A System Dynamics Tool for Evaluating the Impact of Information Quality on Customer Satisfaction in IS Projects

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1 INTRODUCTION

Information quality and customer satisfaction in Information System evaluation has become an important area of research and practice. There is an increasing interest in deriving business value from information systems (IS) investments through effective IS governance (Agarwal and Sambamurthy, 2002 [3], Shane et al., 1999 [73]). In many organisations, IS investment represents a large proportion of capital outlay, and indeed, its expenditures often represent the fastest growing category of investment for the organisation (Strassmann 1997) [88]. Thus IS assets (in terms of computer hardware, software, telecommunications facilities and human knowledge capital) are very significant, and therefore entitled to careful and systematic investigation and management to attain their value and return to management (Willcocks 1994) [102]. Some scholars have questioned whether IS is a cost or an investment (Venkatraman, 1997) [94]; and many executives hold that IS is a utility and can be outsourced like electricity, water, car fleet or even the canteen (Tiernan and Peppard, 2004) [91]. On the other hand, research findings from notable researchers confirm that IS investment is different from other corporate resources and suggest that there are aspects of IS management that should not be left in the hands of external providers (Lacity et al., 1996 [47]; Lacity and Hirscheim, 1995 [48], 1997 [49]; Earl, 1996 [22]; Lacity and Willcocks, 1998 [50]; Willcocks and Lacity, 1998 [97]).

Delone and Mclean (1992) proposed a conceptual model of IS success that comprised of six variables, that is; system quality, information quality, use, user satisfaction, individual impact, and organizational impact. The IS investment evaluation is a procedure which is accomplished before the implementation of a project and thus helps in the selection among alternatives. Consequently, the role of information quality and customer satisfaction in this process becomes very important.

1.1 Background to the Study

The decisions that managers make regarding IS investment most times impact on the cost and eventual success of the IS systems that are put in place. In addition to this, the eventual cost of the IS investment may also depend on the decisions that these managers make. When making these decisions, it is important for them to be well informed with quality information, so as to come out with informed decisions. Accampo (1989) as quoted by Murphy and Simon
(2002) [60] states that "quantitative techniques can be hard to apply to activities in which information is the key commodity". Murphy and Simon (2002) [60] contend that “many of the measures found in the IS literature that are used to evaluate system success are intangible” and that “traditional methods of project evaluation fall short if theses measures cannot be quantified in monetary terms”. In their work on system success, Delone and McLean (1992) [19] have observed that System quality and information quality are related to system development and system use and user satisfaction are relevant to implementation. In this study, system use and user/customer satisfaction reflect expectations of the customer. Delone and McLean (2002) [20] state that information quality and system quality, are the most important quality components to measure the success of an IS in an organisation. On the other hand, Reicks (2001) [64] states that “most people want access to the right information, as they recognize that sharing the right information with the right people at the right time, can empower these individuals”. This helps them make the right decisions. Khalifa and Liu (2004) [44] conclude that perceived benefits (IS success) are measured by expectations, ease of use and perceived usefulness.

Despite these research developments, there is still a poor understanding of the relationship between information quality and customer satisfaction. Research clarifying these variables in IS evaluation is also rare and no research has examined the impact of information quality on customer satisfaction.

This research will clarify this relationship using system dynamics modelling approach.

1.1.1 Definition of Terms to be Used in the Research

To put this research in context, this section defines key theoretical terms used, including System dynamics, System dynamics model, Evaluation, Information Quality, and Customer Satisfaction.

**System dynamics**: Involves the use of a computer program constructed to “mimic” the operation of the system. Typically, a simulation model will have software components which correspond to the major components of the system. In addition, the model will have entities, which model the behavior of the active entities found in the system. The goal is for the behavior of these entities in the model to accurately portray the operation and performance of the real system (Schwetman, 1999) [76].

**System dynamics model**: A system dynamics model is built to understand a system
of forces that have created a “problem” and continue to sustain it. To have a meaningful model, there must be some underlying problem in a system that creates a need for additional knowledge and understanding of the system (Forrester and Senge, 1980) [27].

**Evaluation:** Is the systematic acquisition and assessment of information to provide useful feedback about some object.

**Information Quality:** Delone and Mclean define Information quality as the focus on the output produced by a system and the value, usefulness or relative importance attributed to it by the user (Delone and Mclean, 2002) [20].

**Customer Satisfaction:** Delone and Mclean define customer satisfaction as “the extent to which users believe the information system available to them meets their information requirements”. (Delone and Mclean, 2002) [20].

### 1.1.2 Problems in Evaluation of IS Projects

Several authors have highlighted problems associated with IS investment which makes information quality and customer satisfaction difficult to measure.

1. **Complexity of IS projects is one of the causes of problems in evaluating IS projects.**
   
   It has been found that Information systems themselves are complex social objects inseperable from the organisational context within which they are situated and the infrastructure supporting them, and are products of history and human agency (Symons, 1994) [89]. This means that they affect the people who use them and are in addition affected by these very people. Many IS projects are designed to improve the operation of business activities that are dynamic, complex, non-linear systems which cannot be readily understood by using static modelling approaches. The dynamic systems are characterised by interactions of closed chains (or feedback loops) that, when combined, define the structure of the system and hence how it behaves over time (Kennedy, 2001) [46]. This affects correctness of output and makes it difficult to estimate the exact expenditures and therefore benefits (Marquez and Blanchar, 2004) [55].

2. **IS evaluations are dominated by multiple view points which are not captured using current evaluation methods (Marquez and Blanchar, 2004) [55].**

3. **The role of soft factors such as motivation and perceptions has also not been appreciated in IS evaluation literature (Caulfield and Maj, 2002) [16].** If you omit soft
variables you run the risk of failing to capture something essential to driving human affairs.

4. Poor information quality impairs decision making and promotes inefficiency. One reason for this is that managers depend on this data to order for equipment, select suppliers and contractors.

A better understanding of how individuals interact with information systems requires an understanding of how they perceive the quality of the information delivered by that information system. What has become clear is that people and processes have a greater effect on project outcome than technology (Sabherwal et al., 2005) [71]. The nature of the above problems and their sources as discussed in section 2.3 suggest that there is a need to apply methods that can model complexity and nonlinearity that is associated with feedback systems.

1.2 Statement of the Problem

The measurement of IS success in IS projects has generated a lot of interest among researchers. Key measures of success include system performance, effectiveness, quality, use and user satisfaction. The most commonly used measures of IS success are system usage and user satisfaction. However various studies that have attempted to explore the relationship between system usage and user satisfaction have had inconclusive results (Bokhari, 2005) [10]. No research has been done to establish a relationship between information quality and user satisfaction. The researcher will use the Dynamic Synthesis Methodology (Williams, 2004) [100], which brings together two complementary research approaches; that is System Dynamics (Forrester and Senge, 1980) [27] and Case Study method (Yin, 2002) [103], in order to improve the understanding of information quality and customer satisfaction.
1.3 Aims and Objectives

1.3.1 Aim

The main aim of this research is to develop a system dynamics model as a tool for evaluating the impact of information quality on customer satisfaction in IS investment evaluation. This will help managers and researchers to better understand IS investments and to make informed decisions based on the knowledge and insights generated.

1.3.2 Specific Objectives

The specific objectives of the research programme are to:

1. To investigate issues and identify factors that affect IS investment success related to information quality and customer satisfaction.

2. Design a conceptual system dynamics model incorporating the key variables that comprise the IS investment process.

3. To implement a system dynamics model using Stella simulation tool.

4. Validate the Dynamic Synthesis Methodology as a problem solving method (Williams, 2002) [99].

5. Validate the systems model as a tool for evaluating IS investment projects.
1.3.3 Reference Modes and Dynamic Hypothesis of Key Variables

In System Dynamics research, reference modes constitute perceived qualitative mental models about key variables that are problematic and central to investigation; as shown in the Figs. 1 and 2 (Pages 6 & 7) below:

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Figure 1: Reference Modes of key variables(1)
Inherent problems of IS investment are due to complexity of the IS investment (Symmons, 1994) [89], the quality of information to be derived from the system (Bailey and Pearson, 1983) [7], system quality (Scotland and Norman, 1981) [80] and the total benefits to be derived from the system (Scott, 2000) [79]. We can postulate that the probable effect of increased system quality and reduction in system errors on cost of resources, customer satisfaction, intention to use the system, and total benefits of the IS investment. Fig.1 indicates a mixture of growth and declines in system errors, cost of resources, intention to use the system, system quality, customer satisfaction and total benefits over a period of 5 years.

Figure 2: Reference Modes of key variables(2)
Dynamic Hypothesis

A dynamic hypothesis is an explanation of the reference mode behavior and should be consistent with the model purpose. A modeler uses a dynamic hypothesis to draw out and test the consequences of the feedback loops. A model cannot be built without an understanding of the feedback loops. The dynamic hypothesis of the IS Project Evaluation is shown in the Fig.3 (Page 8) below:

![Dynamic Hypothesis of the IS Project Evaluation](image)

Figure 3: Dynamic Hypothesis of the IS Project Evaluation

The fluctuations in variables presented in Figs.1 and 2 over time form the basis for interventions of IS investment stakeholders through managerial activities concerned with decision making (Delone and Mclean, 2002) [20]. These reference modes provide significant insight into the underlying dynamics present in a system. Fig.3 (Page 8) provides a theoretical statement of the underlying hypothesis proposed in this thesis. It is these interactions as depicted in Fig.3 that determine the process behavior patterns over time as a result of effects from project productivity improvements. The initial IS investment feedback structure
Definition 1-4 Reinforcing Loop (R) or positive feedback is a representation of growing or declining actions. In this case, a positive loop response reinforces the original perturbation.

1.4 Key Factors in IS Investment Evaluation

The IS investment benefits change over time as a result of variations among total benefits, customer satisfaction and cost of resources. Based on the dynamic hypothesis presented in Fig.3 (Page.8), one can deduce that the information system users seem to have mixed satisfaction levels about the total IS success, an end product of the IS investment itself. During some periods, customers discover system errors. These errors increase the cost of resources and at the same time reduce information as well as system quality. When these increase, the intention to use the system reduces, thus reducing benefits and consequently customer satisfaction. When the system errors are corrected, either through repairs or redesigning the system, there is an increase in cost of resources which inevitably reduces customer satisfaction in the shorter term, but later improves information and system quality, which improves customer satisfaction. The problem statement implies that a system dynamics IS investment model should show a tendency towards fluctuations in the IS success, the cost of resources, intention to use the system and customer satisfaction as a result of improvements in the system quality. The problem statement identifies these important variables from the literature. These key variables are as follows: (Delone and Mclean, 2002) [20].

{Units of measure or dimensions are given in curly brackets}

**System Errors**: these are number of errors discovered by customers (Users) during system use and requests are made to either redesign or repair \{Errors\}.

**Cost of Resources**: relates to the total cost of resources in terms of wages, documentation, training, repairs/redesign and initial set-up costs in US Dollars \{US Dollars\}.

**Intention to Use the system**: refers to the fractional use of the computer system and can be affected by the degree to which system characteristics match user task needs \{0-1 Scale, fraction\}.

**System Quality**: refers to fractional performance of the system in relation to data currency, response time, data accuracy, reliability, completeness, system flexibility and ease of use \{0-1 Scale, fraction\}.
Information Quality: relates to the fractional output produced by the system and the value, usefulness or relative importance attributed to it by the user. It looks at accuracy, precision, currency, output timeliness, reliability, completeness and relevance {0-1 Scale, fraction}.

Customer Satisfaction: is a customer’s fractional level of content with the quality of the services provided by the computer system based on perceived quality of the system and the cost of resources passed on to the customer {0-1 Scale, fraction}.

Perceived IS success relates to the fractional output produced by the computer system as a result of all the other variables. It is difficult to isolate any single variable as being the most significant in contributing to the perceived IS success {0-1 Scale, fraction}.

These variables provide a reasonable starting point for conceptualising the feedback structure governing the dynamics in the IS investment evaluation. A description of the quantitative behaviour of these key variables also form a reference mode necessary to reinforce the understanding gained from the problem statement identified, as shown in figures .1 and 2 pages 7 and 8.

1.5 Proposed Research Approach

A number of authors state that forcing evaluation methods into particular categories, be they quantitative/qualitative, formative (as a means of improving programme implementation) /summative (to demonstrate accountability) , is self-defeating and leads evaluators to label themselves as one thing or the other to the exclusion of other methods (Cullen et al., 1993 [18]; Patton, 1981 [62]). Sommerlad (1992) [83] argues that methods need to be chosen according to particular situations based on criteria such as stakeholder, resources, expertise, organisational politics and the nature of evidence required. Herbert and Shepherd (2001) [37] call for triangulation of methods. As a result, studies are able to benefit from the advantages of quantification, representativeness and attribution. They also capture the diversity of opinions and perceptions as well as unexpected impacts. These behavior patterns need a methodology that can adequately capture them.

This thesis adopts the Dynamic Synthesis Methodology research design (Williams, 2004) [100] which combines two powerful research strategies, that is field studies-based case research method (Yin, 2002) [103] and system dynamics modelling (Forrester and Senge, 1981 [27]; Marquez and Blancher, 2004 [55]; Williams, 2004 [100]). System dynamics models help to
understand the relationship between behavior patterns and system structure (Marquez and Blancher, 2004) [55], while case studies (Yin, 2002) [103] capture reality in greater detail and enable analysis of more variables than is possible using other research strategies. As discussed further in chapter three, DSM is an ideal methodology when a feedback system is investigated and the structure is dynamic and non-linear including the effects of delays and system performance.

1.6 Scope

The researcher will use the following scope:
Level of analysis/Project lead time- Any large firm that uses IS, with field study of 3 months.
Case study- The researcher will limit the field case study to the business district of Kampala City in Uganda. The researcher will take the two leading Telecom Companies, that is MTN and UTL which have among them a total of 1.6 million users. Thus they have a very rich database on IS implementation. The research will be limited to finding out customer satisfaction at the strategic level of management decision making, for the selection of candidate IS projects.

1.7 Justification

This research is important in IS projects and is beneficial for the following reasons:
The measurement of IS success has become an important area of investigation to researchers and practicing managers, with the most commonly used measures being system usage and user satisfaction. Various studies that have attempted to explore the relationship between system usage and user satisfaction have ended up with mixed results (Bokhari, 2005) [10]. An investigation into the relationship between Customer (User) Satisfaction and Information Quality will help to better understand and explain the nature of the relationship by resolving any inconsistencies that exist.
In many organisations, IS investments represent a large proportion of capital outlay, and indeed, IS expenditures often represent the fastest growing category of investment for the organisation (Strassmann 1997) [88]. Thus it can be concluded that IS assets (in terms of computer hardware, software, telecommunications facilities and human knowledge capital) are very significant, and therefore entitled to careful and systematic investigation and man-
agement to attain their value and contribution, and return to the organisation (Willcocks 1994) [102].

Dynamic Synthesis Methodology (DSM) models help to understand the relationship between behavior patterns and the underlying system structure because they apply system thinking and simulation modeling of complex situations so that they can ultimately be better understood and managed (Caulfield and Maj, 2002) [16]. Problems related to system behavior can then be solved by exploring the system structure.

Visualisation-IS project outcomes are effectively invisible. This visualisation problem is a source of many IS project failures. Senior managers may ask for functions that are over-ambitious, or even impossible to deliver, without having any sense of the level of complexity entailed in meeting their request (Sauer and Cuthbertson, 2003 [72]). Dynamic Synthesis Methodology helps in bringing out this visualisation in form of models and eventually in the Simulation experiments over time. This helps the Manager get a birds’ eye view of the whole project scope before it is implemented.

Risk Management-An essential element in successful project management is identifying the risks and managing them. It has been shown that risk management is one of the most neglected aspects of IS project management (Sauer and Cuthbertson, 2003 [?] Sau. Using simulation, risks are easily visualised by carrying out sensitivity analysis on the variables used in the modeling process. This helps everyone involved to properly understand the inherent risks at an early stage before implementation. Thus in the extreme, the project would not take off.

The problem of IS investment evaluation has not been well understood. This research will make a significant contribution to the literature in terms of bringing together disparate areas of IS evaluation in a coherent and systematic way. The traditional approaches have been found to be inadequate when used to evaluate IS investments because of their use of only one measure (monetary value) (Ekstrom and Bjornsson, 2003) [24].

IS investment is composed of complex systems and thus have a high degree of feedbacks among variables of interest thus rendering the traditional methods inappropriate in assessing such investments.

The System Dynamics model of IS investment evaluation will constitute a source of new knowledge and provide an understanding of the area to both researchers and practicing managers. The model will be used to help understand the emergent patterns of change or dynamics that a system exhibits over time and to identify the conditions that cause these patterns. The tool developed can be used as a training tool for managers and researchers in
IS investment evaluation projects.

2 Literature Review

This section reviews the literature on IS investment evaluation approaches. Section 2.1 reviews the State of the art in IS investment evaluation, while 2.2 reviews the State of the practice in IS investment evaluation. Section 2.3 reviews techniques/methods used in IS investment evaluation. Section 2.4 deals with sources of problems in IS investment evaluation.

2.1 State of the Art in IS Investment Evaluation

Literature on evaluation of information systems has been growing since the seventies (Frielink, 1975; Joslin, 1977; Borovits and Neuman, 1979). Many studies have been conducted in this area (Kauffman and Weill, 1989; McKeen and Smith, 1993 [56]; Willcocks, 1992; Farbey et al., 1993 [26]; Serafeimidis and Smithson, 2000) [78], and conferences have been devoted to this subject (The 15th International Conference on Information Systems research theme “Improving productivity and adding value through information systems”, and The European Conference on IT investment evaluation, Henley-on-Thames, 13/14 September 1994 and 11/12 July 1995). Failure of value generation of information systems is also documented (Love- man, 1988; Roach, 1989; Svendsen, 1996). A perceived lack of effective IS benefits often creates difficulty in justifying future expenditure and managing the benefits of IS innovations. The problem of identifying IS costs and benefits is neither new nor unique to a given sector. This means that organisations will have successful IS applications only when the drivers for the investing in IS, the expected benefit set, and the organisational mode of working have been carefully considered (Dhillon, 2000) [21]. It has been proposed that IS managers frequently lack a full understanding of their organisations’ business and are often not involved in the senior management decision-making of the company (Andresen, 2000) [2]. Senior management who do understand the business are usually not comfortable with the emerging information technologies (Andresen, 2000) [2]. When considering new IS investments, senior management seldom have feedback from previous investments to provide comfort for their earlier decisions (Ballantine and Stray, 1998) [6].
2.1.1 Models of IS Investment Evaluation

1. Delone and Mclean (2002) [20] give a lot of insight in their model as shown in figure 4 below, but their focus is geared towards the Total Benefits derived from the information system. Renkema and Berghout also carried out research in the Universities of Amsterdam, Delft and Eindhoven. In their work, they reviewed methods for the evaluation of IS investment proposals, with a view to improve insight into these current methods [66].
2. Wilkin and Castleman New IS Success Model (Wilkin and Castleman, 2003) [96]. In this model, the variables were grouped together under the argument of presenting a better model as compared to the Delone and Mclean Model. The problem is that the model ignores feedback, which is very important in IS systems.

![Diagram of Wilkin and Castleman Model](image)

Figure 5: Wilkin and Castleman Model[ 2003]
3. Seddon *et al* IS Effectiveness Matrix (Seddon, 1998) [77]. In their presentation, the researchers 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.

![Seddon IS Effectiveness Matrix](image)

Figure 6: Seddon IS Effectiveness Matrix[ 1998]
2.1.2 Techniques and Methods Used in IS Investment Evaluation

Several authors have indeed evaluated the field of IS evaluation, and a number of techniques and methods that are used to evaluate individual projects as set out below:

1. Strategic Cost Management- This seeks to manage costs for both financial and competitive advantage and long- and short-term control. The accomplishment of this aim is supported by an integration of the fields of management accounting, production, and strategic planning. This provides for formulation of strategies, communicating them through the firm, developing and executing tactics to implement them, and developing and implementing strategic controls. It basically consists of value chain analysis, competitive advantage analysis and cost driver analysis (Adler, 2000) [4].

2. Multiattribute Decision Model (MADM)- This attempts to develop a general measure of utility, defined as the satisfaction of an individual’s or set of individuals’ preferences. A distinct advantage of this model is that it can assess an investment’s impact even when some of the factors cannot be estimated in monetary value. The model is built by putting together a list of factors deemed important in judging an investment. Financial measures such as payback and NPV may be included as well as non financial measures as reduced complexity, improved information, and enhanced company image. A weight representing a factor’s importance to the firm is then assigned to each factor and scaled so that the combined weightings equal 100. Ratings are then assigned to the factors based on beliefs about the effect, the alternative courses of action (including the status quo) will have on each factor. A 0 signifies decreased performance, 1 unaffected performance, 2 improved performance (Adler, 2000) [4].

3. Value Analysis and the Analytical Hierarchy Method- These two are very similar to the Multiattribute Decision Model (MADM) and are considered as its subsets. They only differ in terms of the information-gathering techniques they rely on. The Value Analysis method typically relies on a Delphi technique, which begins with selecting a group of "experts". Each member of the Delphi group is asked to list the benefits that would accrue from adopting the proposed investment. Aggregate group responses (in which no one individual’s response can be detected) are fed back to all group members. This feedback mechanism helps the members ground their thinking in terms of the whole group, ensures confidentiality whereby no one individual can influence the
process due to rank or charisma (Adler, 2000) [4].
The Analytical Hierarchy process surveys a wide group of managers to determine the measures. Unlike the Delphi technique, it asks selected individuals to make pairwise comparisons between factors’ utilities. The comparisons are then analyzed by a mathematical model to establish the relative weights, ratings and probabilities.

4. Payback Method- Requires very short payback periods, typically two to three years, thus failing to account for cash flows after payback period. The cutoff period is arbitrary, ignores time value of money, and may be misleading when evaluating mutually exclusive projects (Berghout, 1997) [9].

5. Accounting Rate of Return Method and Residual income Method- Managers who are evaluated under one of these methods are unlikely to invest in projects that require long lead times. The trend toward shorter job and company tenures means managers are never sure they will be around long enough to reap the benefits of their long-term investments (Berghout, 1997 [9]; Andresen (1999) [2]; Adler, 2000 [4].

6. Cost-benefit ratio- Ignores time value of money, fails to consider the timing of cash flows, the ratio is arbitrarily set, and does not account for qualitative and intangible factors. The cost-benefit ratio method can also be misleading when comparing multiple projects since the technique is insensitive to the magnitude of the project. Worse still, it ignores risk (Andresen (1999) [2]; Adler, 2000 [4]).

7. Return on investment (ROI)- The ratio is compared to arbitrary yardsticks, ignores time value of money, focuses on accounting income not cash flows, which gets tied up with how the firm treats depreciation, does not account for qualitative and intangible factors and ignores risk (Berghout, 1997) [9].

8. Internal rate of return (IRR)- It is very difficult to calculate for multi-year projects with multiple projects, may provide inaccurate rankings when comparing investments of different size or different timing of cash flows. It also does not account for qualitative and intangible factors (Berghout, 1997) [9].

9. Discounted Cash Flow Methods- Despite their avowed purpose to do otherwise, these methods may also promote a short-term decision horizon. The users of these methods have been accused of using excessively high discount factors, thereby greatly diminishing the benefits of later years’ cash flows (Berghout, 1997) [9].
10. Profitability index (Benefit-Cost Ratio)- Can be misleading when comparing mutually exclusive projects, ratios cannot be summed in the same way values can be added. It also does not account for qualitative and intangible factors (Berghout,1997) [9].

11. Net present value (NPV)- Some executives find this approach more difficult to understand and involved in terms of calculations and thus tend to avoid using it. The risk-adjusted discount rate can be difficult to determine, and does account for qualitative and intangible factors (Berghout,1997) [9].

12. Balanced Score Card
The Balanced Score Card approach attempts to create a measurement balance across the overall performance management framework. It recognizes that broad impact of IS’s supporting role and helps strengthen the analysis of intangible benefits(Kaplan and Norton, 2001) [43]. One of the problems of this approach is that no single measure provides clear performance targets and these vary from organisation to organisation. It is also complex. In addition, there is a tendency to struggle to develop "perfect " measures, instead of thinking in terms of improving measures over time (Lingle and Shiemann, 1996) [53]. This leads to bias.

13. Using Multiple Data Collection Mechanisms and Ensuring System Integrity
While there is widespread use of annual customer surveys, most organisations note that they are very limited in the information they provide that can tie to corrective action strategies (Dhillon,2000) [21]. Another problem is that these only capture problems or feelings and may not be able to capture data to act on.
14. Information Technology Results Success Chain

This methodology involves everyone in the organisation as seen from the figure below. Developing performance measures that demonstrate the impact of information technology on mission performance requires management commitment, experience in constructing and evaluating measures, and a constant learning environment. This presents a potential problem as most IS managers do not know how to formulate these measures. This makes the methodology complex and leads to bias (Brizius and Campbell, 1993) [11].

Figure 7: Information Technology Results Success Chain: Source (Brizius and Campbell, 1993) [11]
2.2 State of the Practice in IS Investment Evaluation

An IS project has two key factors to assess and manage; the hard ones on the nature of the technology and what it can do and soft ones associated with the social and organisational consequences of implementing and using the technology. Many projects have failed because they embrace certain technologies or buzzwords based on their popularity. The methodologies that are recommended by industry and academia are in most cases, not known by managers and practitioners and where they are aware, they are rarely used in practice (Bergh Outstanding, 1997) [9]. According to Brown (2005) [12], ”various researchers have realised that one of the most persistent results of field work on evaluation practice, whatever the original aim of the study, is the continuing relatively unsophisticated and low level of evaluation activity in all types of organisations”. This then means that little or no meaningful IS investment evaluation is being carried out.

In a study of UK construction organisations, CIRIA (1996), as quoted by Andresen et al., (2000) [1] reviewed the procedures used by seven major construction organisations for their internal assessment of potential investments in IS. These organisations included building and civil engineering contractors, civil engineering consultants and one large joint venture construction project. CIRIA concluded that, in the construction industry, formal cost-benefit analysis is not widely used to assess possible investments in IS. This proves to show that neither a consistent approach within individual organisations nor a consistent approach across organisations is done in evaluations.

2.2.1 Some Case Studies

Some case studies from a study by The Royal Academy of Engineering of the UK are reproduced herebelow: (Source Sauer and Cuthbertson, 2003 [72]).

1. Case Study- Libra

Libra was designed to provide a standard IT system for magistrates’ courts including upgraded infrastructure, office automation facilities, a national casework application and electronic links with other criminal justice agencies. The original contract for BP 184 Million was awarded in 1998 but following implementation problems the deal collapsed in July 2002. After renegotiation later in 2002, the infrastructure portion
alone cost over BP 232 Million. The total system would now take 8.5 years to develop and eventual cost was over BP 318 Million.

2. **Case Study-Unrealistic Expectations**

A prominent telecommunications company took on a contract to deliver a major complex IT system. The value they quoted to the customer was $13 Million. After spending $85 Million, the systems delivery team eventually admitted that they could not deliver what they had promised. On hearing that this was the case, the customer responded by accusing the supplier of trying to get out of a difficult situation and forced them to pay $3 Million in liquidated damages. In the end it became clear that the original specification was simply undeliverable and the supplier eventually designed and delivered an alternative solution at a cost of a further $10 million. The seeds of failure were sown at the project outset because the expectations of both the customer and the supplier were much higher than the capability of the supplier to deliver.

3. **Case Study- Scale**

Many retailers store information on what their customers purchase and use loyalty cards to identify each customer. A major supermarket chain decided to use the shopping history held on a central database to identify special offers of particular interest to each customer when they arrived at the checkout and presented their loyalty card. In this case the system held a record of all the items the customer had purchased during the last six months and the supermarket had approximately nine million customers everyday, each purchasing an average of about 30 items. Although the project seemed attractive from a commercial viewpoint, it would have involved searching a four terabyte (4,000GB) centralised database, analysing the results and delivering the information remotely almost instantaneously, to all stores concurrently. Given the existing system architecture, this was impossible.

4. **Case Study- Measurement of Earned Value**

A control system project was taking longer than planned to complete the requirements analysis. The supplier therefore decided to claim that the project had met its milestones without defining the human computer interface. The customer readily agreed, being keen to maintain the project schedule. As a result, the pressure was taken off the definition of the human computer interface and by the time the coding stage commenced, the interface had still not been defined. Programmers were therefore
forced to make assumptions, eventually resulting in a great deal of expensive and time-
consuming work. It was pointless to attempt to progress the design without defining
the most important external interface and the reasons for the requirements analysis
taking longer than expected should have been addressed directly. Measurement of
earned value could have identified the problems much earlier.

2.3 Sources of Problems in IS Investment Evaluation

The review of the literature identified a need for a better method for evaluating IS investment
projects and to make better-informed decisions on past and future investments for the
following reasons:

1. It has been shown that IS managers frequently lack a full understanding of their organ-
isations business and are often not involved in the senior management decision-making
of the company (Andresen, 2000) [2]. At any point in time there is only limited capital
available for investment and IS investments must compete with other demands on cap-
ital. This means companies must recognise that the full benefits of an IS project can
only be realised as part of an overall business strategy. To make matters worse, the
business case for IS investment is normally prepared by the IS manager of an organisa-
tion for decision making by senior management, but then senior management who do
understand the business and have to make the decisions are usually not comfortable
with the emerging information technologies. (Andresen, 2000) [2].

2. When considering new IS investments, senior management seldom have feedback from
previous investments to provide comfort for their earlier decisions. It is thus very
important that any tool produced to evaluate new investments should also be capable
of evaluating earlier investments and providing feedback on their success or failure.
(Ballantine and Stray, 1998) [6].

3. Complexity. Although significant numbers of IS projects are routinely completed suc-
cessfully, a recent study on the state of IS in the UK carried out by Oxford University
and Computer weekly reported that a mere 16% of IS projects were considered suc-
cessful (Sauer and Cuthbertson, 2003) [72].
4. Visualisation. IS project outcomes are effectively invisible. This visualisation problem is a source of many IS project failures.

5. Risk Management. Apart from a risk register, risk is never given the prominence it deserves.

6. Traditional analysis focuses on the separation of individual pieces of what is being studied. Systems thinking, in contrast, focuses on how the thing being studied interacts with the other constituents of the system—a set of elements that interact to produce behavior of which it is a part. This results in sometimes strikingly different conclusions than those generated by traditional forms of analysis, especially when what is being studied is dynamically complex or has a great deal of feedback; like IS investment projects have.

### 2.4 Characteristics of SD Tool for Evaluating IS Projects

A system dynamics tool has the following essential characteristics:

1. **Dynamic**- This is represented as the relationship between levels and flows. The level of a system determines its state at any point in time and the rates of the flows, accumulated by the levels, constitute the dynamics of the system. Although simple in principle, people often find it difficult to distinguish between real levels and flows and to identify the behavioral consequences of flows acting on levels (Spector, 1995) [85].

2. **Interactive**- This is represented by the building blocks for models that a modeler can use to quickly come up with a particular model. This hides the complexity of the modelling language and eases the modeler’s work.

3. **Customizable**- This means that a modeler can change the face of the tool as well as extend it by adding or removing modules. It is open to scrutiny by other researchers since all that is done is documented. It is also important for the tool to be able to adapt to the ever-changing needs of modelers as they mature in their command of the subject.

4. **Flexible**- This means that the tool should be able to undergo change or modification. This allows for adaptation of the system behavior to the specific characteristics of an...
individual user, improving in such a way the usability of the system, the economy of the interaction, and the capabilities of the system of understanding.

2.5 Conclusions

This could be the reason why most IS projects fail, not for technical reasons, but for human and organizational reasons brought about by these changes. While most organizations develop elaborate plans to get the technology in, few establish plans to realise the expected business benefits (Ward et al., 1996) [95]; Peppard and Ward, 2003 [63]) It is concluded that it is not lack of trained staff, equipment or resources that bring about the problem of failed IS investments. Rather it is lack of "understanding" of the various forces at play by the managers and other stakeholders. The traditional approaches have been found to be inadequate when used to evaluate IS investments because of their use of only one measure (monetary value), ignoring feedback and delays. The more complex methods, are rarely used in IS investment evaluation for a number of reasons. First, because of little awareness of these methods by practitioners/managers. Second, some critical problems like intangibles or 'soft factors' are not catered for in the methods (Berghout, 1997 [9]; Andresen (1999) [2]. And lastly, there is no visualisation of the project process and scope, which would provide the manager with a lot of insight.
3 Methodology

3.1 Current Research Methods

A number of research methods are available for investment evaluation as set out below:

1. The Financial Approach—which comprises payback period, internal rate of return (IRR) and net present value (NPV). These were discussed in great detail in Section 2.3 Pages 17-18.

2. The Multi-criteria Approach—which comprises information economics and SIESTA. Information economics looks at enhanced return on investment (ROI), the business domain as well as the technology domain. A financial evaluation of a proposed IS investment, called enhanced return on investment ROI is made. The ROI looks at cash flows arising out of cost reduction and cost avoidance and also provides additional techniques like:

   • Value linking: additional cash flows that accrue to other departments;
   • Value acceleration: additional cash flows due to reduced time scale for operations;
   • Additional cash flows through restructuring work and improved job productivity;
   • Innovation valuation: additional cash flows arising from the innovating aspects of the investment.
The total evaluation of the IS investments proposal has three steps, covering financial, business and technological concerns, that can be positive or negative as shown in Figure 8 (Page 27) below:

**EVALUATION CRITERIA**

<table>
<thead>
<tr>
<th>Enhanced ROI</th>
<th>Business Domain</th>
<th>Technology Domain</th>
</tr>
</thead>
<tbody>
<tr>
<td>-Cost Reduction</td>
<td>-Strategic Match</td>
<td>-Strategic IS Architecture</td>
</tr>
<tr>
<td>-Value Linking</td>
<td>-Competitive Advantage</td>
<td>-Definitional Uncertainty</td>
</tr>
<tr>
<td>-Value Acceleration +</td>
<td>-Competitive Responses</td>
<td>+ -Technical Uncertainty</td>
</tr>
<tr>
<td>-Value Restructuring</td>
<td>-Management Information</td>
<td>-IS Infrastructure Risk</td>
</tr>
<tr>
<td>-Innovation Valuation</td>
<td>-Organizational Risk</td>
<td></td>
</tr>
</tbody>
</table>

= **Value of IS Investment**

Figure 8: The Information Economics Method [Adapted from Renkema and Berghout, 1997] [66]
On the other hand, SIESTA which stands for *Strategic Investment Evaluation and Selection Tool Amsterdam* is concerned with a model that uses multi-criteria methods available to the evaluator. This method looks at the *market, business strategy, business infrastructure, information infrastructure and the information strategy* (Renkema and Berghout, 1997) [66]. The method is supported by questionnaires and additional software. A distinction is made between the business and technology domain with three levels of decision making during the process being identified. A diagrammatic view of the model is given in Figure.9 (page 28) below:

Figure 9: SIESTA [Adapted from Renkema and Berghout, 1997] [66]
3. The Ratio Approach—which comprises the return on management method and IS assessment. The return on management presupposes that in today’s information economy, management has become the scarce resource. In this method, the value added by management is related to the costs of management. IS assessment focuses on the analysis of financial and non-financial ratios (Bergout, 1997) [9]. The ratios are subsequently compared with benchmarks of other organizations. The mode of calculation is shown in the equation below:

\[ \text{ROM} = \frac{\text{yieldings} - \text{fulloperatingcosts}}{\text{totalcosts} - \text{fulloperatingcosts}} = \frac{\text{valueaddedbymanagement}}{\text{full cost of management}} = 1 + \frac{\text{economicprofitbeforetaxes}}{\text{full cost of management}} \]

4. The Portfolio Approach—which comprises Bedell’s method, investment portfolio and investment mapping. Bedell’s portfolio method answers three questions, that is; Should the organization invest in information systems?, In which activities should the organization invest? And which information systems should be developed. The prioritization of investment proposals is carried out by calculating the contribution of each information system and plotting three portfolios. In investment portfolio three criteria are used to simultaneously evaluate IS investment proposals. These are; the contribution to the business domain, the contribution to the technology domain and the financial consequences, by means of net present value (NPV) calculation. The investment map, investment proposals are plotted against two main evaluation criteria, that is, the investment orientation and the benefits of the investment (Renkema and Berghout, 1997 [66]; Berghout, 1997 [9]).

5. System Dynamics/Dynamic Synthesis Methodology (DSM) Systems Dynamics Methodology is concerned with creating models or representations of real world systems of all kinds and studying their dynamics or behavior. The purpose in applying System Dynamics is to facilitate understanding of the relationship between the behavior of the system over time and its underlying structure and strategic policies or decision rules (Caulfield and Maj, 2002) [16]. It uses computer simulation to take the knowledge we already have about details in the world around us and to show why our social and physical systems behave the way they do. 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) [59]. To create a useful simulation model, its theoretical presuppositions need to have been thought through with great clarity. Every relationship to be modelled has to be specified exactly and every parameter has to be given a value, for otherwise it will be impossible to run the simulation. This discipline means that it is impossible to be vague about what is being assumed. It also means that the model is potentially open to inspection by other researchers in all its detail.
3.2 Critique of the Research Methodologies

A partial taxonomy is presented in Table 1 to assist us in comparing the research methodologies we have discussed.

Table 1: Approaches to Information Systems Research: Y means that that Research Methodology follows the type of study on the left of the table:

<table>
<thead>
<tr>
<th>Research Approach</th>
<th>Financial Approaches</th>
<th>Multi-criteria Approaches</th>
<th>Ratio Approaches</th>
<th>Portfolio Approaches</th>
<th>DSM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Laboratory</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Field experiments</td>
<td></td>
<td>Y</td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Surveys</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Case Study</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Theorem of Proof</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Subjective/Argumentative</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td></td>
</tr>
<tr>
<td>Empirical</td>
<td>Y</td>
<td></td>
<td>Y</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Reviews</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Action research</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Longitudinal</td>
<td></td>
<td>Y</td>
<td>Y</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Descriptive/Interpretive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Forecasting/future research</td>
<td>Y</td>
<td>Y</td>
<td></td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Simulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 compares IS research approaches as already discussed above. Subjective analysis shows DSM has greater coverage in terms of theory development, testing and extension than other research approaches contrasted in table 1.
3.3 Proposed Methodology

The study will follow the methodology as espoused by Williams (Williams, 2004) [100], as illustrated in Fig. 10, where simulation is one of the main strategies, as well as the case study method.

Figure 10: Dynamic Synthesis Methodology [Adapted from Williams, 2004] [100]
The study follows the following steps:

(For the detailed Methodology, please refer to Appendix B, Page.43)

1. **The Problem Statement:**
   Identification of the problem or behaviour to be analysed. Only after the relevant symptom has been clearly identified can the boundary of the system be determined, which comprises the components required for the analysis of the systems behaviour (Tignor, 2004) [92].
   The word “problem statement” is used in preference to research questions because modelling and analysis being part of System dynamics requires solving problems rather than answering questions. The statement of the problem is an important early phase in modeling and analysis (Williams, 2000) [100].

2. **Field Studies**
   Field studies and supporting data collection methods provide invaluable insights and discoveries during the System dynamics research. Field study is a term that applies to a variety of research methods, ranging from low to high constraints. These methods share a focus on observing naturally occurring behaviour under largely natural conditions (Williams, 2000 [100]). Gable (1988) [31] argues that fieldwork is a poor method for objectively verifying hypotheses. However Attewell and Rule (1991) [5] suggest that the use of data collection techniques like the survey is strong in areas where field methods are weak. The strengths of field studies are the collection of data, and description of the phenomenon in its natural settings. Surveys, semi-structured interviews, participant observation and document analysis are data collection techniques which will be used in this study. Field studies are used to collect on site information on the current systems; process owners and required proposed system are gathered to facilitate identification of user and specification of system requirements, and constraints. Input and output information to activities identified in a Descriptive process model resulting from field studies are used to identify activities, resources and products used by the process. Data on processes, resources and product are used to develop a generic system dynamics model.
   For this research, it is intended to use structured interviews in which subjects will be asked to describe and quantify project outcomes as compared to the dynamic hypothesis illustrated in Figure.3 (Page 8). Data obtained will be used to generate the key
variables along with those identified from the literature.

3. System Dynamics Model Building

System dynamics model development is a system stage process that begins and ends with understanding (Forrester, 1980 [27]; Williams, 2000 [100]). The result of field studies should provide a descriptive model, on which SD conceptual feedback structure can be developed. The feedback structural model is developed with the help of a causal loop diagram. The next stage is the conversion of the causal loop diagram into stock and flow diagrams, which is a formal quantitative model of the problem in question. In order to simulate the model, we must define the mathematical relationship between and among variables. Stocks are accumulations and fully describe the condition of the system at any point in time. Stocks, furthermore, do not change instantaneously: they change gradually over a period of time. Flows on the other hand do the changing. Flows increase or decrease stocks not just once, but every unit of time. All systems that change through time can be represented by using only stocks and flows. Richardson and Pugh (1981) [68] in Figure 11 suggest that a system dynamics modelling effort begins and ends with understanding.

Figure 11: System Dynamics Modelling Process [Adapted from Williams, 2004] [100]
In this research, after identification of key variables, these will be used to convert the
dynamic hypothesis as illustrated in Figure.3 (Page 8) to level and rate equations as well as select parameter values. The dynamic characteristics of feedback systems are represented in the form of differential equations “pseudocode”. These mathematical models, in the SD approach, are continuous and non-linear in terms of:

- Identification of dynamic feedback structure,
- Equations being primarily deemed continuous; the chosen formulation helps to concentrate on the continuously interacting forces in the system rather than on discrete events arising within this central framework,
- Identification of time delays, and
- Incorporation of non-linearity in the equations deemed critical to match a real complex system.

STELLA, one of the system dynamics software packages supports process modelling very well. It provides a graphical user interface and symbols that represent elements of a process. The symbols are used to quickly generate system dynamic models by creating relationships among elements that represent some process. The four basic elements are Levels, Rates, Auxiliaries and Connectors as illustrated in Figure.12 (Page 35) below.

Figure 12: Four Basic Symbols Used in System Dynamics Modelling [Adapted from Williams, 2002] [99]
1. Level:
Collects or accumulates whatever flows into and out of the Level. An example is a water reservoir. As the water flows into the reservoir, it is stored. When the water is needed, the water is released at some outflow rate.

2. Rate:
Allows resources to move to and from Levels. This is analogous to a valve that one can allow the flow rate of water either into or out of a reservoir.

3. Auxiliaries:
Serve two purposes. EITHER holds values for constants, defined external inputs to the model OR calculates algebraic relationships, and serves as the repository for algorithmic functions.

4. Connector:
Illustrates a relationship and its direction between two elements.

This terminology of levels and rates is consistent with a Stock and Flow structure orientation. A Stock and Flow diagram offers a much more precise pictorial of the model structure than does a causal loop diagram. The Stock and Flow structure identifies explicitly the variables chosen to model the system; it distinguishes between integrals and derivatives; it states the parameters involved in each equation. In Figure 13 (Page 36) below, the level describes the state variables of the system. Its knowledge at time \( t \) is sufficient to retrieve the instantaneous value of any other variable.

Figure 13: Schematic Conventions of System Dynamics Stock and Flow Diagrams in STELLA [Adapted from Williams, 2002] [99]
As illustrated in Figures 12 and 13, the “clouds” signify the sources or sinks of information resources. The levels accumulate (or integrate) the results of action in the systems, an action always being materialised by flows in transit. the derivative of a level, or equivalently the rapidity at which it is changing, depends on its input and output flows and the delta time (simulation interval). The computation of a level is approximated by a differential equation of the form:

\[ \text{Level}(t) = \text{Level}(t - dt) + (\Sigma \text{InputRate} - \Sigma \text{OutputRate}) \cdot dt \]

Where: \( t \) is the present moment in time, \( (t-dt) \) is the past moment in time, \( dt \) is the solution interval used in the model (in this case the time interval between the present moment in time and the past moment in time). The rates are what change the value of levels. Their equations state how the available information is used in order to generate actions. A rate has four conceptual components: an observed condition is compared to a goal, and the discrepancy found is taken as a basis for action (flow) generation. The rate equation that formalises this policy is an algebraic expression that depends only on levels and constant values. Auxiliary variables can be used for intermediate computation. The level and rate variables must alternate along any feedback loop, which can be classified according to three attributes:

- Polarity, negative (derivation-counteracting feedback) or positive (deviation-amplifying feedback),
- Order (number of levels),
- Linearity or non-linearity (in rate equations).

It is the presence of non-linear higher-order loops in the system that makes the derivation of analytical solutions unfeasible. It can be shown that even simple low-order systems may exhibit a large variety of behaviour patterns; in practice, any system of interest will involve a high-order, multiple-loop, non-linear structure as illustrated in Figure 10. Simulations can then be run on the important variables. Once confidence is gained, through validation and ownership by stakeholders, then the model is available to test hypotheses or policies of interest. In some cases a developed model can be validated, using a post-mortem analysis or case studies for prediction or prescriptive purposes.
4. Case Study Research Method

A case study is an empirical investigation that probes and examines responses of convenient influences within the real operational environment of the task, user, and system. The case study approach generally refers to group methods, which emphasise qualitative analysis (Yin, 2002 [103]; Gable 1988 [31]), although some case studies are quantitative in nature. In the SD literature quantitative case studies have been used to validate SD simulation models (Forrestor and Senge, 1980 [27]; Graham et al., 1982 [32]).

We will use another Telecom Company, CELTEL to act as a case study to test the model and data collected from the other two Telecom Companies in the field study stage.

5. Simulation Experiments:

Simulation models are abstracts of the real world-view of a system or problem being solved. During the course of simulation, the model mimics important elements of what is being simulated. The model is used as a vehicle for experimentation in a “trial and error” way to demonstrate the likely effects of various policies. Those policies, which produce the best result in the model, will be implemented in real life (Williams, 2000) [100]. In such situations, simulation can be an effective, powerful and universal approach to problem solving in different areas of application, to extend existing theories or identify new problems (Williams et al., 1999 ) [101]. The behaviour of the various system components over time will exclusively be identified by computer simulation. This will be done after initial values had been entered into the model. This permits modeling of systems that would be too complex for mathematical analysis.

In this research, simulation will involve testing the model assumptions, the model behavior and validity as well as sensitivity to perturbations.

6. Model Use and Theory Extension:

The System dynamics modeling approach takes a philosophical position that feedback structures are responsible for the changing patterns of behaviour we experience in complex problems. A dynamic hypothesis, can be tested verbally, or as a causal loop diagram or as a stock and flow diagram. Since it has the capacity to deal with the dynamic complexity created by interdependencies, feedback, time delays and non-linearity; System Dynamics can be used to complement traditional scheduling and project management tools (Williamset al., 1999) [101]. Figure 10, provides a detailed
description of DSM and how the resulting products of each research phase contribute to theory building and testing. Earlier sections discussed the merits and objectives of the dynamic synthesis methodology presented and overall reference research design. The main objective of Figure 10 (Page 31) is to depict input and outputs of each phase and their relationships and outputs and to identify data requirements and data collection methods of each phase, and validation and verification points within the methodology.

DSM as an applied research methodology has to demonstrate its usability in practice (Jayaratna, 1994) [41]. While customers may understand the problems that need to be solved, problem solvers or researchers may refine those problem statements depending on known problems. The Dynamic Synthesis Methodology uses a general model, (Figure 10) to illustrate the relationship and interconnections between different phases and artefacts. The phases, their relationships and resulting artefacts are dynamic. We will test the model’s response to different policies and translate study insights to an accessible format for users to effectively interact with the resulting tool.
REFERENCES


30. Galliers and Land


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Appendix A-QUESTIONNAIRE FOR IS EXECUTIVES

**PERSONAL PROFILE:**

<table>
<thead>
<tr>
<th>Question</th>
<th>Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1. Age</td>
<td>Under 25 ☐, 25 – 34 ☐, 35 – 44 ☐, 45 – 54 ☐, 55 and over ☐</td>
</tr>
<tr>
<td>Q2. Gender</td>
<td>Female ☐, Male ☐</td>
</tr>
<tr>
<td>Q3. Educational level</td>
<td>Basic College certificate/OND ☐, BSc ☐, MSc ☐, PhD ☐</td>
</tr>
<tr>
<td>Q5. Job function</td>
<td>(Please tick one of the following activities that forms the core part of your job function): a) IT Management ☐, b) IT strategy and planning ☐, c) Business Services ☐, d) IT Consultancy ☐, e) Systems Management ☐, f) Research &amp; Development ☐, g) Software engineering ☐, h) Others (Please specify): ☐</td>
</tr>
<tr>
<td>Q6. Core area of expertise</td>
<td>(Please tick one): a) Business analysis ☐, b) Corporate Planning ☐, c) Corporate Modeling ☐, d) Financial systems strategy ☐, e) IT strategy/planning ☐, f) Systems Management ☐, g) Project Management ☐, h) Others (Please specify): ☐</td>
</tr>
<tr>
<td>Q7. Years worked for organization</td>
<td>Under 1yr ☐, 1 – 2yrs ☐, 3 – 4yrs ☐, 5 – 6yrs ☐, 10yrs+ ☐</td>
</tr>
<tr>
<td>Q8. Total years worked as an IT Manager/decision maker</td>
<td>Under 1yr ☐, 1 – 2yrs ☐, 3 – 4yrs ☐, 5 – 6yrs ☐, 10yrs+ ☐</td>
</tr>
<tr>
<td>Q9. Management level</td>
<td>(Please tick one): a) First line Supervisor or Manager ☐, b) Mid-level manager (supervising other managers) ☐, c) Executive (Top) level Manager (Vice President, President, Chairman of the board of Directors etc) ☐</td>
</tr>
</tbody>
</table>
Q10. What is your organization’s approximate annual IT budget?
   a) Under 120M
   b) 121 - 400M
   c) 401 - 600M
   d) 601 - 800M
   e) 801 - 1000M
   f) Over 1000M
   g) Others (Please specify): ................................

Q11. What is your organization’s perception of IT?
   a) Threat
   b) Opportunity
   c) Resource
   d) Competitive Weapon
   Others (Please Specify): ................................

Q12. How important is IT to your organization?
   a) Very important
   b) Important
   c) Fairly important
   d) Not important
   e) Don’t know

Q13. How important is IT to you as a decision maker?
   a) Very important
   b) Important
   c) Fairly important
   d) Not important
   e) Don’t know

Q14. Which project attributes are considered important? Tick any that apply
   a) Type
   b) Size
   c) Scope
   d) Risk
   e) Budget

Q15. How important is the quality of information to your decision making?
   a) Very important
   b) Important
   c) Fairly important

Q16. How often do you make decisions for your organization?
   a) Very often
   b) Often
   c) Occasionally
   d) Never

Q17. How important and relevant are your decisions to the survival of your organization?
   a) Very important
   b) Important
   c) Fairly important
   d) Not important
   e) Don’t know

Q18. What is the basis of your decision making process?
   a) Models
   b) Rule of the thumb
   c) Intuition
   d) Past experience
   e) Don’t know

Q19. If the models form the basis of your decision-making process, what model do you follow?
   a) Rational
   b) Political
   c) Process
   d) Garbage Can

Q20. Have you ever combined different models?
   a) No
   b) Yes

Q21. What strategic tools does your organization use for IT decision-making?
   a) Business Process management
   b) Scenario analysis
   c) Monte Carlo Simulation
Q22. What are the factors do you think can influence your decision-making?
   a) Education level
   b) Years of experience
   c) Organizational Culture
   d) Age

Q23. At what level does your organization’s decision-making take place?
   a) Corporate level
   b) Strategic Business Unit
   c) Departmental Level
   d) Others (Please specify): ....................

Q24. What measure do you use to assess IT decision-making effectiveness?
   a) Effective feedback
   b) Rule of the thumb
   c) Return on investment
   d) Payback period
   e) Cost/benefit analysis
   f) Others (Please specify): ....................

Q25. To what extent is top management involved in IT decision-making?
   a) Fully involved
   b) Partially Involved
   c) Not involved
   d) Don’t Know

Q26. What form does your company take?
   a) Centralized
   b) Decentralized
   c) A mixture of the two
   d) Don’t Know

Q27. Please indicate whether you would accept being interviewed after the collection of this questionnaire.
   a) Yes
   b) No
## Appendix B

### The Detailed Work Plan for the Study

Table 2: The research activities for the study are as follows.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activity</th>
<th>The Tasks in activity</th>
<th>Duration in months</th>
<th>Period</th>
<th>Deliverable (outputs)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Proposal writting</td>
<td>Review Literature Write proposal</td>
<td>8 Aug 05 to Apr 06</td>
<td>Completed Proposal</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Write Chapters 1-3</td>
<td>Continue the Lit. Review.</td>
<td>4 May-Aug 06</td>
<td>Chapters 1-3</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Problem Definition</td>
<td>-Define Model boundary and identify key variables -Reference Modes -Describe the behavior of the variables</td>
<td>2 May-Jul 06</td>
<td>Dynamic Hypothesis</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Survey Data</td>
<td>Design of Research instruments</td>
<td>1 Sept 06</td>
<td>Questionnaires and Interview guides</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Data collection</td>
<td>Surveys in 2 leading Telecom companies (UTL and MTN)</td>
<td>5 Oct06- Feb07</td>
<td>Case study Data to support the overall study</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Analysis of data</td>
<td>Identification of key variables</td>
<td>1 Mar 07</td>
<td>Presentation of Preliminary findings</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>System Dynamics Model Building</td>
<td>Convert feedback diagrams to level and rate equations Estimate and select parameter values</td>
<td>3 Apr-Jun 07</td>
<td>Completed System Dynamics Model</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Simulation Experiments</td>
<td>-Simulate the model and test the model assumptions -Test the Model for Validity -Test the Model behavior and sensitivity to perturbations</td>
<td>1 Jul 07</td>
<td>Refined System Dynamics Model</td>
<td></td>
</tr>
</tbody>
</table>
The detailed Work Plan - continued

Table 3: A Continuation of table 2

<table>
<thead>
<tr>
<th>Phase</th>
<th>Activity</th>
<th>The Tasks</th>
<th>Duration</th>
<th>Period</th>
<th>Deliverable</th>
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<tbody>
<tr>
<td>9</td>
<td>Implementation</td>
<td>-Test the Model’s response to different policies</td>
<td>2</td>
<td>Aug-Sep 07</td>
<td>System Dynamics Tool</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-Translate study insights to an accessible format</td>
<td></td>
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<tr>
<td>10</td>
<td>Final Report Writing</td>
<td>Write all Chapters</td>
<td>6</td>
<td>Apr-Sep 07</td>
<td>Draft Report</td>
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<tr>
<td>11</td>
<td>Prepare for Defence</td>
<td>Revise Chapters</td>
<td>1</td>
<td>Oct 07</td>
<td>Defence Presentation</td>
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<tr>
<td>12</td>
<td>Make Corrections</td>
<td>Correct all Chapters</td>
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<td>Nov 07</td>
<td>Corrected Final Report</td>
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<tr>
<td></td>
<td></td>
<td>Bind and Resubmit</td>
<td></td>
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<td>Submitted</td>
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</table>

Table 4: The Budget

**BUDGET (Uganda Shillings)**

<table>
<thead>
<tr>
<th>QTY</th>
<th>ITEM</th>
<th>UNIT COST</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Laptop</td>
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<td>3,000,000</td>
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<tr>
<td>1</td>
<td>Modeling and Simulation Software</td>
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<td>1,200,000</td>
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<td>Stationery</td>
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<td>400,000</td>
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<td>300</td>
<td>Transport</td>
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<td>Research Assistants</td>
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<td>Conferences</td>
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<td>8,000,000</td>
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<tr>
<td>5</td>
<td>Binding</td>
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Sub Total 17,500,000

<table>
<thead>
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<th>QTY</th>
<th>Contingency (10%)</th>
<th>UNIT COST</th>
<th>TOTAL</th>
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<tbody>
<tr>
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<td></td>
<td>1,750,000</td>
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</table>

GRAND TOTAL 19,250,000