SYSTEMS THINKING AND DYNAMICS

System Dynamics

Forrester · Sterman · Meadows

PAPER 02 / 03

A Furtherance reference compendium on the intellectual traditions behind organisational design, leadership, execution, and culture.

IN THIS PAPER

The foundations describe systems qualitatively; this paper makes them quantitative. It covers system dynamics – the modelling of feedback, stocks, flows and delays that produce counter-intuitive behaviour. The question it answers: why do well-intentioned interventions so often fail, and how can structure be modelled to predict it?

Forrester founded the discipline and showed social systems behave counter-intuitively; Sterman demonstrated that people systematically misperceive feedback; Meadows made the field accessible and identified where in a system to intervene for greatest effect.

Jay Forrester 1918–2016

The founder of system dynamics · MIT

CORE THESIS

Complex systems are governed by **feedback loops**, **stocks and flows**, and **delays** – and these produce behaviour that is **counter-intuitive**, so that sensible-looking policies often make things worse. Simulating the structure reveals what intuition misses.

FRAMEWORK

Building block	Role
Stocks and flows	Accumulations and the rates that change them
Feedback loops	Reinforcing (amplifying) and balancing (stabilising)
Delays	Lags that cause overshoot and oscillation
Policy resistance	Systems push back against well-meant interventions

METHODOLOGY

Computer simulation of feedback systems, from industrial to urban to global models.

SIGNIFICANCE AND CRITIQUE

Created system dynamics and demonstrated the counter-intuitive behaviour of social systems. The critique: models are sensitive to assumptions, and his global models (behind Limits to Growth) remain controversial.

John Sterman Business Dynamics, 2000

System dynamics · the misperception of feedback · MIT

CORE THESIS

People are **poor at understanding dynamic systems**: we misperceive feedback, underestimate delays, and fail to reason about accumulations. This “misperception of feedback” explains policy resistance and phenomena like the supply-chain **bullwhip** – and rigorous modelling is the corrective.

FRAMEWORK

Concept	What it shows
Misperception of feedback	We reason poorly about loops and delays
The beer game	Small demand changes amplify wildly up the chain
Stock-flow failure	People confuse rates with accumulations
Management flight simulators	Virtual worlds let managers learn dynamics safely

METHODOLOGY

Modelling combined with controlled experiments on how people (mis)understand dynamics.

SIGNIFICANCE AND CRITIQUE

The leading modern system-dynamicist, with strong experimental evidence that we misjudge dynamic behaviour. The critique: building and validating models is demanding and resource-intensive.

Donella Meadows 1941–2001

Systems thinking · leverage points

CORE THESIS

Systems have **leverage points** – places where a small shift produces large change – but the most effective ones are the least obvious. Tweaking parameters barely helps; changing **goals** and **paradigms** transforms the system. Meadows made these ideas accessible and actionable.

FRAMEWORK

Leverage (weak to strong)	Example
Parameters	Subsidies, taxes, standards – popular but weak
Feedback loops	Strengthen or weaken the loops that govern behaviour
Information flows	Give actors the feedback they currently lack
Goals and paradigms	Change the system's purpose and mindset – strongest

METHODOLOGY

Systems modelling made accessible, from Limits to Growth to widely used leverage-point analysis.

SIGNIFICANCE AND CRITIQUE

Made systems thinking usable for a broad audience, and the leverage-points hierarchy is widely applied. The critique: the Limits to Growth projections remain debated.

Synthesis

Theorist	Contribution	Key idea	Register
Forrester	Founded the field	Feedback; counter-intuitive behaviour	Modelling
Sterman	The human limit	Misperception of feedback	Modelling + experiment
Meadows	Where to intervene	Leverage points	Accessible / applied

FOR THE OPERATOR

System dynamics makes invisible structure visible – feedback, stocks, flows and delays drive counter-intuitive behaviour (Forrester), which people systematically misperceive (Sterman), and which can be shifted at leverage points, the highest of which are goals and paradigms (Meadows). For the operator: structure drives behaviour, delays and feedback defeat intuition, and the greatest leverage is rarely where you would first push. The final paper turns to control and self-regulation – cybernetics and viable systems.