How to get Managers to Use System Dynamics

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Abstract

This article aims to identify actions that will lead to an increased likelihood of managers adopting system dynamics. The specific purposes are:

- to explain how to implement successfully information technology that supports managers;
- to identify the implications of adopting system dynamics as regular support software;
- to see if there is a need for system dynamics by examining how managers use information for decision-making.

Executive information systems are an example of information technology that is being used by managers. Lessons from the successful implementation of executive information systems are shown to be relevant and research on decision-making is used to show why managers need system dynamics. The main message is that system dynamics modelling needs to be done by internal support staff who actively adapt the support system to managers' needs.

HOW TO GET MANAGERS TO USE SYSTEM DYNAMICS

Introduction

System dynamics is an information technology with the potential to improve managers' understanding of the future consequences of current policies, but to date this potential remains largely untapped. Therefore, it is important to know how we can enhance the likelihood of the adoption of system dynamics within organisations. One of the problems, with sophisticated information technology for managerial decision-support, is that managers do not adopt it as widely as its creators would wish. We contend that system dynamics is one such information technology. Recently, Maloney (1993) has argued that, to apply system dynamics to business modelling, data-intensive robust and rigorous models are required that are integrated into an enterprise's information systems. In this article we seek to learn from the experience of a data-intensive information technology that has encountered the problems of robustness and rigour but that is being widely adopted by managers.

Overall, the aim of this article is to identify actions that will increase the likelihood of the adoption of system dynamics by managers. Specifically, our purposes are: to see how information technology that supports managers is successfully implemented; to identify the implications of adopting system dynamics as regular support software; to see if there is a need for system dynamics by examining how managers use information for decision-making. The subjects of our inquiry are variously known as executive support systems, management support systems, enterprise information systems or executive information systems (EIS). These names all describe essentially the same type of information technology. Here we will refer to these systems simply as EIS. Although initially only larger enterprises could afford to develop this technology in-house, today there is a range of products available to suit most corporate environments. Not all systems have been successful, but the successes can teach us lessons that are relevant to system dynamics.

How executives use information systems

System dynamics is similar to other information technology designed to support managerial decision-making. Information technology, in the sense we will adopt here, refers to systems that incorporate five components: procedures, people, data, hardware and software. System dynamics falls within this definition because it embodies procedures for capturing data about people's decision-making and the outcomes of their decisions, for constructing models and for simulating these models using software and hardware. Furthermore, the aim of a system dynamics study is usually to improve decision-making by analysing old policies (decision rules) and designing new policies that will enable people to adapt their behaviour and achieve desirable results.

Many of today's managers regularly use computers to deliver information although they do not seem to use them for exploratory modelling. Most notably, senior managers have begun to use information systems. The phenomenon was first documented in the academic literature by Rockart and Treacy (1982) and Rockart and DeLong (1988) who, at that time, called the computer systems used by top managers 'executive support systems'. This terminology was reminiscent of decision

support systems (DSS) and suggested that the executives were using the computer for the sort of *ad hoc* analyses that are the hallmark of decision-support technology. Although these computer systems are capable of providing models, particularly financial models, Laska and Paller (1990) found that managers do not use them for *ad hoc* analysis. Researchers (Millet and Mawhinney, 1992) who have compared EIS with DSS and management information systems (MIS) found that they are more like MIS than DSS. These findings indicate that senior managers use information technology for information delivery, rather than for modelling. For system dynamicists, it may be disappointing to learn that managers do not use the modelling functions of the software. However, the implication is that emphasis needs to be on presenting the results of system dynamics analyses to managers.

Gaining approval

Successful implementations

If the aim is to have managers using system dynamics as regular support software, the first step should be to convince a senior executive of the value of system dynamics. We know from EIS experience that successful adoption requires the support of a top manager and that the project usually fails when the manager withdraws this support (Rockart and Delong, 1988). EIS vendors are aware of this and usually target their sales effort at a senior executive, who then becomes the executive sponsor. Vendors try to side-step the information systems (IS) department in the first instance. However, the IS department usually becomes involved later to offer technical advice and support the implementation. It is often the IS Director who becomes the operating sponsor for the project, ensuring that it comes to fruition. Thus, the second step should be to get a senior IS person to join the project team, to advise on how best to integrate system dynamics modelling within existing information systems.

Organisational resistance

The introduction of a new managerial information system has political consequences. System dynamics models, by providing new information and new insights, will change the organisational power structure. This problem is most acute when executives perceive the organisation to be in volatile and unfamiliar conditions. These are, of course, the conditions where managers most need support. Rockart and DeLong (1988) have identified four sources of political resistance to executive support systems. The first comes from those people who traditionally supply information to senior managers and fear the loss of their control over the information. As will be seen below, instead of bypassing these people, the information system should acknowledge them as the authors of models and originators of data. The second source of resistance is from subordinates who fear their superiors' intrusion into their domain of responsibility. The third source comes from subordinates, or executives who are not users, and who fear from ignorance of how managers will use the information. These two sources are linked. Often, resistance disappears when people are shown that understanding flows from better information and that it is in their interest for managers to have a better understanding of the enterprise. They may also become involved as users of the system themselves. Also, senior executives need to avoid any tendency to use the information to allocate blame and punishment. The final source of resistance is from other senior executives and it often arises from a fear of computers. As we will explain below, it is essential to have an easy to use graphical interface that will encourage managers to use the system.

Importance of active support

Senior executives' information requirements change frequently. However, executives are unlikely to turn to the IS department for help if current systems fail to meet their needs. Instead, they will ask subordinates who have the technical knowledge. We know (see for example, the case of Yorkshire Building Society documented by Rolph and Bartram (1992)) that where an EIS has been successful, the organisation will have set up a technical support team (of one or more persons) to champion the project. These support personnel are not usually IS specialists but are better described as information analysts: people who understand both the technology and the enterprise. They administer the system, modifying it regularly in response to the ever-changing requirements of managers. This means that there will also need to be one or more persons dedicated to system dynamics modelling within the support staff. Their roles would be to monitor the use of existing models, identify the need for enhancements, and actively to seek new applications. These people would need to have the authority to maintain the integrity and security of system dynamics models.

Information providers

Up to now the discussion has mentioned two classes of people, these are managers and support personnel. There is a third class, known as information providers, who would play an important role if managers were regularly to apply system dynamics. Consider what currently happens with an EIS. Whenever possible, the support personnel extract data from corporate data bases. When they cannot satisfy the data requirement from their existing data sources, they look elsewhere within the organisation (or to an external data vendor). The person who has the authority to release the desired data is an information provider. The information supplied might include external data and local data that may only be available from departmental records. Also, the information provider may make available a model to analyse the data. Responsibility for the information's consistency and timeliness lies with the support staff, but responsibility for the accuracy of shared data and models rests with information providers. Thus, it is good practice to give, on each screen that uses the information, the identity and contact details of the information provider. If an organisation were to adopt system dynamics modelling, we should expect to have information providers contributing data or even models. The system dynamics support personnel would control the quality, accuracy and consistency of these data and models.

Developing applications

Cost justification

It is important to ensure that the sponsors see the benefits of system dynamics modelling. Even if a full cost-benefit analysis is not possible before implementation, benefits will need to justify costs if budgetary support is to continue. The experience from EIS is that cost justification does not necessarily precede budgetary approval. There were no cost-benfit assessments for many of the systems studied by Rockart and DeLong (1988). However, the sponsor will want to see early benefits in order to renew the budget for the project. (In the longer term, the project needs to justify itself by expanding its user base and thus demonstrating that it is a valuable support for many managers, as explained below.)

First applications

The initial system dynamics modelling efforts should be in low risk areas and clearly targeted at managers' critical decisions. If the first models are small they can be

developed rapidly. (See Lane (1993) for an example of just such a system dynamics model.) Although these first applications should be modest, they should aim to yield clear benefits because success at this early stage is essential if the project is to continue to have a budget. At the same time, if the first applications are selected for their growth potential, they will ensure the long-term survival of the project.

A manager will appreciate the benefits of information that focuses on personal critical success factors (CSF). The CSF concept (Rockart, 1979) refers to the limited number of factors that each manager regards as critical for success. Each CSF will be measured in terms of one or more key performance indicators. These, in turn, should use data that are up to date. The sources of information for critical factors are likely to be evident from an inspection of the manager's existing data sources, such as reports and communications. It must be possible for the manager to act upon the information received. The information must be relevant and comparable to a desired standard. Thus each manager's CSFs are essentially the information inputs to the policies (in system dynamics terms) that the manager is following. Although systems analysts have generally adopted the CSF concept, it only refers to *current* managerial behaviour. System dynamics gives a means to explore the consequences of alternative policies (or CSFs) on organisational behaviour. As we will show, there is an opportunity here for system dynamics to facilitate the manager's transition to a new mode of thinking[1].

Fast development

The capability of software to offer fast application development is also a key requirement. IS specialists favour prototyping as the software development approach for management support systems (Guimaraes and Saraph, 1991). In outline, the prototyping development process is as follows. After gathering details of the user's critical information requirements and existing sources, the developer rapidly creates the beginnings of a support system. It is essential, of course, that the developer's software kit includes tools for such rapid development. The developer shows the user an example of results. This could be a simply screen showing a chart. From the user's reaction, the developer modifies the application. The cycle of modification and gauging user reaction continues to the satisfaction of the manager. The aim would be to provide the bulk (e.g., 80%) of the manager's requirements well within a tactical time frame (i.e., before strategic change is likely to alter those requirements). In reality, the manager's requirements will be continually changing. The support personnel need to maintain a dynamic equilibrium between the demands of managers and supplying new models. This implies that the tools for system dynamics modelling should permit rapid prototyping. (See Simons (1993) for an indication of the capability of current software.)

Technological aspects

The system interface

The system dynamics modeller should make full use of graphics to provide high calibre interfaces to models. Kleinmuntz (1993) has discussed the problems of communicating feedback structure to decision-makers. He argues that people detect feedback if they see covariance between past actions and current results, if the time lag between these events is short, if the events are similar and if exogenous variables are not relevant. He suggests that the information display should be manipulated to enhance the perception of feedback. He proposes the simultaneous display of past and present data (such as differentially lagged time series), the use of compatible formats for different data (to ease comparison), and a reduction of the perceived

relevance of exogenous factors. Essentially, these are suggestions for displaying results in sophisticated ways that will enhance the visible effects of endogenous causes.

Experience with EIS (Watson and Frolick, 1992) and system dynamics (Probert, 1982) confirms that the quality of the visual interface is important. The display of information should be attractive and it should be possible on a single screen to combine a table, chart and graphics. Screens should be interactive, so that when the manager points or clicks on a button or "hot spot" the display changes to a new screen. For example, clicking on a chart might reveal a spreadsheet display of the data. There should be a logical (e.g., hierarchical) association between screens (e.g., so that as one moves down a level one sees information in more detail). The quantitative data held in an organisation are multi-dimensional, just like the output from a system dynamics model. EIS software has a neat way to display these multi-dimensional data.[2] The EIS interface provides an intuitive way of switching dimensions as desired, so this type of interface is suitable for system dynamics models as well.

Linkage to other IS

If managers are to use system dynamics, the software must join seamlessly with other information systems that the manager uses already. This probably will mean that system dynamics models will become components[3] of existing EIS rather than *vice versa*. There is no fundamental difficulty here. As explained above, the existing EIS will already provide an interface to multi-dimensional data. However, the onus will probably fall upon system dynamics software developers to ensure that outputs from system dynamics models are consistent with existing interface standards. Similar remarks also apply to the inputs to system dynamics models. If these require data from corporate information systems or external sources, the software will need to translate files into a suitable format and import these data on a regular basis..

Managers' use of software

How system dynamics would be used

It appears that managers do not like to experiment with software but instead want results that are reliable (Laska and Paller, 1990). This implies that professional support staff should run any system dynamics model and generate results from several scenarios for a manager to examine. The pattern of time spent by managers using their computer resembles that revealed by research into the time-span of managerial activities.[4] Most activities last a few minutes only. Little time is available for deep thought and so managers do not spend enough time to carry out deep investigations. Thus system dynamics *results* are likely to be used by managers but system dynamics *modelling* is likely to be delegated to support staff. Managers also do not have time to adjust to different views, which explains the reported need for a consistent interface. Therefore, output from system dynamics analyses should have a personalised focus and should have a consistent appearance that suits individual executives, or an executive group.

How successful systems evolve

The pattern of system evolution is also of interest. Senior managers may initially be the ones who ask for a support system but with time, as awareness grows, lower-level managers will demand to use it also. These users have a more constrained decision space and so an analyst can more easily define their information requirements. With

an EIS, it is likely that they eventually become the major users[5] because the system will more easily answer their requests (Wheeler *et al.*, 1993). The evidence from a U.S. study (Watson *et al.*, 1991) showed that systems had no more than a few tens of users in their first few months. However, systems that remained active for three years had more than one hundred users. The size of these systems, measured in screens, grew with the user base. Our analysis of the survey data presented by Watson *et al.*, (1991) indicates that about six screens were added for each new user. This shows that new users required their own screens and that existing information provisions were not sufficient for them. In other words, even when there is a large number of managers using it, a support system must provide a personalised view for each of them. This has implications for system dynamics development. It suggests that each manager, or workgroup, will want a personal view of a corporate system dynamics model, or will want a personalised system dynamics model, or may want both.

The opportunity for system dynamics

If the information technology supporting managers should enable them to perform at their best, currently it falls short of the mark. We can deduce this by comparing research into successful decision-making with the characteristics of most installed technology. Research on managerial decision-making suggests that some ways of solving problems are more successful than others. Nutt (1993) determined the nature of diagnostics used by executives and the tactics used to solve strategic decision problems.[6] The most popular tactic was to use an existing idea to set the direction: the manager imposed the selected solution on the decision process and used qualitative or impressionistic diagnostics. However, this approach did not lead to the best results. He found that when a problem or a cause for concern stimulated a decision the result was almost always unsuccessful. Target-setting was the second most popular decision tactic and it also was the second most successful tactic. In target-setting, the manager formulated desired ends as an objective or target to guide the decision process. Performance targets were either specific (e.g., a given rate of improvement) or generalised (e.g., a desire for improvement). Nutt found that the most popular and the most successful diagnostics were quantitative when setting targets. Target-setting using quantitative diagnostics suits current EIS technology, which should deliver to the manager key performance indicators derived from critical success factors. When the manager employs the information system in this way, *current* policies are the basis for monitoring and control.

Reframing and decision success

Thus far, Nutt's findings concur with current practice in EIS implementation but they do not leave much room for system dynamics.[7] However, we have yet to discuss the most important finding. Nutt's results showed clearly that *reframing* was the most successful decision tactic. Reframing involved the identification and justification of new norms. By highlighting performance shortfalls, reframing led to the adoption of new practices. We can explain the difference between reframing and target-setting in terms of critical success factors. When a manager adopts target-setting, existing CSFs define the mananger's information requirements. When reframing is used, the manager conjectures new CSFs and explores their consequences. The manager selects new norms in order to put existing performance in an unfavourable light. Reframing centres on identifying and justifying the selection of new norms and it relies upon the wisdom of the selection for its success.

However, reframing was the least popular approach used by the executives in Nutt's study. This is interesting, because it suggests that there are barriers to the use of this

decision tactic. We do not have direct evidence to say with certainty what these barriers might be, but we can speculate that a major barrier is the lack of technological support. The manager needs help to explore the consequences of new performance indicators. Thus, the support system needs to have the ability to model the effect of policy changes on organisational processes. The methodology that could offer this support is system dynamics. Although system dynamics could benefit an organisation in this way, at present, it is not available to managers within the typical corporate information system portfolio. We contend that there is a gap in current executive IS that system dynamics shoul fill.

Discussion

Consultants have used system dynamics to inform managers in a wide range of enterprises over many years. Typically, external system dynamics analysts have carried out these studies, or internal experts have acted as if they were consultants (see Winch (1993) or Lane (1993) for recent examples). However, Naill (1992) has suggested (in concluding an article on a successful strategic study) that few of these models are 'truly implemented.' Naill adopted the phrase 'truly implemented' in the sense of an on-going pattern of use to support decision-making. This is also the sense that we have chosen. Naill suggested that although a good model is important, other factors, including a good problem area, a real policy need, timing and good clients, are possibly more important. Naill's study was a large-scale policy investigation for the U.S. Department of Energy. Our concern is with policies that are considerably more modest. Even so, our conclusions are remarkably similar. For each manager or workgroup, a good problem area relates to the personal span of control, where there is feedback, dynamic behaviour and a need for policy analysis. Timely model development is essential and requires the in-house support of dedicated staff. Naill noted that there must be a specific task for the model, and we have noted the need to focus system dynamics applications on a manager's critical success factors. Finally, Naill noted that his client organisation had internal expertise in system dynamics. In our scenario of successful system dynamics implementation, we envisage technical knowledge residing with support personnel and domain knowledge residing with managers. We envisage the transfer of knowledge about dynamic behaviour occurring through high-quality graphical presentation of results. This should cause managers to ask for either changes to models or new models.

Our belief is that system dynamics will remain peripheral to an organisation unless managers regularly use it to support their work. We have seen that managers are currently using executive information systems. However, EIS are only a partial solution because they focus on the organisation as it is now and as it was in the past. They deliver information about the manager's critical success factors, in other words, inputs to current policies. Really effective decision-making comes about when managers are able to define new critical success factors for themselves and for subordinates. Managers can then design new indicators to show gaps in current performance compared to targets on new norms. At present most managers do not have the tools available to redesign policies. We conjecture that this explains why reframing is the least popular mode of decision-making.

Notes

[1] Senge (1984) has discussed the idea that models in system dynamics are like Buckminster Fuller's notion of artefacts, these are tools that facilitate the transistion to new models of thinking . See laso Senge (1991).

[2] The data are held in tables for every required two-dimensional pairing. Consolidated data lead to further two-way tables that aggregate data from a lower level. However, the user is unaware of these details because the inetrface provides an intuitive way of switching dimensions and levels as desired, so that at any time the user sees just one of these tables.

[3] In the wider context of daily problem-solving, system dynamics should be seen as one of several tools that managers may wish to use. This point has been discussed by Lane (1993).

[4] The research of Stewart (1967) and Mintzberg (1975) showed that managers spent most of their time on short-term activities, with longer periods of reflection occurring infrequently (for example, periods of half an hour alone occurring once a day or so). Similarly, the majority of EIS users spend less than half an hour a day with their computers (Watson *et al*, 1991). Therefore they do not spend nough time carrying out deep investigations and so they tend not use the programming capability of systems. This contrasts with the time required for managers to understand even a simple model in their own area of expertise, as recounted by Lane (1993).

[5] Morecroft (1985) has discussed system dynamics with respect to different strategic contexts, making the distinction between corporate, business and functional strategy. He remarked that system dynamics is best associated with business or functional strategy (ie. it is to be implemeneted at the business unit level) rather than with corporate strategy. This suggests that system dynamics will also be more suited to mid-level managers.

[6] Nutt (1993) classified decisions according to the way a direction was chosen for the decision process. Directions arose from either : existing ideas (ready-made solutions); or problems (concerns and difficulties); or targets (objectives indicating desired ends); or reframing (this referred to creating new norms to guide the decisions). The decision diagnostic was the mnethod of monitoring the progress of the process. He classified diagnostic as quantitative, qualitative, a mixture of both quantitative and qualitative, or impressionistic. He then found the most popular and the most successful combinations of decision direction and diagnostic. He measured the success of decisions in terms of percentage of initial adoptions, sustained adoption percentage, perceived value and the speed of decision.

7 Unless system dynamics is to be used to design the information delivery system, for example by using the Bradford Information System Evaluation Methodology of Wolstenholme *et al.*, (1993).

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