A System Dynamics Tool for Evaluating IT Investment Projects

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Abstract.
Systems dynamics modeling is the technique of constructing and running a model of an abstract system in order to study its behavior without disrupting the environment of the real system. The process simulated in this study, that is, evaluation of IT investment projects, is one of increasing importance as it has been observed that 90% of all senior IS managers have no idea how to determine the value of information systems. In an era where cost overruns and cancelled projects cost millions of dollars, a simulation tool which can rapidly calculate the benefits to be derived from an information system can be very useful. The existing literature identifies noticeable gaps between academic theories, commercially available methodologies and actual evaluation practices promoted by organizational rules and structures, informal practices implemented by stakeholders and academic recommendations which are not used in practice. Problems relating to evaluation of IT investment projects were established-. Understanding these problems would in the long run reduce losses due to failed IT investments. In this study, five different methodologies were investigated taking into account the suitability or goodness of the framework, bias, focus and complexity. The System Dynamics Methodology was found to be the best as the others had serious shortcomings. A model derived from earlier work by Seddon *et al.,* as well as Delone and Mclean was used to construct a dynamic hypothesis that helps to realize the interrelationships between the critical variables. A causal loop diagram derived from the dynamic hypothesis was also constructed. A simulation tool for evaluating IT investment projects was developed to help managers cut down on time spent debating investment decisions, cut down on costs, reduce information overload and help researchers evaluate related problems. The simulation tool was used to analyze how different variables interact to affect the total benefits of an information system. It was observed that only a strong interaction of people, information, and technology can improve business performance, and consequently lead to Information Systems success.

Keywords: Evaluation; Decision Support System; Modeling; Simulation.

INTRODUCTION

Increased competition and the global economic aspects have forced companies to cut costs significantly, through the empowerment of lower-level staff and the removal of middle management.
These trends are increasingly supported by developments in information technology (IT) (Serafeimidis and Smithson, 1998) The existing literature (Willcocks and Lester, 1994; Ballantine *et al.,* 1995; Ward *et al.,* 1996; Farbey *et al.,* 1999; Serafeimidis and Smithson, 2000 identifies noticeable gaps between academic theories, commercially available methodologies and actual evaluation practices promoted by organizational rules and structures, informal practices implemented by stakeholders and academic recommendations which are not used in practice.
Many organizations are experiencing difficulties with evaluating information systems. It is further indicated that more than half of the organizations do not apply any formal evaluation at all (Willcocks, 1996; Dhillon, 2000). And it has been shown that 90% of all senior IS managers have no idea how to determine the value of information systems (Dhillon, 2000) .
Many researchers have stated problems and suggested solutions related to evaluation of IT investments and IS projects, notably (Hirscheim and Smithon, 1988; Orlikowski and Crash, 1994; Farbey *et al.,* 1995; Dhillon and Backhouse, 1996; Irani and Love, 2001) , but they are not appropriate for a developing country like Uganda, where managers are not comfortable with information Systems (Dhillon, 2000). Although there are already other studies in IT investment evaluation, they are not customised to support an individual manager at the desktop. Others are overly complex in nature and require experts to operate them. It is impossible to design a perfect Decision Support system that would be both highly pre-customised and highly customizable

(Gachet and Haettenschwiler, 2003). The growing dependence of organisations on IT is viewed by many as a source of uncertainty. It is difficult to identify and measure the potential benefits and costs of an IT investment (Serafeimidis and Smithson, 1998). It is also true that IT evaluation is complex and elusive (Hirscheim and Smithson, 1988; Dhillon, 2000). According to Dhillon (2000), a phenomenal amount of money is lost because of inability of organisations to realise IS/IT benefits. Figures coming from the United States suggest nearly $ 59 million in cost overruns and some $ 81 million in cancelled IS/IT projects (Johnson,1995). In Uganda, IT investments seem to have run into difficulties with the latest being the Electoral Commission Voters' Register System. It was hatched in 1995 but todate, its benefits have not been realised. Executives often face information overload when they have to decide whether to invest in new IT projects or when management demand an audit of a completed project. The existence of a simple and easy to use tool for evaluation would greatly reduce this information overload.

IT INVESTMENT EVALUATION

The essential questions are how and when to evaluate IT investments. There are three interrelated questions. How does information technology (IT) improve business performance? How do we decide the IT projects in which to invest? How do we assess the performance of systems after their implementation? The use of different evaluation techniques to answer

This question varies from organisation to organisation. Research into the use of these techniques and their value to different organisations provides varying responses (Serafeimidis and Smithson, 2003; [69], Berghout, 1997; [10]). Earl (1989), stresses that not all organisations face an identical challenge, their business sectors differ, the competitive forces they combat vary, their histories are not alike and they make different strategic choices. In addition, organisations must evaluate where in their evolution of IT developments they stand so as to ensure that they are able to make and manage the appropriate degree of strategic change. Farbey *et al.*,(1993) argue that the search for a single technique for evaluating investments in IT is fruitless. The range of circumstances that one technique would have to be applied to is so wide that no single technique is likely to be applicable. Berghout (1997) concludes that a mixture of both qualitative and quantitative methods should be used.

Seddon *et al*- IS Effectiveness Matrix (Seddon, 1998) was a clear breakthrough. In their presentation, they argued that a large number of IS effectiveness measures can be found in the IS literature. What is not clear in the literature is what measures are appropriate in a particular context.

The traditional evaluation methods and their shortcomings are discussed below (Berghout, 1997;Andresen (1999); (Kennedy, 1999; Adler, 2000):

To guide management decision making in the Information Systems Investment Appraisal process a number of "traditional" investment appraisal techniques, based on financial management techniques are normally employed. As commonly used these "traditional" investment appraisal techniques such as Payback, Accounting Rate of Return [ARR], Net Present Value [NPV] and Internal Rate of Return [IRR], are not able to measure many of the benefits offered by IS investments that are intended to gain tactical or strategic business advantages. This is a particular problem with those projects designed to achieve a 'transformation' of the business processes

We may conclude that each of these methods does have a shortcoming as far as ease of use, bias and objectivity are concerned. This shows that a common platform is needed for managers to have confidence in the decisions they make (Berghout, 1997; Andresen 1999; Adler, 2000)

METHODOLOGY

Nowadays, more modeling and analysis techniques often based on simulation or work flow techniques are used in predicting the effects of change. System dynamics is a method for analysing the behaviour of any kind of system: biological, physical, sociological, economic, and others. It provides a high level view of the system emphasising the interactions between its constituent parts, as well as the impact of time on its dynamic behaviour (Hustache *et al.,* 2001). It is also a technique of constructing and running a model of an abstract system in order to study its behaviour without disrupting the environment of the real system. Simulation is the process of forming an abstract model from a real situation in order to understand the impact of modification and the effect of introducing various strategies on the situation (Williams, 2004).

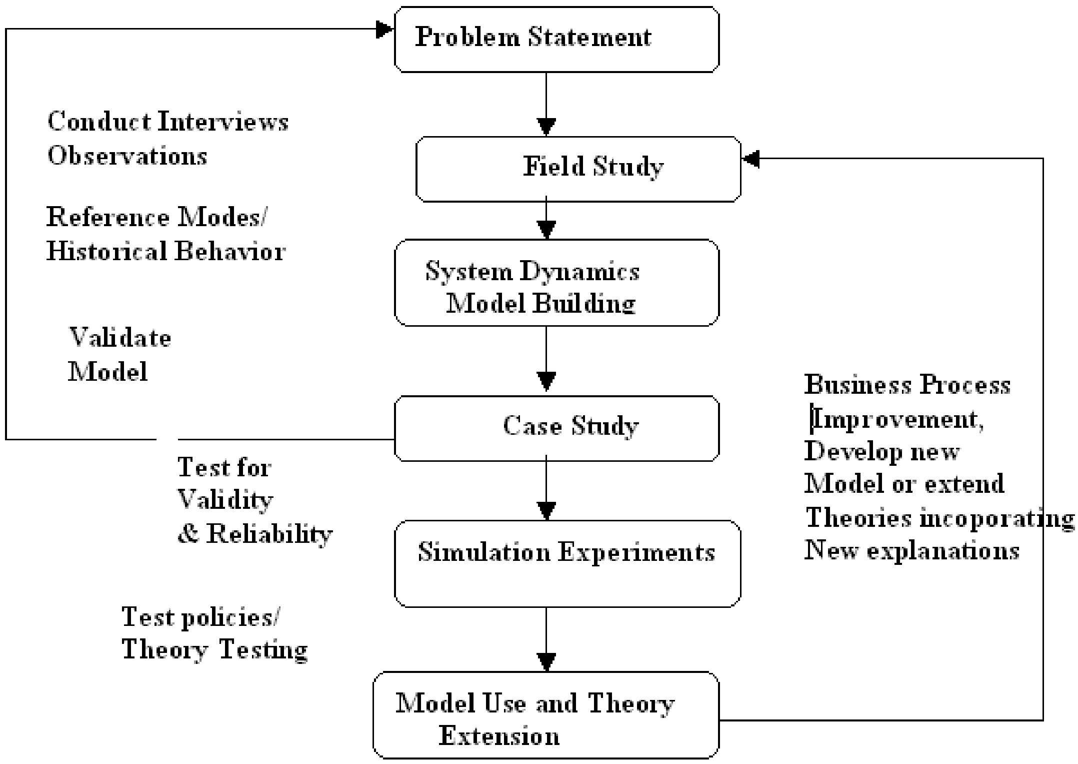


Fig2. System Dynamics Methodology (Adapted from Williams, 2004)

The study followed the methodology as espoused by Williams (Williams, 2004), Fig.2; where he advocates simulation as one of the main strategies for this kind of research.

MODEL SUBSYSTEMS

The simulation tool had three subsystems, that is the Information System, Users and Benefits.

Information System

The key variables for the Information System are: Rate of Information Quality, User Satisfaction, Rate of System Quality, and Service Quality. The information system sector provides intention to use, user satisfaction, information quality as well as system and service quality to the users sector.

User Interaction with the Tool

The user opens the tool by double clicking on it. When the tool opens, the graphical interface for running the simulation also opens. The user can click on the question marks of each sector to view the documentation about that particular sector. By using the navigation keys, she can navigate between the interface and the stock and flow part. In case the user wants to change the variables to run in the experiment, she simply double clicks the graphical interface, which allows her to change them. Clicking on the Run button on the tool starts the experiment.

Users

The key variables for the Users sector are: Individual Benefits, Organisational Benefits, and Society Benefits. The inputs to the Benefits Sector are the Individual Benefits, the Organisational Benefits, and Society Benefits. The users generate individual benefits, society benefits and organisational benefits to the benefits sector.

Benefits

Benefits are fed back to the information and users sectors as feedback, thus bringing in complexity.

The Dynamic Hypothesis

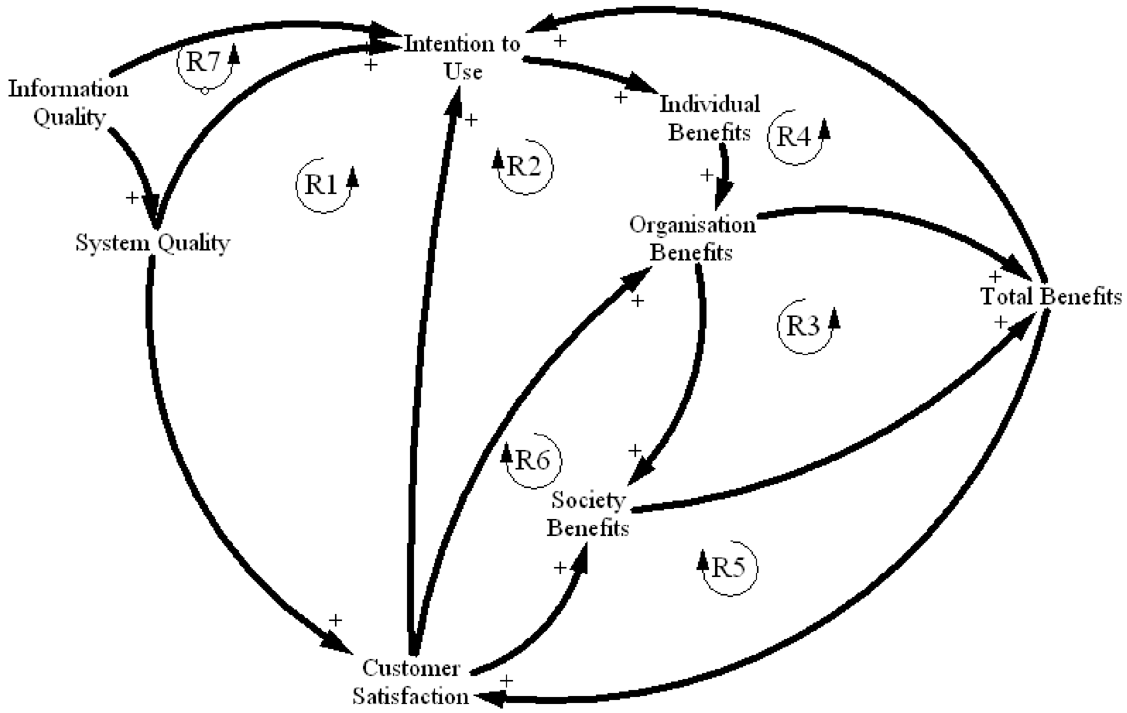


Fig3. The Dynamic hypothesis

The total benefits change over time as a result of variations in system quality and information quality. These affect the users' intention to use the system and customer satisfaction. The result is that individual, society andorganisation benefits are influenced which again affects total benefits in another feedback loop. Achange in total benefits has a direct effect on customer satisfaction and users' intention to use that system. This is what is captured in our dynamic hypothesis in Fig. 3.

The initial IT investment feedback structure (Fig.3) contains seven dominant feedback loops all of which are **R**einforcing loops (**R**). An increase in Information Quality leads to an increase in System Quality, giving rise to an increased Intention to use the system by the users. On the other hand, an increase in System Quality gives rise to increased Customer Satisfaction, which in turn increases the Intention to use the system by Users. Increased Customer satisfaction increases both Society benefits and Organizational benefits. These serve to increase the Total Benefits giving rise to an increased Intention to Use the system by the Users and increased Customer Satisfaction.

SIMULATION EXPERIMENTS

A number of simulation experiments were carried out as seen from two of them in Fig. 4 (page 5) and Fig 5 (page 5).

As the graph below shows (Figure 4), both the total benefits and user satisfaction rise slowly up to around 10 months where the two intersect and user satisfaction increases at a higher rate than total benefits. Intention to use increases slowly up to 15 months where it is affected by changes in individual benefits. On the other hand, individual benefits are sporadic but low up to 15 months when they rise and increase sporadically. From Figure 4 we can infer that the changes in user satisfaction and total benefits are affected by feedback that affects the changes in individual benefits.

Fig 4. Total Benefits as a function of User Satisfaction, Intention to Use and Individual Benefits.

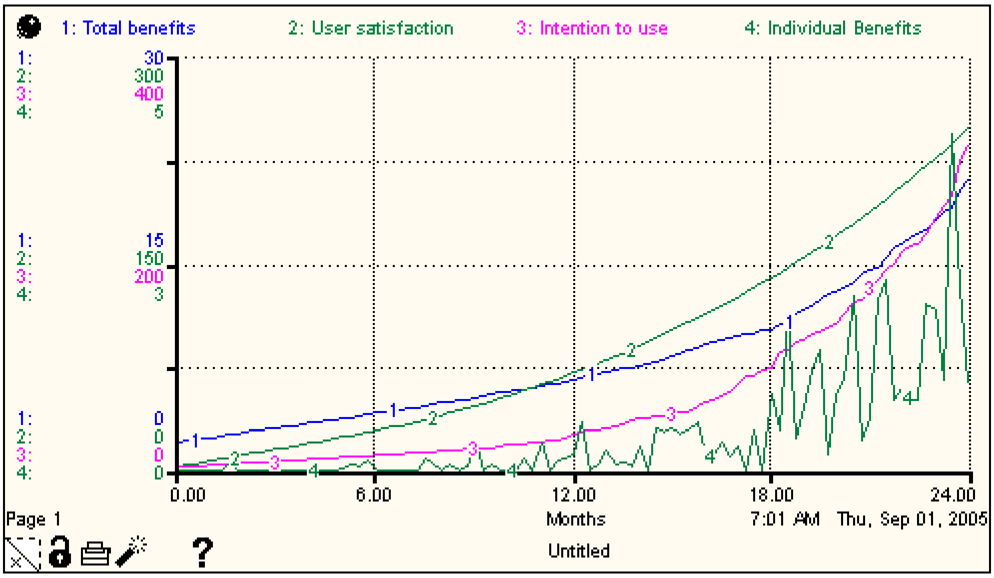
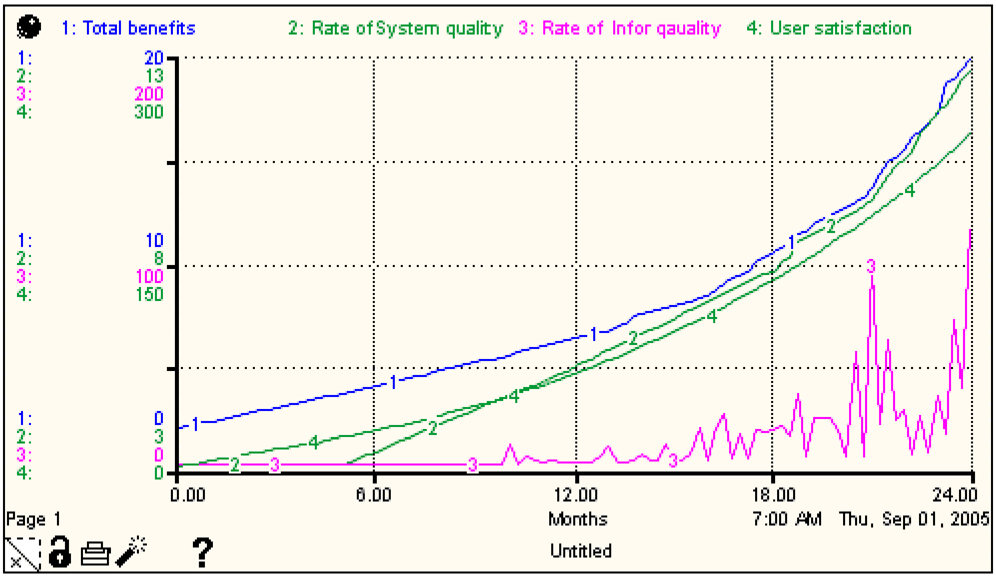


Fig 5. Total Benefits as a function of Rate of System quality, Rate of Information Quality change and User Satisfaction.

As the graph below shows (Figure 5), total benefits and user satisfaction rise at a slow rate giving an almost straight line from the start up to 13 months, as opposed to the other variables. It is observed that these are spurred on by an initial rate of system quality, which also increases gracefully up to 18 months. Around 18 months, the rate of system quality suffers from sporadic increases, which could be the reason why the rate of system quality suffers from some instability at this time. Information system success in this experiment is very stable and rises predictably. From Figure 5 we can infer that this scenario captures the most important elements related to information system success.



DISCUSSION OF FINDINGS AND CONTRIBUTION

Shortcomings in evaluation of information systems were identified. Critical variables in information system evaluation were identified for inclusion in a simulation-based tool. Five different research methodologies were investigated taking into account the suitability or goodness of the framework, bias, focus and complexity. The Systems Dynamics Methodology was found to be the best as the others had serious shortcomings.
The literature review highlighted the fact that depending on the background of the manager, they would use a different evaluation method. This means that there is no common platform or communication language for managers to communicate their decisions and the reasons as to why they arrived at particular decisions. This study made an attempt to provide that common platform by presenting a Systems Dynamics Tool for evaluation of information systems.
The Simulation tool runs with a maximum of five variables. When the model is run it shows us a peep into the future of what our policies and actions can do without taking the real risk of trying them out in the real world. These can be changed until a satisfactory mix of policies and actions are arrived at.
This research makes a significant contribution to the literature in terms of bringing together disparate areas of IT evaluation in a coherent and systematic way. The System Dynamics model of IT investment evaluation constitutes a novel source of new knowledge and provides an understanding of the area to both researchers and managers. The model helps in understanding the patterns of change or dynamics that a system exhibits over time and identifies the conditions that cause these patterns to be stable or unstable. This knowledge of the system can then suggest what kinds of prescriptions for governing it will work and what kinds may not.

CONCLUSIONS AND FUTURE WORK

The main contribution of this paper is a tool that will help managers cut down on time spent debating investment decisions, cut down on costs, reduce information overload and help researchers evaluate related problems.
The simulation model was used as a tool for evaluating the benefits derived from an information system using different variables like rate of information quality, rate of system quality, intention to use, user satisfaction, individual benefits, society benefits, organisation benefits, as well as total benefits. It was possible to calculate and observe the total benefits, user satisfaction, rate of information quality, rate of system quality, organizational benefits, societal benefits as well as intention to use. It was observed that the combination of rate of system quality, rate of information quality, and user satisfaction provided the best combination for information system success. System dynamics demonstrates how most of our own decision-making policies are the cause of the problems that we usually blame on others, and how to identify policies we can follow to improve our situation (Morecroft, 1999) . The purpose in applying Systems Dynamics is to facilitate understanding of the relationship between the behavior of the system overtime and its underlying structure and strategic policies or decision rules (Caulfield and Maj, 2002). Taking a close look at the variables at play, it is evident that only a strong interaction of people, information, and technology can improve business performance, and consequently lead to Information Systems success.
Further research will be necessary to improve the tool in order to assess the theoretical content of the model. Another area that could be investigated could be the inclusion of the cost of the resources like equipment, software and people as a variable to be modelled along with the original variables in the model.

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BIOGRAPHY

Paul Ssemaluulu obtained a FTC in Telecommunications from Uganda Polytechnic Kyambogo in 1985. He also holds a BBA from Makerere University in 2001, a Msc in Computer Science in 2006 and is a PhD student in Information Systems at Faculty of Computing and IT, Makerere University.

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