CECAN Webinar:

How can System Dynamics support policy evaluation?

Wednesday 9th September 2020, 13:00 - 14:00 BST

Presenter: Jonathan Nichols, Environmental Consultant; Chair: Ben Shaw, Deputy Director (CECAN)

Welcome to our **CECAN Webinar**.

All participants are muted. Only the Presenters and CECAN Chair can speak. The webinar will start at **13:00 BST.**

Jonathan will speak for around 45 minutes and will answer questions at the end.

Please submit your questions at any point during the webinar via the question box in the Zoom webinar control panel.

Today's webinar will be recorded and made available on the CECAN website.

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How can System Dynamics support policy evaluation?

Jonathan Nichols | CECAN Fellow



Key questions

- 1. What is System Dynamics?
- 2. How can System Dynamics help tackle some of the challenges of policy evaluation in complex systems?
- 3. What insights has CECAN's research using System Dynamics generated so far?

1. What is System Dynamics?

System Dynamics

A method ...

... for developing models (diagrams and computer simulation models) ...



... to help us learn about dynamic complexity and understand the sources of policy resistance ...



... and design more effective policies.



(Sterman, 2000)

Origins

- **Grounding:** nonlinear dynamics and feedback control systems theory developed in mathematics, physics, and engineering
- Draws on: social science, economics, cognitive and social psychology
- **Developed:** 1950's and *Industrial Dynamics* to help corporate managers improve understanding of industrial processes
- Early applications: "nexus" problems in the 1960's and 1970's with Urban Dynamics and The Limits to Growth









Thinking in Systems

- Dynamic perspective: problems are manifest as patterns over time
- Modelling: understand the structure underlying problematic behaviours
- **Process:** refine our *mental* models to develop new policies



Why model ...?



(Zagonel, 2002)

Why model ... with System Dynamics?

The foundation of systems thinking and system dynamics [...] is often implicit or even ignored: it is the "endogenous point of view" (Richardson, 2011)



System Dynamics modelling

Uncover endogenous sources 1. of problematic behaviour



• Build and test dynamic



2. Identify leverage points for policy intervention



• Analyse how feedback loops

interact over time (simulation)



3. Design policies and test their effectiveness

 Build in policy structures and run virtual experiments



Causal loop diagrams (CLDs)



What:

- Qualitative model showing causal connections between variables
- Depicts the influence of variables on each other (+/-)
- Highlights feedback loops (R/B)

Good for:

- Communicating essence of a dynamic hypothesis
- Eliciting and communicating mental models of individuals or teams



Stock and flow diagrams (SFDs) + simulation software



What:

- Quantitative model where relationships between variables are represented mathematically
- Distinguishes stock, flow, intermediary and exogenous variables

Stock and flow diagrams (SFDs) + simulation software



Good for:

- Running virtual experiments for different scenarios into the past and/or future
- Understanding the policy implications of accumulation, delays and shifts in feedback loop dominance over time
- Identifying leverage points in a system to designing and test policy structures
- Generating outputs which can contribute to wider policy appraisal processes e.g. calculating NPVs/BCRs



Total population

Infectious contact frequency



More than modelling

- ✓ Participation: rich participatory modelling and facilitation practices to incorporate stakeholder expertise and promote model ownership
- Community: active international community of practitioners and researchers, System Dynamics Society and conference
- Case history: mature and constantly expanding casebook of applications in both corporate strategy and public policy







Policy contributions



(Meadows et al., 1972)



• Munro Review: child protection system in England (Lane *et al.*, 2016)



• COVID-19 response: Kent and Medway health system

(Whole Systems Partnership, 2020)

Key message 1

System Dynamics is a mature, model-based policy design and evaluation method 2. How can System Dynamics help tackle some of the challenges of policy evaluation in complex systems?

Policy evaluation

• Counterintuitive behaviour of social systems:

- more roads, more traffic, need more roads
- more technology, less leisure
- more pesticide, more pesticide needed
- more antibiotics, more virulent pathogens
- Policy Evaluation: understand what works, why (or why not) and for whom (HMT, 2020a)





Complex systems

• Properties make them especially counterintuitive ...

- Change over time (dynamic complexity)
- Feedback
- Emergence
- Non-linearity
- Levers and hubs
- Path dependency
- Domains of stability and tipping points
- Multiple perspectives
- Difficult to communicate

• ... and intensify challenges for evaluation

(HMT, 2020b)



See Magenta Book 2020 Supp Guide

Handling complexity

• System Dynamics has features that can handle ...

- Change over time (dynamic complexity)
- Feedback
- Emergence
- Non-linearity
- Levers and hubs
- Path dependency
- Domains of stability and tipping points
- Multiple perspectives
- Difficult to communicate
- ... and can help tackle these challenges for evaluation



SD modelling language and analysis

Participatory modelling/GMB and visual tools, interfaces

Key message 2

System Dynamics can support policy evaluation by:

a) enabling users to understand how the properties of complex systems promote or hinder policy success

Enable learning to improve policy making

The Policy Cycle



- "Appraisal and evaluation are essential activities at all stages of the policy development cycle"
- "Evaluation should inform thinking throughout the ROAMEF cycle- before, during and after implementation"
- Evaluation as a practice

SD and the policy cycle

Feedback

What have we learnt? How will we

use these results in future?

Evaluation

Research and analysis to answer:

Did the intervention work as

expected? What was the impact, on

who and why? Was it cost-effective?

- Use learning to improve dynamic hypothesis
- Inform scenarios to test model/policy
- Interpret model structure to understand drivers of policy success or failure
- Use model outputs to assess cost effectiveness

• Use data to test/calibrate model

 Use model structure to understand reported results

Rationale Why is govt intervening? What is the problem govt is trying to solve? What does the evidence say about this problem?

Objective

What would success from the intervention look like? What metrics can we use to measure success?

Appraisal

What are the options for intervening? What is the evidence on the likely effectiveness and costeffectiveness of these options?

Monitoring

Data collection to answer: did we do what we said we would do? How are our success metrics changing over time?

(Adapted from HMT, 2020a)

- Identify problem variables and behaviour over time
- Build dynamic hypothesis (model) using available evidence
- Test model to understand which structures drive behaviour / gaps
 - Define desired behaviour of problem variables (SMART)
 - Define desired behaviour of non-target variables
 - Test model to identify leverage points for intervention
 - Design and test intervention structures in model using simulation
 - Include relevant appraisal structures in model to enable integration with other tools e.g. CBA/BCRs

SD and when evaluation happens

- **Before:** design to leverage
- During: track and adapt
- After: look back to learn



Key message 2

System Dynamics can support policy evaluation by:

- a) enabling users to understand how the properties of complex systems promote or hinder policy success
- b) delivering complex systems insights throughout the policy cycle as a "ready to go" complexity toolkit

Enable learning to improve policy making

evaluation as

Support

a practice

3. What insights has CECAN's research using System Dynamics generated so far?

Fellowship 2019









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The problem

Soil degradation is leading to a loss of valuable ecosystem services



The ambition

"By 2030 we want all of England's soils to be managed sustainably, and we will use natural capital thinking to develop appropriate soil metrics and management approaches" (DEFRA, 25 YEP)

"A programme of investment in natural capital by the private and public sectors is required to deliver the Government's 25 Year Environment Plan ambition" (NCC, 2017)



The challenge

The dynamic relationships between soil health and economic value are unclear



Policy resistance?

Research objectives

Develop a dynamic understanding of the problem to identify policy implications

- **1.** Identify dynamic structures underlying soil natural capital degradation in England, highlighting dynamics linking soil health to systems of financial investments and incentives.
- 2. Use these dynamic structures to identify opportunities and limitations for the effectiveness of natural capital investments in regenerating soils in England.





Synthesised existing knowledge in a model, then used it as a laboratory



Problem insight

Balancing feedback drives the behaviour of the SOC indicator



—— Best Case Hoosfield Manured Annually

Policy insight

Investment can introduce reinforcing feedback ... but biology rules



Policy implications

Initial conditions are important



Future contributions

Refine dynamic hypothesis with experts and stakeholders



Model as policy "boundary object"



Complexityappropriate evaluations of soil health programmes

Natural capital investment appraisal tool

Market research



Engaging private institutions



CECAN's research using System Dynamics has generated the following insights so far:

- a) Achieving 25YEP targets is subject to the dynamic complexity of natural capital stock management
- b) Natural capital investments could transfer returns from healthy soils to restoring degraded ones





Opportunities ahead

- **1. Methodological cross-pollination:** other methods can learn from SD practice and vice versa e.g. PSM and GMB
- 2. Overcoming application challenges: understanding barriers and selling the "opportunities of complexity"

(see Barbrook-Johnson et al., 2020)



Find out more ...

- Community and learning
 - System Dynamics Society and online course catalogue
 - Operational Research Society
- Books
 - Meadows (2008) Thinking in Systems
 - Sterman (2000) Business Dynamics
 - Meadows et al. (1972) Limits to Growth
 - Vennix (1996) Group Model Building
- Papers (selected examples)
 - Gerber (2016) <u>https://doi.org/10.3390/su8101036</u>
 - Lopes & Videira (2017) <u>https://doi.org/10.1016/j.ecoser.2017.09.012</u>

Thank you

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Software options

- Vensim Personal Learning Edition (PLE) free <u>https://vensim.com/vensim-personal-learning-edition/</u>
- iseesystems https://www.iseesystems.com/store/products/
- More info on software from the SD Society <u>https://www.iseesystems.com/store/products/</u>