# System dynamics and the credibility syndrome

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**ABSTRACT**

Classical system dynamics has been presented as a paradigm in its own right. Causal explanations and repeated simulations are the main forte of the method. However, the perceptions on the nature and purpose of the method are so varied that many researchers cannot even place system dynamics in a taxonomy of modelling methods. It is difficult to assess the value of system dynamics and justify the choice of such a method. Does the method lack real life significance and suffer from a credibility crisis? The paper looks at the credibility problem from both a philosophical and researcher's perspective.

**THE SITUATION**

The author pursued his research work in a leading institute of technology in India. It was decided to adopt the system dynamics technique to solve a marketing problem involving the diffusion process of a technology-based product. It was, as earlier said, a technological institute where people were interested in specific results and not in a plethora of scenarios. The subjective nature of the method with its educated guesses, the supposed non-linearity introduced by TABHL functions and the sluggishness of the model to respond to parametric changes drew fire and the author faced an identity crisis with regard to his work vis-a-vis that of others who treaded the well-trodden path.

And now for an introspection.

**THE METHOD**

In most cases the existing system is the subject of investigation. The sequence is somewhat like this (Willard, 1980):

* Defining problems dynamically, in terms of graph over time.

* Looking for an endogenous, behavioural view of the significant dynamics of the system.

* Dealing with real system as continuous, consisting of multiple nonlinear feedback loops linked together in a complicated manner.

* Representing all systems that change through time by varying levels and rates.

* Obtaining data for the equations by the combination of available data and educated guesses.

* Constructing computer simulation models to rationally analyse the structure, interactions and modes of behaviour and thereby.

* Providing a framework for policy testing.

* Synthesizing changes in the feedback structure of the model that will improve system performance.

**THE KNOWLEDGE**

The kinds of knowledge (Margaritha, 1990) involved in SD model building process are:

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|---|---|
| Mental Models | - Expressed in ordinary language the knowledge about the interactions that produce known behaviour. |
| Reference Models | - The empirical knowledge about the system. |
| Operational Models | - The knowledge to simulate the dynamic phenomena of the modelled system. |

**THE PARADIGM**

The system dynamics has traditionally been presented as a paradigm. The perceptions on the nature and purpose of the paradigm are so varied that many researchers cannot even place SD in a taxonomy of modelling methods. The central idea of the paradigm is to conceive of societal phenomena as feedback or closed system. The second fundamental idea is the examination of the long-term dynamic behaviour of the system (Bernard, 1980). In SD model building process the absence of a precise and established theoretical knowledge is conspicuous.

## THE CONFLICT

The classical system dynamics method heavily relies on expert opinion, intuition and personal acquaintance with the real system as information base for model specification (Mansfred, 1984). SD models need data primarily for initial level values and for parameter measurement.

The main thrust of SD is towards improving the mental models of corporate managers which, in turn, could translate into effective organisational learning. This is possible only when the decision makers themselves build the model. Mere passive consumption of model results does not transfer systems thinking ability into organisation.

SD models address policy level issues. Policy analyses could be either system-specific or generic. Due to the presence of nonlinear elements closed-form solutions are by passed in favour of a simulation methodology. The simulation aims to demonstrate the characteristic behaviour of the system rather than to predict specific events. Simulation is neither duplication (as the genesis of that behaviour is not repeated) nor explanation (not knowing what is happening and why).

Dynamics do not simply happen, but that the states of the system, depends on the system history (expressed by its current states), any exogenous input and the policies by which the system attempt to regulate its own behaviour. Policies are evaluated by observing the effect of changes in model parameters (input) and model structure (equations) on the simulated behaviour of model variables (output). A policy which is not designed to be consistent with the type of shock the system could encounter and the particular structure of the system could make matters worse.

The dynamic behaviour of a system is insensitive to fluctuations of many system parameters and structural variations of equations.

## THE SCENARIO

A scenario does not seek numerical precision. It provides a more qualitative and contextual description of how the present will evolve into the future and is dependent on the structure (and its delays) of the system. The policy simulation modelling emphasises a continuing interaction with the model. Comparisons are made across possible futures, each reflected in a separate run of the model. No attempt is made to produce sophisticated measurement of the variables of interest. Multiple scenarios are all plausible futures for the system but none would be assured.

## THE 'ism's

In the perspective of Hilary Putnam's 'internal realism', realistic compromises have to be adopted only from the inside of conceptual schemas (Margaritha, 1990). Mental models can discriminate the realistic context of SD models. The conceputal schemas can be diverse and have objective truth criteria inside them, but they do not lead to radical relativism. Relativism rests on continuity and change. There is always continuity in some form or other after a change.

The Systems Science covers the whole spectrum from refutationistic to holistic approaches (Raimo, 1990). Refutationistic approach insist on causal explanations. SD models have greater potential for refutability than other models.

All these 'isms' rooted in philosophy have, instead of clarifying the issues, have really made the SD philosophy more abstract. This tends to lend an air of respectability to SD models, just to differentiate them from the disparaging remark 'yet another simulation'.

## THE TOOL

For the analysis of structural characteristics of SD models, a variety of tools have been used - causality loops, flow diagrams and structural equations. However, these methods are lacking in objectivity and precision. Presently, problem solving seems to be the principal use of SD - either for real or hypothetical situations.

## THE LOOP

The traditional definitions of positive and negative links in causal loop diagrams hide the fact that definitions and characterization in terms of dynamic behaviour are not possible (Richardson, 1986). The deceptive simplicity of the causal loop diagrams lead to misunderstandings as they make no distinction between information links and rate-to-level links. Polarities cannot be defined in terms of dynamic behaviour alone.

## THE STRUCTURE

The SD method offers no guidance about how to move from a group of case-specific models to generic structures (Mark, 1985). There are no procedures or methods for synthesizing a mass of case-specific analyses into something more general. The transferability of structures across fields may not be appropriate for solving specific problems.

**THE RATIONALE**

System dynamics paradigms usually are so broad in scope, in time and space, and so complex in logic that it is difficult to analyse the entire framework to know the working of the system. An important task in the analysis of a behavioural simulation model is to explain clearly how the models' assumptions lead to its simulated behaviour. In an article, Morecroft (1983) has proposed two methods of analysis - Premise Description and Partial Model Testing respectively, to examine the bounded rationality of policies in the light of cognitive limitations and to expose the intended rationality of a policy mix whether they produce sensible actions with respect to their premises. They may serve as diagnostic methods for simulation modelling.

**THE MODEL**

A generic system dynamics model has been developed to understand the diffusion process of a new product-based technology - Personal Computer in the Indian Context (Govindarajan, 1990a, 1990b, 1991, 1992). The model endogenously generates a variety of decisions and outcomes that can directly or indirectly affect the diffusion process. Several subsectors like buyer pool, company sales, marketing effort, product development, user perception, post-adoption behaviour, capacity, competition, business, customer and new product have also been defined.

For instance the buyer pool is represented as

**PBPOOl.K=PBPOOL.J+(DT)(D1-D2)**

**where** **D1=NRADVT+POSINT**
**D2=FORGET+NEGINT+AADOPT**

**and** **POSINT.KL=(ALPHA1)(PBPOOL.K+PSBUYA.K)**
**POSINT=POSITIVE INTERACTION (BUYERS/YEAR)**
**ALPHA1=POSITIVE INTERACTION COEFFT (DIMENSIONLESS)**

**Similarly ALPHA2=NEGATIVE INTERACTION COEFFT(DIMENSIONLESS)**
**THETA=FORGETTING COEFFT(DIMENSIONLESS)**

Needless to say, that the values for the above coefficients are purely subjective and the simulation is 'trial and error'. The question is how to really assess the values for dimensionless quantities?

Another instance: The Sales performance is defined as

**SALPER.K=EXP(S*LOGN(FMKTLNC.K))**

where S is the Sales Performance Coefficient.

FMKTLNC=Fraction of Market lost to New Competiton.

The assumption is that the sales performance follows a log function. Another way of calculating is to take the ratio of current to long term averaged sales and the effective sales performance is a clipped value of the above two. Extremely difficult to justify. The model, however, works.

Similarly it is difficult to give values (with confidence) to 'indicated' variables. So are the behavioural variables like acceptance, user perception and functional capability.

The model should adopt to variability in the environment. Hence constant coefficients yield wrong signs for the parameters. Hence the concept of feedback and this results in 'indefensible' values of constants. The only way out is that the model can be tested in various ways by adducing evidence in favour of initial assumptions or by testing conclusions drawn from the model.

## CONCLUSIONS

A model is a set of assumptions about the factors which are relevant to a given situation and the relationships which exist between them. The SD models make sweeping assumptions leading to 'leap of logic' between equations and consequences. Hence, the credibility syndrome.

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