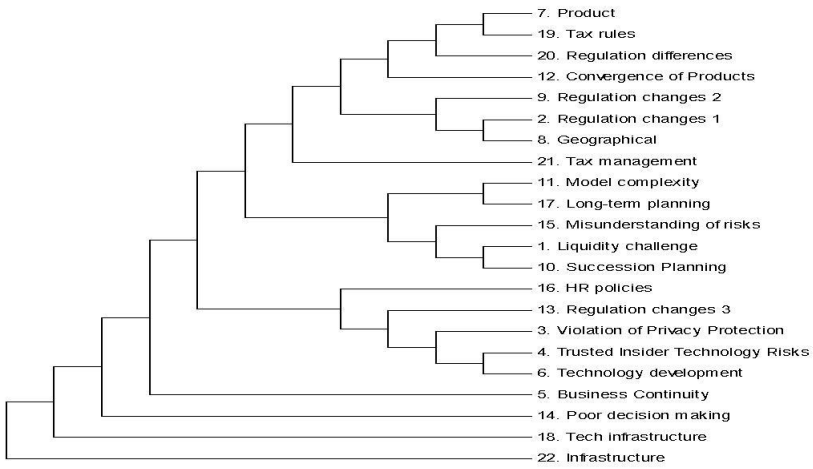
Analysing Risks Using Multiple Characteristics

Now categorise risks according to “all” the characteristics they have

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

37

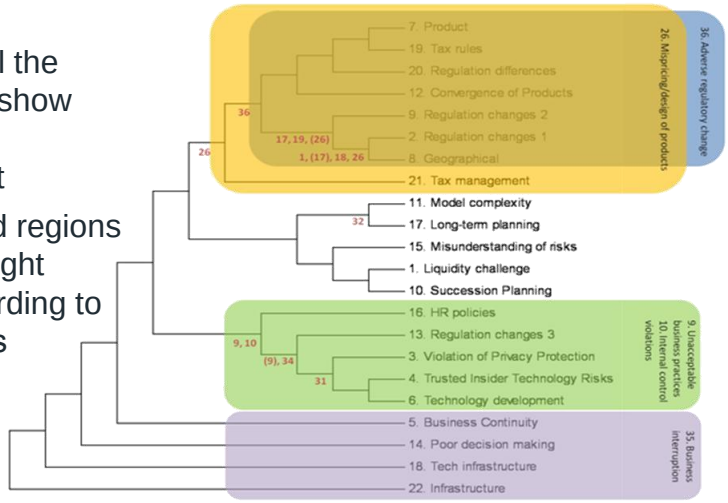
Compute cladistic tree



38

Interpretation knowing path dependency

- We can label the branches to show "ancestor" development
- The coloured regions help to highlight groups according to "early" genes



39

Summary

- We can frame companies/industries as complex adaptive systems
- Complex adaptive systems give out signals
- Using the right scientific tools you can spot them
- Interactions are the important part
- Early warnings are possible
- Don't throw away information – look for patterns
- Try not to guess what is going on before you look at the data
- Evolution is informative about possible future trends
- Improved understanding facilitates better models/management

Questions or comments?

Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

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