THE PROPER ROLE FOR SYSTEM DYNAMICS MODELS IN THE PROCESS OF POLICY MAKING IN BUSINESS AND GOVERNMENT

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In the assessment of strategic policy, greater use of system dynamics models will not be encouraged unless more attention is given to the role of the model in the policy process. Its proper role is to offer improved understanding and insight in the milieu of policy deliberation, but not necessarily to offer 'answers'. System dynamics models can be seen as providing computer based scenarios of the future -- a range of possible paths of which none is assured. The ideas of boardroom systems and group decision support systems offer, respectively, a hardware and a software infrastructure which sustains the assimilation of a formal model into the policy process.

Introduction

Those in the general management science community who know of the existence of system dynamics, but who have never practised system dynamics modelling, often exhibit a varied number of different perceptions of the nature and purpose of the method. Some think it has a role in forecasting while others categorise it under a general heading of simulation (not even distinguishing between system dynamics simulation and discrete-event simulation). Few with practised skills in the area would wish to argue that mis-perceptions of the nature of system dynamics are something of a rarity. Many management scientists cannot easily place system dynamics in a taxonomy of modelling methods. Indeed, it is often omitted altogether from MS/OR textbooks whereas many other model-based techniques, with little to offer in the way of supporting strategic policy, are given significant coverage. If fellow professionals in the management science community have difficulty in understanding what system dynamics can offer, how can we expect the general swathe of potential senior managerial clients to grasp its true worth?

It is incumbent on proponents of system dynamics to emphasise to a client the model's role in the policy process in addition to its likely technical content. Until relatively recently no significant attention had been given to describing the role of the model in that process. It must be admitted, however, that developments in both software and hardware have been largely responsible for creating this opportunity to redefine the role of a system dynamics model and these developments have occurred only within the last five years. The following builds upon the work of Morecroft (1984, 1988) and Lane (1989).

Strategic policy and the use of models

System dynamics models address policy level issues. Policies are not decisions; the latter are made within a framework set by policy. If this framework is deficient or non-existent then, besides system underperformance, severe stress can be placed on the middle management stratum of an organisation. Because the focus of attention with a system dynamics model is strategic policy, an attempt has been made to assess to what extent models of any sort have contributed to defining and clarifying strategic policy issues. This literature survey is described elsewhere (Dangerfield, 1991). The gist of it is that deterministic financial simulation type models were found to be the most popular type of corporate model. Within the climate that such models are used, the emphasis is on "making plans". Mention was made of "making better plans" or "being able to plan in more detail" as a result of having a corporate model. By contrast no mention was made of managerial learning or improved understanding as a benefit. This buttresses the conclusion that little use is made of the sort of models which are the subject of this paper. Most emphasis seems to be on models which lend themselves to the production of formal print-outs which then pass as the 'Corporate Plan'. What is encouraging, however, is that there is clearly a reservoir of goodwill towards the concept of corporate modelling, even though system dynamics practitioners would sense that the enthusiasm is not targetted at the best modelling method available.

Recent surveys of system dynamics modelling activity, while not exclusively directed at its use in business and government, have produced only mildly encouraging results. For instance, a survey by Sandra Joy (1988) attempts to assess the state of system dynamics in the United Kingdom. Although it is tempting to criticise an unpublished piece of work such as this, there are nonetheless important messages coming from the survey which she conducted. Its objective was "to assess the potential for the growth of the subject of system dynamics in the U.K.".

Her orientation was clearly the role of system dynamics within the "systems movement" (a more 'academic' orientation) and not an exploration of its pragmatic role in corporate strategic policy making which is the purpose here. Of the 66 questionnaires she distributed, only 16 were completed by non-academics and, of these, only 3 returned the supplement to the questionnaire specially created for people working in industry. (Analysis of this was duly abandoned.) Whether this indicates a lack of co-operation with academic surveys by those working in industry, an inability to uncover enough contacts in the industrial sector or a reflection of the truth about system dynamics in the UK is not addressed. But the message from the result, taken at face value, is that the majority of practitioners are in the academic sector. Indeed, Joy states that there are only four key practitioners in the UK and they are all in academic institutions!

Her final analysis, though, is encouraging. The use of system dynamics is clearly on an upward trend. Some 70% of respondents thought they were spending more time on system dynamics work than they did 10 years ago and the subject is "definitely increasing in popularity and it is growing".

The survey conducted by Wils (1988) reached some 200 practitioners world-wide but seems to be heavily biased towards members of the System Dynamics Society and workers at academic and government institutions. The survey, prompted by the Dutch Department of Science Policy, like that of Joy makes for interesting reading. Twenty-seven out of fifty-six questionnaires were returned from people in Western Europe. Again there was a marked lack of any mention of system dynamics in use in the private sector which confirms the suspicion that few people in this sector either use system dynamics regularly or are aware of its potential. The picture which must be inferred is that, whenever system dynamics *is* used within a private firm, it is often for a specific one-off project. Industrial practitioners feel no great loyalty to the method. Some academics, on the other hand, are teaching and researching the material regularly and see a continuing involvement with the subject. This is not particularly unexpected but the general inference does indicate that there is extensive opportunity to arouse the interest of managers in the private sector in Western Europe, principally because so few seem to have used it so far!

In the USA on the other hand there is apparently much more extensive use of the method by private sector companies and, by the government, in particular for determining energy policy. Many consultancies have grown up in the Boston area and are experiencing heavy demand for their services in building system dynamics models -- for clients all over the country. The demand is not the result of particularly heavy advertising but rather information spread by word of mouth.

What is particularly encouraging is the tone of many of the responses made by practitioners of system dynamics. Clearly they see it in the same light as the main theme of this paper and the following collection of comments reflects this:

> *"The ability to look at a wide range of scenarios clearly and quickly is becoming of greater importance".*

> *"The focus is shifting towards long term, high-tech scenarios and non-equilibrium situations. This provides an opportunity for system dynamics".*

> *"System dynamics is for learning more than problem solving".*

> *"Practising system dynamics aims at changing people's way of thinking and organisations' ways of behaving, but people and organisations have a great resistance to change".*

Wils own comments in assessing and synthesising the responses he had received are thought-provoking, none more so than the comments surrounding what he calls a 'new realisation' of the practice of management.

> *"The new realisation is that in practice the actual behaviour of managers is mostly controlled by, to a large extent, unconscious mental models. It does not suffice to have the right answers. What matters is to offer managers, in addition, a learning environment in which they are helped:*

- *to observe the differences between actual reality and expected reality;*

- *to interpret the actual reality, so that the right answers are found; and*

- *to experiment and practice the new answers so that these can become integrated in their mental models".*

Wils' report ought to be seen as a catalyst for an agenda which practitioners on this side of the Atlantic should address. They must be prepared to promote the system dynamics method but, more importantly, do so by showing how it can best be employed. It is not sufficient merely to promulgate its technicalities. Unless this is prefaced by an exposition of the most effective way of utilising such a potentially powerful tool, anything that follows is likely to be misunderstood. If such an exposition can be put across to senior managers and civil servants, providing it concentrates on the themes of 'strategic policy-making', 'scenarios' and 'managerial learning' it should excite the curiosity of the intended clientele into wanting to know more about the method.

It is people employed at director (or equivalent) level to which strategic policy models are addressed yet there is just no current information available as to the type of models (if any) being used by this specific group; most of the substantive studies were done in the 1970's. This informational vacuum concerning contemporary strategic policy models should be remedied urgently. The present author would now like to see a large survey conducted to investigate the extent of use of *any* type of model to support strategic policy making in business and government. Instead of practitioners, managers and civil servants would be targetted in order to elicit the views of the people who ultimately matter. The various types of model employed would emerge from the results of such a survey along with the extent of use of such models.

Besides the detailed factual information concerning the type of models employed, the survey should elicit senior managers' and directors' *attitudes* to embracing a modelling input in the first place. It would be interesting to know, for instance, if only a handful of system dynamics studies were conducted but they were very well received and led to some change in behaviour whereas a significant number of 'spreadsheet' type models were created but received little support from policy-makers. To avoid problems of comparability which have bedevilled surveys in the past, perhaps the same survey instrument could be disseminated to firms and government agencies on both sides of the Atlantic.

Scenario generation and policy modelling

In what context are policy models for business and government best presented? To this author a preferred answer is to see policy models as a means of creating one or more *scenarios* which can be used to confront managers' mental models. Unfortunately the literature on scenarios does not always relate their generation to the building of computer models. (See for example, Godet (1987).) A synthesis of the two is a primary goal of this paper. It is posited that scenario generation is a niche into which policy models of the system dynamics type fit quite happily.

Scenario is a term claimed to be coined first by Herman Kahn. In a book published in 1979 (Kahn, 1979) he asserts that the term was used first in this sense by himself and fellow researchers at the RAND Corporation in the USA in the late 1950's. The term was thought to be apt because it deglamourised the projection being outlined. They would say, "remember it's only a scenario". Policy makers exposed to models capable of projecting one view of the future should appreciate such tools for what they are, namely distillations of the real world which do not lay claim to embracing the ultimate truth.

Scenarios must be distinguished from forecasts (Godet, 1987). As noted by Schnaars (1987) a scenario provides a more qualitative and contextual description of how the present will evolve into the future. A scenario does not seek numerical precision. It is one possible view of the future which, if generated by a system dynamics model, is more a product of the structure of the system and its constituent delays than a function of model parameter values.

The style of policy modelling advocated herein 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 in *absolute* terms. Projections *relative to one another* are what matter in this context, as is stressed by, for example, Chandler and Cockle (1982).

Multiple scenarios would be considered and evaluated. All would be possible futures for the system but none would be assured. Rather than trying to predict what *will* happen in *the* future a system dynamics model should aid contemplation of what *might* happen in *any feasible* future. Within the model (and its policy derivatives) futures are not merely some mathematical manipulation of past data but must be seen as the confluence of many forces: past, present and future. This is how Schnaars (1987) sees scenarios and coincidentally how system dynamics models evolve a behaviour mode through time.

To further the discussion it would be useful at this point to introduce a discriminating terminology. It is posited that scenarios should be conceptualised separately as external scenarios or internal scenarios. The former relates to the understanding of scenarios which is mirrored in the general body of literature on the subject. As described above, this sees a scenario are being basically a projection of some facet of the system's environment. The projection is created using a systematic approach and by no means can it be considered a mere extrapolation. The extrapolation element is just the starting point for the formulation of an external scenario. Impacts against that extrapolation are then considered.

An internal scenario, on the other hand, is one which projects possible consequences of alternative policies adopted by the organisation. It can be viewed as a conjunction between candidate policies and the possible futures being offered by the external scenarios. In some situations the chosen policies may be adopted as a direct consequence of the specific external scenarios. External scenario generation is a logically prior activity to consideration of internal (policy) scenarios. Millett (1988) uses the term 'cascading scenarios' (although in his case not quite in the same context) and this is an apt way of thinking about the two processes.

A niche for system dynamics modelling activity is in the creation of internal scenarios. If an external scenario(s) has been made beforehand then this would be used as an exogenous input to the model but it is not absolutely necessary for this particular procedure to be adopted.

The Technology supporting policy debate around a model

It is clearly necessary to review a little of the infrastructure which supports the process of managerial learning via a system dynamics model. This section offers an opinion on a combination of hardware and software which will facilitate the policymaking process when it is utilised in support of a system dynamics model. It is this setting which Morecroft (1988) calls a *microworld* for policy debate, following Papert (1980). A microworld is an 'incubator for knowledge', a setting in which policy-makers engage in a learning experience through interaction with text, systems diagrams and computer simulations.

Hardware

For the purposes of eliciting hypotheses and beliefs ingrained in the managers' mental models it is not computer hardware which functions best but a pedagogic piece of hardware -- namely a whiteboard. Lane (1989) notes how an experienced consultant using a whiteboard and working with up to six senior managers can develop an influence (causal loop) diagram which draws out the complexity and the dynamics of the issue under investigation. Such a session would last maybe two to three hours and, if it is going well, the attendees would want to move to the whiteboard to add to or change the diagram. The whiteboard holding the emerging diagram is the focal point and, as such, is indispensable.

This is underlined by Vennix et al (1990) when they describe the conceptualisation of a health care model. Three sub-groups were formed to look at different aspects of the problem in isolation. When they returned for the plenary session their efforts were aggregated on a whiteboard into one influence diagram using different colours to reflect relationships identified by the different groups. On merging the sub-models various feedback loops were created and the consequences of these loops discussed.

In terms of computer hardware, the 'Operations Room' depicted in colour photographs on the inside of the dust cover of Beer's *"Platform for Change"* (1975) is likely to be too intimidating for senior managers and directors. The room described by Beer was set up in Santiago, Chile when he was consulting to the Chilean government in the early 1970's. It included a number of comfortable armchairs incorporating keypads on the arms. Different keystrokes would cause different types of colour display to appear on large screens affixed into the walls of the room. Ministers and government officials could summon up-to-the-minute plots of industrial production and other relevant economic variables. In addition they could evaluate potential policy changes in the light of system dynamics simulations of the future also instigated by a special keypad sequence.

While this is perhaps too clinical, too akin to a laboratory rather than a boardroom, it is undeniable that some form of large-screen colour display is needed if all the people present are expected to contribute to the debate. It is possible to use a device that sits on top of an overhead projector screen. This device can relay information from the computer screen onto the wall-screen directly. Although these systems can be useful in a classroom environment their widespread use is questionable especially since the quality of the image is often not high and also they transmit only in monochrome (although, at the time of writing, colour versions are now available).

Much better are proper RGB projectors which produce a large-screen colour image. These are the mainstay of what are now known in the UK as 'Boardroom Systems', commercially available hardware/software installations used for quality presentation of boardroom information. A good account of such systems is given by Preedy and Bittlestone (1985). In the UK in 1988 three different vendors had boardroom systems on offer commercially. British Airways had developed their own, called AIMS. At present these systems are used only for reporting information in a meaningful way. They do not involve any modelling, either of the firm in question or indeed any policy issue it may be grappling with. This must be the next step, however, and this author sees the integration of system dynamics modelling with boardroom systems as a highly promising (and logical) development in policy support tools.

Sometimes progress in several separate lines of development needs to be fused in order to allow an applied discipline to make a quantum leap forward. Besides the advent of boardroom systems, developments in 'group decision support systems' (Eden and Radford, 1990) seem to offer immense scope for the further promotion of system dynamics models in a policy support role. In fact, boardroom systems would be seen by some as part of the formal achitecture of a group decision support system, something which has been defined by Huber (1984) as "a set of software, hardware and language components and procedures that support a group of people engaged in a decision-related meeting". However, given the precise nature of most group decision support systems, it would be somewhat inappropriate to integrate such processes into a formal board meeting. A more suitable context would be an ad hoc meeting which may be called purely to explore a specific issue, perhaps at a location away from the normal office environment.

In terms of hardware, Ackermann (1990) writing in the Eden and Radford book, sees such an environment as "including a series of terminals or workstations linked together through some form of networking, a large main screen visible to all and controlled by the facilitator, large sheets of paper and a three-colour video projector or large monitor". The large screen display is seen as important because, if each participant had their own display screen together with a capability to control what appeared on it, there would be hardly any interaction between them either verbally or non-verbally.

Further contributions to the volume by Eden and Radford include those by Huxham (1990) and by Hickling (1990). Their chapters explore the advantages and disadvantages of particular types of room layout and of the supporting facilities in those rooms. Here there is less emphasis on the role of the computer itself but rather in the use of whiteboards (in particular photocopying whiteboards) and other non-computing hardware.

Software

The last three years of the decade just ended have seen a remarkable transformation in system dynamics software and this transformation has been made possible by the vastly increased power of microcomputers. Not only are such devices so much more inherently user-friendly, they allow direct control of a graphics image on-screen using standards which have successively improved the resolution and the maximum number of permissible colours.

As long as the use of computers implied a terminal hooked up to a mainframe or minicomputer, an installation to act as a vehicle for assisting policy debate and dialogue was always going to be a rather uncommon sight in corporate offices. Networked links were liable to disruption and in any case the bandwidth of the line was often a limiting factor, predisposing the graphics screen image to be created far too slowly.

Coincidentally and totally independently the three main systems for system dynamics simulation on a personal computer (PC), Professional DYNAMO (Pugh-Roberts Associates, 1986), DYSMAP2 (Dangerfield and Vapenikova, 1987) and STELLA (Richmond, 1987), appeared within two years of one another. What singles out these systems is the fact that they allow one equation for each model variable which can be placed anywhere in the list. The software automatically sorts the equations into a computable sequence and then executes the model. All three systems include special library functions which are of direct help in this kind of modelling work, together with an integrated graph plotting capability, so necessary for reviewing the results from policy explorations. In essence, these software systems provide an environment which makes it feasible to conduct real-time policy explorations using simulation models.

Whichever program is selected for the purpose there is no denying that it is capable of discharging the task of providing, in conjunction with a suitable model, a means to learn and understand the consequences of strategic policy. Quite simply no other general purpose languages or specialist systems can match the combination of free-ordering of equations, simple syntax, powerful function library and rapid graph plotting which these three offerings make available.

All these developments are underscored by the results of a survey which was conducted by the British business magazine *"Business Computing and Communications"* in 1987. The magazine surveyed 1500 chief executives, managing directors and finance directors of organisations employing over 750 people. Questionnaires were returned by 118 executives, 49% of whom worked for companies with an annual turnover in excess of £100 million. Just over 40% of respondents worked for manufacturing companies in the metal goods, engineering and vehicle industries. Relevant results in the present context were that almost one-third of respondents would like to see information provided in more comprehensible, graphic form. Of greatest importance, however, was the finding that 40% would like "the provision of possible scenarios for strategic planning". In other words, they were appealing for the availability of data on scenarios, but put into a more conducive (graphical) form. This is an encouraging finding.

The developments in group decision support, referred to above, have a 'software' element too. This is the process by which the strategic issue is tackled. Eden (1989) has been associated with the development of one such process called Strategic Options Development and Analysis (SODA). The use of formal computer simulation models as an ingredient of this process is not prohibited and so the software element can be defined to embrace both process and content. Indeed Eden (1990) offers a very interesting opinion:

> *"There are indications that the use of computers for any future improvement in decision-making by very senior managers may incorporate a class of certainty-geared models that serve to clarify thinking about the dynamic interdependencies of complex systems. ..... Cognitive maps (Eden et al, 1983) and system dynamics models (Morecroft, 1984) are not only similar in that the causal relationships between variables typically are 'hard-wired' (rather than probabilistic) but also because they are typically 'information-free', that is, built on impression, belief, judgement, wisdom and intuition rather than on formally gathered data. Representing the world through the construction of a 'processual toy' which can become a learning instrument seems to be a promising development (DeGeus, 1988). 'In a sense, such models have exhausted empiricism and placed no bounds on rationality' (attributed to Rohrbaugh at the Toronto conference on which this book is based)."*

Unfortunately the contribution by Ackermann, which follows on directly from the section in which the above quotation appears, does not support the sentiment expressed by Eden. Here Ackermann, quoting Winograd and Flores (1986), suggests that the appropriate role for the computer in group decision support is not as a surrogate expert but rather a sophisticated medium of communication. The emphasis is on data and the capability to access it concurrently. Whatever is emphasised in system dynamics models it is certainly not formal statistical data, as Eden's quote bears testimony. DeGeus (1988) would agree and he argues counter to Ackermann. Indeed, DeGeus would say, that a computer model *should* be considered for use as a 'surrogate expert'.

Tomlinson (1990) offers a taxonomy which is useful for putting the ideas of 'group decision support' in context. He distinguishes between 'process' models and 'product' models. The former describe the relationships between the decision-making group and the process by which the decision can be reached. Group decision support emphasises the 'process' model to the apparent exclusion of product models which incorporate the values, beliefs and concerns of senior managers; this category would include system dynamics models.

There must be many types of strategic problems in business and government for which the adoption of a group decision support method *alone* would mean that there was a well-defined *process* but little or no substantial *content*. This imbalance would operate to the detriment of the process and also, possibly, the enthusiasm of the participants. Similarly, to press ahead with a system dynamics model which was not embedded within a group decision (or more appropriately policy) process might risk a very real miscasting of the role of that model by those involved. Earlier sections of this paper have elaborated on the desirability of setting out very carefully the proper role for system dynamics models in the policy process. For deliberations made outside of a formal board meeting with its fixed agenda, the ideas of group decision support seem to offer the best platform via which this role can be discharged.

Conclusion

For the role of a system dynamics model in the process of policy debate, a fusion between model generated scenarios, boardroom systems and group decision support systems provides the platform to offer a degree of learning by senior managers and directors or civil servants. Merely through the act of its creation, a system dynamics model developed in this structured environment is capable of releasing understanding in a situation of some complexity.

But care should be exercised in the sort of system dynamics models which are produced as a contribution to policy making. The days of creating 'glory models', which sometimes seem designed to cloak the intended audience in a mixture of bewilderment and forced acquiescence, should be banished forever. Specific issues call for specific models. Parsimony replaces comprehensiveness. Properly constructed, couched in the context of a learning tool and set within the framework outlined above, a system dynamics model supporting an issue of corporate or public policy has far greater potential to elevate the level of policy debate than has the yield from any other modelling method.

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