

# Complexity and what it means for policy design, implementation and evaluation

A CECAN Evaluation and Policy Practice Note for policy analysts and evaluators



"...it is complex interventions that present the greatest challenge for evaluation and for the utilization of evaluation, because the path to success is so variable and it cannot be articulated in advance." —Patricia Rogers<sup>1</sup>

Complexity is a concept that has major implications for policy development, implementation and evaluation. In day-to-day use, the word complexity is often used as a synonym for issues that are considered challenging, difficult or intractable. Paradoxically, complexity is quite a simple concept to grasp and once understood it can change people's way of looking at and responding to policy challenges. Managing and responding to complexity demands different approaches building on traditional policy analysis and evaluation methods.

Complexity is present in many social and natural systems and in the major policy challenges we need to address. It is also an important factor in accounting for the success or failure of policies. Making this complexity explicit can result in better and more effective policy development and delivery. Ignoring complexity risks policies that are ineffective, fail or behave in unexpected ways, all of which waste limited taxpayers' resources.

This briefing<sup>2</sup> explains what complexity science and systems thinking means for people developing and delivering policy. It also introduces a common language and set of symbols to help frame thinking, conversations and action on complexity.

## What is a 'system' and what makes a system 'complex'?

A 'system' implies a certain level of organisation and coordination of components or elements that interact with each other within some defined spatial and temporal boundary to create a unified whole that has both structure and function.

There are many definitions of complexity, but systems are generally seen as complex when:

- they have many diverse, interacting components;
- there are non-linear and non-proportional interactions between the components;
- there is adaptation or learning by the components in response to change.

All social systems are complex systems. Examples include ecosystems, economies, societies, cities, industrial networks, and the interconnections between them.

The Appendix 'Properties of complex systems' (included as a separate sheet to this briefing note) defines eleven properties of complex systems that have particular relevance to policy making and policy evaluation. These give policy makers, analysts, evaluators and wider stakeholders a common language to help frame thinking, conversations and action on complexity.

## What are the implications of complexity for policy making?

The behaviour of complex systems is difficult to predict. They may for example:

- be in a state of continual change;
- be resistant to change, and
- evolve and interact with other systems in unexpected ways.

It is this unpredictability that can make complex systems particularly challenging, both in the implementation of effective policy interventions and for their evaluation. Treating a system or policymaking as deterministic, i.e. that the same outcome will result from repeating the same action or intervention, is inappropriate when complexity is present.

In complex situations, policy interventions may:

- result in responses that are non-linear, for example, varying widely across the system or differing from those expected or predicted;
- lead to unexpected indirect effects at points remote from the intervention;
- have outcomes that depend on what happened before, so that the order in which interventions are made makes a difference;
- have different outcomes in different contexts or when delivered in slightly different ways;
- be viewed differently by different actors within the system.

### Examples of non-linearity

- The energy of a moving object is not proportional to its speed. The relationship is non-linear. This means, for example, that the braking distance of a car at 30 mph is more than twice that at 20 mph;
- A new product may be slow to take off, but after a certain point, sales accelerate before slowing again as the market becomes saturated.

### Examples of unexpected indirect effects

- The interaction between changing agricultural practice (e.g. increased winter planting), climate change (e.g. more extreme rainfall) and housing policy (e.g. building in floodplains) may have decreased resilience to flooding;
- US initiatives to promote biofuel production by increasing ethanol production from maize, combined with financial deregulation leading to increased investor speculation on commodity markets, may have driven up global food prices leading to social unrest including the "Arab Spring".

## What factors lead to greater complexity?

Even a relatively straightforward policy intervention can have some elements of complexity. However, the complexity is greatly increased when:

- the problem being addressed has multiple causes and potential effects;
- the environment in which it is being introduced is, itself, in a state of flux, or there are already other initiatives taking place;
- the policy is being delivered at more than one level, or involves a range of different interventions;
- there are large numbers of actors (organisations or individuals) who need to be engaged in delivery of the intervention, increasing the likelihood of conflicts of interest;
- the issue transcends established boundaries and cuts across different areas of policymaking and governance.

## How can evaluation help policymakers address these challenges?

Policy interventions in complex domains will often need to evolve over time in response to the way in which the system is adapting. In these situations, evaluation activities are invaluable, supporting flexible and adaptive management of interventions. Evaluation can be particularly helpful when:

- appraisal and evaluation become merged into a continuous process of learning and policy evolution;
- evaluation commissioners, clients and providers challenge the usual approaches and explore new ideas and methods so that:
  - » evaluative activities become integral to the implementation of the intervention, and analysis is carried out as part of policy design;
  - » evaluations explore not only how well the intervention is working and how it can be improved, but also question whether quite different approaches might have produced better results.
- governance and management of evaluations are flexible so they can respond to emergent changes to the intervention, or to system responses;
- key stakeholders are included in planning and “mapping” of the intervention to help anticipate complexity;
- expectations and assumptions are carefully managed so that:
  - » stakeholders with different views on the policy, the complexity and the appropriate evaluation strategies are engaged effectively;
  - » commissioners and other key stakeholders accept that the level of quantitative rigour and certainty of outcome may be limited, even when using sophisticated evaluation methods;
  - » this level of engagement is maintained throughout the evaluation, especially when key individuals leave or join the programme.

## References

- 1 Rogers, P.J., 2008. Using programme theory to evaluate complicated and complex aspects of interventions. *Evaluation*, 14(1), pp.29-48.
- 2 This briefing is based on *HM Treasury Magenta Book 2020 Supplementary Guide Handling Complexity in Policy Evaluation*, to which CECAN contributed. [www.gov.uk/government/publications](http://www.gov.uk/government/publications)
- 3 CECAN, *Handling Complexity in Policy Evaluation – Magenta Book 2020 Supplementary Guide* [www.cecan.ac.uk/resources](http://www.cecan.ac.uk/resources)
- 4 Government Statistical Service (2017), *Statistical Press Notice: Monthly Delayed Transfers of Care Data*, England, March 2017

## Acknowledgements

Joanna Boehnert, Alex Penn, Pete Barbrook-Johnson, Martha Bicket, and Dione Hills *The Visual Representation of Complexity: definitions, examples and learning points*. [www.cecan.ac.uk/resources](http://www.cecan.ac.uk/resources)

Images in the Appendix 'Properties of complex systems' have been adapted from those Dr J Boehnert created for CECAN and are published under a Creative Commons license: Attribution-NonCommercial-ShareAlike 4.0 International.

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The Centre for the Evaluation of Complexity Across the Nexus (CECAN) is a £3m national research centre hosted by the University of Surrey, which brings together a unique coalition of experts to address some of the greatest issues in policy making and evaluation.

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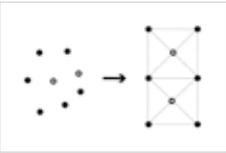
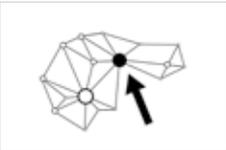
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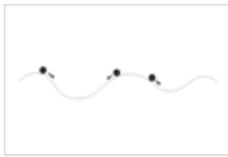
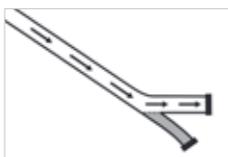
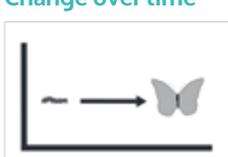
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## Properties of complex systems

Property	Definition	Examples
<p><b>Adaptation</b></p> 	<p>Components or actors within the system can learn or evolve, changing how the system responds to interventions as they are applied.</p>	<ul style="list-style-type: none"> <li>species evolve in response to change in their environment. For example, bacteria evolve resistance to antibiotics;</li> <li>people communicate, interpret and behave strategically to anticipate future situations.</li> </ul>
<p><b>Emergence and self-organisation</b></p> 	<p>New, unexpected, higher-level properties can arise from the interaction (and self-organisation) between the components (individuals, groups or organisations) within a system. These properties are said to be emergent if they cannot easily be predicted from the properties of the lower level components.</p>	<ul style="list-style-type: none"> <li>the resilience of an ecosystem to external change is an emergent property of the interactions between its species;</li> <li>emergent properties can be seen in the formation of social movements, social norms and new markets, or even in the formation of a queue;</li> <li>policies often aim to encourage emergence by, for example, imposing tariffs to help markets form; economic policy relies on emergence in the form of the “invisible hand”; regulation may also be needed to protect us from emergent phenomena.</li> </ul>
<p><b>Unexpected indirect effects</b></p> 	<p>Long causal chains within systems, generated by multiple interactions between components, can mean that intervention or change in one part of the system can lead to unexpected change in another, seemingly remote, component.</p>	<ul style="list-style-type: none"> <li>reintroduction of wolves to Yellowstone led to revegetation, more beavers and changing river flow, as elk avoided grazing in valleys in response;</li> <li>the interaction between changing agricultural practice (increased winter planting), climate change (more extreme rainfall) and housing policy (building in floodplain) may have decreased resilience to flooding.</li> </ul>
<p><b>Feedback (and feedback loop)</b></p> 	<p>Feedback occurs when the result or output of a process influences the input into the next iteration of the same process. This can happen either directly or indirectly and can both increase and accelerate or suppress changes taking place.</p>	<ul style="list-style-type: none"> <li>a crowd may stampede if the panic of one individual spreads to others, creating panic and a rush to escape throughout the crowd (example of positive feedback);</li> <li>people increased their cigarette consumption when nicotine levels were reduced, a negative feedback stabilising nicotine consumption.</li> </ul>
<p><b>Levers and hubs</b></p> 	<p>Some components of a system may have a disproportionate influence over the whole because of the structure of their connections. Their activity may help to mobilise or slow down change, their presence or absence make a system vulnerable to disruption.</p>	<ul style="list-style-type: none"> <li>if a ‘keystone’ (highly influential, but low abundance) species in an ecosystem becomes extinct, there may be cascading extinctions amongst connected species;</li> <li>a well-connected individual or organisation may become a major obstacle to change through vetoing or blocking this (e.g. the NRA in USA in relation to gun regulation).</li> </ul>
<p><b>Non-linearity</b></p> 	<p>A system behaving in a non-linear fashion is one where the effect of inputs on outcomes is not proportional: small changes may lead to large effects in one situation, but have little impact in another. Sudden large-scale changes, or reverses in direction, may occur despite small or consistent changes in inputs.</p>	<ul style="list-style-type: none"> <li>a species’ population size does not increase without bounds as food sources increase, but will plateau as it is limited by other factors such as build-up of wastes or lack of space;</li> <li>in a weight loss programme, it was found that a six-week programme had a significant impact, but a three-week programme with similar content had minimal impact (i.e. its benefits were not half of those of the 6-week programme).</li> </ul>



Property	Definition	Examples
<b>Domains of stability</b> 	<p>Systems may have more than one relatively stable state (called attractors in complexity science) and these may change as the context evolves. Complex systems will tend to gravitate towards these states, and then remain in them until some external change causes significant perturbation.</p>	<ul style="list-style-type: none"> <li>the planet may exist stably with or without ice caps, but not at intermediate states; as the polar caps shrink, less sunlight is reflected and warming accelerates, and vice versa as ice cover increases;</li> <li>the level of public transport provision in a suburban area may be stable either at a very low level, with few, marginalised, users or at a high level, at which the service makes money, is reliable and its use becomes habitual; providing support for an insufficient level of transport for an insufficient time may not generate the positive feedbacks needed to stabilise high provision.</li> </ul>
<b>Tipping points</b> 	<p>Closely linked to 'domains of stability', tipping points refer to the threshold beyond which a system goes through rapid change into a different state. The system can slide rapidly into another state, a change that may be very difficult to reverse.</p>	<ul style="list-style-type: none"> <li>a forest ecosystem may be stable over a large range of average rainfall, but may rapidly become desert if rainfall decreases beyond a certain threshold;</li> <li>the gradual, then sudden, gentrification of a neighbourhood, changing its demographics and character rapidly;</li> <li>social media 'storms' in which minority opinions become the majority.</li> </ul>
<b>Path dependency</b> 	<p>The future development of a complex system depends on its history - how it got to its present state - as well as where it is currently. The order in which policy instruments or decisions are introduced may affect their cumulative impact.</p>	<ul style="list-style-type: none"> <li>evolution is a highly path-dependent process. Organisms cannot radically change from their predecessors but change and modify themselves by mutations of adaptations that already exist. This is partly why evolution seldom finds optimal solutions;</li> <li>the health over the whole of the lifespan of an individual can be influenced by the diet and wellbeing of their parents and the conditions under which they were born and brought up (one of the causes of health inequality).</li> </ul>
<b>Openness</b> 	<p>An open system is a system with many links and connections into its wider environment, which means that it can be powerfully affected by changes happening elsewhere. The links may take many forms including the exchange of information, inflow and outflow of materials or energy, or of individuals and social groups and money.</p>	<ul style="list-style-type: none"> <li>invasive species such as grey squirrels or Himalayan Balsam arrive in ecosystems and out-compete similar native species. This may or may not have profound consequences for ecosystem function depending on the differences between the behaviour of the original and the new species;</li> <li>a 'delayed transfer of care' occurs when a patient is ready to leave a hospital but is still occupying a bed. While the NHS is responsible for the majority of delays, the social care system is responsible for a substantial proportion: 37% at the beginning of 2017/18.<sup>4</sup> Longer stays in hospital can affect a patient's health and impact waiting times in A&amp;E departments and for planned surgery.</li> </ul>
<b>Change over time</b> 	<p>Complex systems develop and change their behaviour over time. This is due to their openness and the adaption of their components, but also the fact that these systems are usually out of equilibrium and are hence continuously in a process of change.</p>	<ul style="list-style-type: none"> <li>social norms, customs and cultures change radically over time and can never be said to have reached an end point. On a small scale, a local community partnership changes direction when one of the constituent partners changes its policies;</li> <li>new technological and social developments constantly drive policy change. For example, social media, the mass availability and use of individuals' data within a globalized economy have led to new behaviours and business models, with huge policy and legal implications.</li> </ul>