Can strategic modelling make a contribution to management decision making?

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"*All models are wrong – but some are useful*"
George Box

Introduction and difficulties of managerial decision making

Decisions[1] have to be taken in an increasingly complex an uncertain environment where decision makers are limited by bounded rationality (*Simon, 1957*). Hence models are used, at the most basic stage mental models, based on our vision of the world. Despite being flexible and adaptable, mental models tend to be fairly simple (when compared to real world complexity), difficult to communicate to others and possibly based on flawed assumptions (Do our senses depict the world as it really is?) (*Sterman, 1988*). But in the absence of perfect information we have to take decisions with the help of simplifying models. And therefore, all our decisions are based on models (*Forrester, 1961*).

"Decisions are the core transactions of organisations. Successful [organisations] 'outdecide' their competitors in at least three ways: they make better decisions, they make decisions faster, and they implement decisions more" (*McLaughling, 1995, p. 443*). And given that strategic decisions (or policies) have a large effect on the continued survival (or well-being) of the organisation (or affected group), such decisions should clearly not be taken based on an individual's mental model.

Naturally, the literature offers a great variety of models to reduce either uncertainty (i.e. statistical & probabilistic models, time series analysis, statistical inference, risk analysis) or to counter disagreement (i.e. decision tree, linear & dynamic programming, multicriteria decision models, multiattribute models).

Systems Thinking (mainly qualitative) and System Dynamics (as ST but followed by quantitative modelling, forthwith used interchangeably with "Strategic Modelling") are the tools which will be discussed in this essay.

Compared to traditional decision making tools, which try to achieve precision through detailed complexity, System Dynamics takes a more holistic approach that seeks to detect dynamic complexity. System Dynamics sees interrelationship and interconnectedness rather than linear cause-effect chains and models processes of change rather than snapshots (*Senge, 1990*). Subsequently, the structure of the system gives rise to its behaviour.

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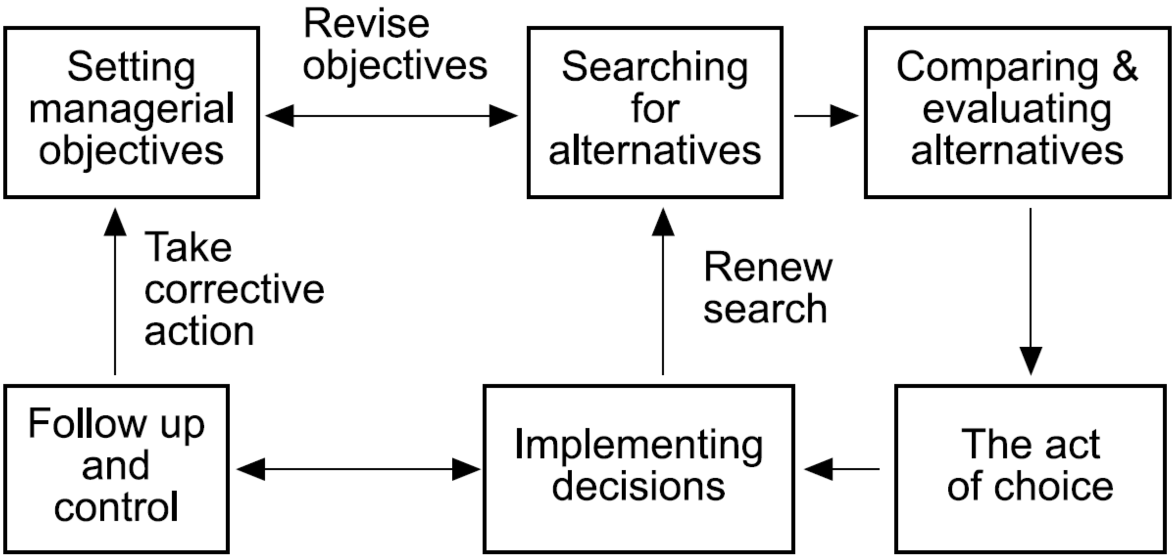
[1] Defined by Harrison (1999) as "*a moment in an ongoing process of evaluating alternatives for meeting an objective, at which expectations about a particular course of action impel the decision maker to select that course of action most likely to results in attaining the objective*."

Systems recognise that "no lever is connected to any outcome directly; likewise, no outcome is connected to any lever directly. Rather, levers and outcomes are connected indirectly, as regards both logic and time" (*Sherwood, 2002*).
Some of System Dynamics unique feature amongst modelling tools is its ability to model feedback, time delays and stock flows. The difficulties in using everyday English to describe the multiple feedback processes in an organisation alone shows the usefulness of Systems Thinking.

The diagram in Figure 1 below shall be loosely used to illustrate the different stages of the management decision making process and the problems associated with each, and in which stages and how System Dynamics can facilitate the process. The possible problems are manifold; there could be too much unclassified information available, the problem might not be well defined, different parts of the decision making team may have conflicting objectives, or the difficulties could be due from a combination of the above, to name but a few. (*Pidd, 2003, p.23*)

Figure 1: The managerial decisions making process



Harrison & Pelletier, 2000

The following section will show how Systems Thinking and Systems Dynamics can facilitate or improve the process, drawing on examples whenever possible. Reference is primarily made to Homer's Burnout model (*Homer, 1985*), which explores the dynamics of worker burnout and to Lyneis' model used to forecast the market for commercial jet aircraft (*Lyneis, 2000*).

Although the essay will illustrate the specific contributions that system dynamics could make to the decision making process in each case, most of these are transferable to similar problems.

Systems Thinking

Qualitative modelling. At a qualitative level Systems Thinking can support decisions, for example when used as a group support system. Since most decisions are taken by groups such as the board of directors, legislature or committees (*Kocher & Sutter, 2005*), this form of modelling becomes highly applicable to the decision making process.

Drawing from various sources and own experience, Vennix (*1995*) describes several main benefits of Systems Thinking as a group support system:

- Group model building increases team learning and promotes insight into the strategic problem.

  In the case described (*ibid*) it helped to restructure existing, but scattered, knowledge by putting it in a systematic perspective which revealed new relationships and thereby created knowledge for the group.
- It acts as a communication tool. The quality of communication is improved because it is not possible to hide behind vague statements, since variables and effects must be clearly defined.
- Group model building is claimed to create consensus (reduce disagreement). Different viewpoints can be integrated into a common view of the problem and enable working towards a common goal.

Yet, the success of group model building is ‘limited’ by several factors. First, when members of different disciplines come together, not everyone might speak the ‘systemic language’ language. Here it was necessary to employ a facilitator (Jac Vennix) to make the basic modelling tools available to the group and would lead the discussion and technical aspect of the modelling. Secondly, the required participants have to exhibit the willingness and dedication to take part in these exercises. Willingness to sacrifice time for learning is therefore a limiting factor, just as participants have to be ready to cooperate and be prepared to listen to other points of views. These limiations could be summarised as the ‘human factor’.

Using only Systems Thinking there are sometimes ambiguities in the behaviour of stock flows, this could be alleviated by introducing more advanced notation (Stock Flow Diagrams) into the discussion, but this would require more learning at the same time.

Roles of Systems Dynamics

While Systems Thinking is mainly confined to qualitative use, System Dynamics goes further and assigns values to variables to allow computation and the simulation, forecasting or optimisation of different scenarios.

Learning. Homer’s model explains the dynamics behind worker burnout in individuals who have a tendency towards workaholism.

At first sight, the model seems to offer to chance to find the maximum sustainable working limit, possibly 69 hours for Jack Homer. Every human resource department would be happy to have such a tool. However, this is not how systems dynamics can support decision making in this case. The model makes too many assumptions and the values assigned are based on individual characteristics (Homer’s own). Since everyone responds differently to stress the finding can’t be generalised in terms of working hours. If one wanted to use this model to monitor employees, it would have to be calibrated for each employee to find his/her personal work/life balance. This might be either impossible or very costly. Energy levels would have to be measured regularly and this might also prove difficult, or if inferred from the time worked, who could guarantee its accuracy?

Data availability is low and data intangibility is high at the same time. I.e. the data of employee's stress profile is not available and variables such "energy level" are too soft to be quantified.

Of course assigning values and running a quantitative simulation of Homer's model was essential to derive the insight he documented.

This model is more about understanding the dynamics and causes of burnout than finding optimal working hours, its main focus is on learning. How is this achieved? Going through the model several questions must be asked which when thought about challenge beliefs and assumptions. Obvious actions (e.g. work more) produce non obvious consequences (e.g. lower productivity), there is dynamic complexity.

The following is an example in which the author believes an understanding of Homer's model can help managers to design better policies. (adopted from *Milgrom & Roberts, 1992, p.372*)":

> "*Many professions like management consultancy or lawyers seem to be characterized as a 'rat race', with people working much harder and longer hours to keep up with the pack (any maybe get a little ahead). The rewards in these jobs are high, but it seems unlikely that the last few hours yield extra output to justify the costs. Particularly young lawyers at prestigious firms make a point of being seen in the office day and night. This will act as a signal to be willing to work hard to the partners in the firm and hence who to promote.*"

Companies with these kinds of organisational cultures must be aware of worker burnout, especially since Homer could show that a stable work/life balance is more productive. The insights from systems dynamics can be used in the training of HR staff (select efficient workers, analyse a person's position in the burn out cycle, etc.). Assuming that monitoring energy levels is not possible, alternative policies could be designed such as peer-monitoring or limiting office hours to counter burnout.

Forecasting. In the role of an advisor, PA Consulting developed a dynamic model to forecast demand in the aircraft industry *(Lyneis, 2000)*. The quantification of soft variables was less of a problem in this case and most variables could be assigned specific, unambiguous numbers.

In the systems thinking stage the development of the model led to new insights (entry of leasing companies) and a better understanding of the dynamics of the industry in general. Systems dynamics models provide a mean of understanding the causes of industry behaviour and thereby monitors changes in the industry structure as part of an early-warning or on-going learning system.

Sterman (*1988*) distinguishes between two broad purposes of computer models; simulation and optimisation models, where econometric forecasting is considered a subcategory of simulation. Uncertainty has already been mentioned as a major obstacle to the decision making process. Forecasting is frequently used to predict the future, but not so commonly with the help of system dynamics models.

In the aircraft industry, due to the required investments, the decision to make a plane is often a bet-the-company decision. Such a decision is the most strategic of all when it is defined as "a decision that will have a large effect on the continued survival of the organization". Therefore it should be based only on the most accurate and reliable of forecasts. System dynamics could produce superior forecasts compared to traditional extrapolations of past observations (statistical models), which ignored the changing industry structure.

This can in part be attributed to the rigorous Systems Thinking stage which enforces clear thinking, and in part to the flexibility of system dynamics models which made it easy to expand the model to accommodate new influences (leasing companies, noise regulations). These features were responsible for Systems Dyanmics' ability to predict reality as closely as possible and at the same are the features that traditional models neglect *(Lyneis, 2000)*:

- Reinforcing and balancing loops
- Stocks and aging chains, which create delays and inertia
- Non-linearities in decision processes

"Simulation models incorporating accurate circular causal structure and information feedback can provide laboratory setting for experimenting with [..] [different market developments] in complex management systems" *(Richardson, 1996, p. xiv)*. So that with the model delivered, management could model different scenarios and use these as inputs to decisions and policies. At the same time, understanding the industry dynamics indicates which uncertainties the forecast is most sensitive to, so that these can be monitored with particular care. Because the system is broken up into different parts (loops) it also becomes easier to design any eventual policy interventions.

In this case the model could achieve all the targets it was set out to achieve. The following limitations are described example-specific but also apply to system dynamics models in general.

Obviously a limit to the accuracy of this method for forecasting is cost or resources in general, this can be either the cost to employ a skilled consultant or to train and allocate an individual in-house to conduct this kind of analysis. The model will be limited by the skill and expertise of the individual conducting it, another cost factor. The quality of the outcome will be decidedly determined by the assumptions made and the quality and relevance of the data used to calibrate the model.

Unfortunately, when starting out to construct a model, or when reviewing the work of a consultant, the accuracy and reliability of the work is not immediately visible to the client. Greater involvement of some key personnel could counter this uncertainty source but the final verdict of the quality of the work can only be made after the forecast could be compared to the real life outcome, and if the model enabled the firm to formulate the best possible strategy response.

Uncertainty can still not be eliminated and exogenous effects will still not be predictable (e.g. 9/11). Using several models simultaneously might be a way to reduce uncertainty.

The model can only make (accurate) short to medium term forecasts (or as long as there is no change in the assumptions), but if the industry structure changes are regularly updated, as suggested previously in the form of an industry monitoring system, then the model can continue to produce good forecasts. This is facilitated by Systems Dynamics' flexibility and ability to grow with the task.

What might complicate this task though, is the danger of complex but poorly documented computer models which obscure the assumptions and make it difficult to update them (*Sterman, 1988*).

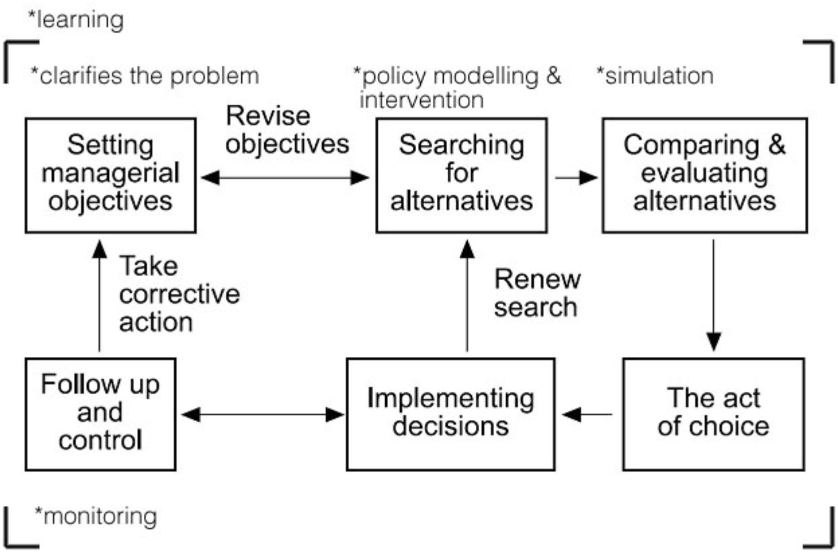
Another problem that can occur in the design of system dynamics models, is the wish to approximate too much to reality. In this case it will be difficult to define the boundaries of the system (when considering that in the real world everything is connected). However adding too much detail defeats the purpose of modelling which is to achieve manageable complexity, while maintaining the essential behaviour of the system.

Conclusion

Using the case studies it could be shown how System Dynamics can support decision making in particular situations, generalising these can be attributed to the following aspects of managerial decisions making:

- Setting managerial objectives (ST clarifies the problem, unifies the vision)
- Searching for alternatives (Designing policies and interventions)
- Comparing & evaluating alternatives (Running experimental simulations, scenario planning)
- Follow up and control (Does the projected course agree with the actual?)

Figure 2: The managerial decisions making process – and how SD fits in.



Adapted from Harrison & Pelletier, 2000

Relating the examples to the management decision model in Figure 1 and 2, it could clearly be shown in which areas System Dynamics could make contribution and where not. This supports the idea that it might be most effective to use System Dynamics jointly with other formal tools which are stronger in areas in which system dynamics is weak, to further reduce uncertainty and improve decision quality.

Learning through formal models (see Homer's burnout) improves understanding and therefore decision making in general but this effect can't be assigned to a specific stage in the decision making process in Figure 2, hence it is marked in as an underlying, overarching the whole process effect.

The dimensions of decision making which System Dynamic also addresses but which are not mentioned in the Figure 1 and 2 are the reduction of uncertainty, disagreement and complexity. Systems Thinking group support systems and System Dynamics as a forecast model have shown how all of these three factors could be reduced to allow better decisions. How well formal modelling can address these problems will vary from case to case, it will depend on how well variables can be quantified and on the aforementioned limitations that are cost and time, amongst other factors.

Figure 2 also shows where Systems Dynamics can not help. Most notably, it cannot support the implementation of a decision, it can help picking the best path, but not how to get there.

"All models are wrong, but system dynamics models tend to be the most useful"? (*Sharif, 2005, p. 615*), this should not be fully agreed with unqualified. It is unlikely that System Dynamics is the best model for every problem[2], especially if there are time and cost constraints there will be quicker and simpler models to reach a good decision with an equally probability to lead to a high quality decision. If low complexity decisions can be with the use of mental models as well as with formal modelling then mental models should be preferred for their speed and lower cost. Unless there is dynamic complexity it might not be necessary to employ Systems Dynamics. Models and modelling are 'tools for thinking' - models and their use must selected sensibly (Pidd, 2003). For problems that suit the methodology of Strategic Modelling, System Dynamics has the potential to offer the greatest scope in expanding bounded rationality. Regardless of the benefits put forward for any method, models will remain a simplification and both model and results should be viewed critically for relevance and validity.

Wordcount: 2767

[2] Quoted in Pidd (2003, p. 24): "*if the only tool you have is a hammer then you tend to treat everything as if it were a nail*"

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