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Part 4: Methodological developments in the field

Resetting the clock: a feedback approach to the dynamics of organizational inertia, survival and change
ER Larsen and A Lomi

Qualitative *vs* quantitative modelling: the evolving balance
EF Wolstenholme

Simulation by repeated optimisation
RG Coyle

System dynamics is an active field with a well-developed research agenda. The three papers in Part 4 sample a few of the important methodological developments in the discipline.

System dynamics has been used to explore and test theory from other disciplines. One famous example is a model of the decline of the Mayan civilisation in which a system dynamics modeller worked with archaeologists to express their theories of societal demise more explicitly in dynamic terms.[1] Erik Larsen and Alessandro Lomi develop this methodological theme of theory testing in a model of organisational inertia, and its implications for survival and change. They remark that much research into organisational survival and fit is based on static analysis and ignores the potential for multiple paths of evolution as change occurs. Their work is firmly founded in the academic literature on change, which is then transformed into a dynamic model. In its very simplest terms the model postulates that change produces forces which are resistant to change; a negative or counteracting feedback which inhibits the change attempt. The authors develop their feedback view into a formal algebraic simulation model with significant implications for change management. Static or equilibrium thinking has become a sophisticated habit in many research domains, born of analytical frugality and (historically) limited computational capacity. The computational power of system dynamics offers researchers an escape from this habit and the chance to reveal significant dynamic processes at work in their own fields. It is a promising and exciting area for interdisciplinary work.

In a discipline built on unrationed computational capacity it has long been almost an article of faith that a system dynamics analysis *must* involve a quantified simulation model. Eric Wolstenholme takes a less extreme view and his paper describes work in which purely qualitative, diagrammatic, models have been used to explore managerial problems. He refers to the large fraction of managers for whom quantitative analysis is an obstacle and goes on to discuss the spectra of audiences and problem-solving methodologies, subsequently considering the advantages and disadvantages of quantitative and qualitative analyses. This review leads the author to the development of a process which he calls Accelerated Business Learning in which qualitative models are used for general management learning by a wide range of managers and related quantitative models are used for strategic and operational learning by small project teams. In this way, he suggests, the two strands of system dynamics, qualitative and quantitative, can be intertwined and a judicious balance of methodologies can be found.

In the final paper of Part 4, Geoff Coyle describes the use of heuristic optimisation for policy design in system dynamics. He benchmarks the classical approach to improving the dynamic behaviour of a modelled system: conduct an evolving series of planned simulation experiments in which parameters representing policy and structure in the model are varied and the resulting change in model behaviour is explained and understood by reference to the model's feedback loops. The evident weakness of the approach is that the analyst can always conceive of one more experiment, so the process might not have an obvious termination. A more profound difficulty is that even medium size models of one or two hundred variables may have thousands of feedback loops, so the interpretation of results can be difficult. To overcome these difficulties the author describes the use of optimisation techniques in which the parameter variations are performed automatically. An optimisation algorithm searches for improvement to an objective function which rewards desirable behaviour and penalises unsatisfactory dynamic performance. He describes unconstrained and constrained cases. The subtlety is, he suggests, that improvement in behaviour leads the analysts to formulate better objective functions. The approach is therefore, consistent with the classical approach of guided experimentation, though the guide is the evolving behaviour of successively improved objective functions rather than the analysis of feedback loops.

References

1 Hosler D, Sabloff JA and Runge D (1977). Simulation model development: a case study of classic Maya collapse. In: N Hammond (ed), *Social Process in Maya Prehistory* Academic Press, London. The work is summarised in Coyle RG (1996) *System Dynamics Modelling*, Chapman and Hall, London.

Geoff Coyle and John Morecroft