CHAPTER 1

INTRODUCTION

Enterprise Resource Planning (ERP) is a set of integrated, configurable information systems used to manage an organisation's internal resources, which include tangible assets, financial resources, materials and human resources. The main purpose of the system is to facilitate the flow of information within and across all functional areas, based on standard processes inside the boundaries of the organisation[1] (Bidgoli, 2004). ERP systems typically handle the manufacturing, logistics, distribution, inventory, shipping, invoicing and accounting for a company.

The term 'Enterprise Resource Planning' originally derived from manufacturing resource planning (MRP II), which developed in turn from material requirements planning (MRP). MRP evolved into ERP when 'routings' became a major part of the software architecture and a company's capacity planning activity also became part of the standard software activity.

The following section provides background information about ERP, including the Australian context. The chapter then presents a summary of the research topic, the research question, and the rationale and methods used in the study. The final sections outline the limitations to the study, the ethical guidelines followed, and the thesis structure.

1.1 ERP evolution

Advances in information technology in manufacturing and services companies during the 1960s were reflected in the form of inventory control and accounting information

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systems. The 1970s witnessed a shift towards more focus on planning, and resulted in Material Requirement Planning (MRP), which translates the master production plan into requirements for sub-assemblies, components and other raw material planning and procurement. In the 1980s the entire plant optimisation, including shop floor and distribution management activities, was given the label of Manufacturing Resource Planning or MRP-II. MRP-II was further extended to include areas such as finance, human resources, engineering, project management, and so on (Akkermans et al., 2003; Anderegg, 2007). This was the birth of a new generation of business applications, called Enterprise Resource Planning or ERP. The term was coined by the Gartner Group of Stamford, CT, USA in the early 1970s (Shehab et al., 2004). In contrast to its predecessors, ERP focuses on processes rather than functions and covers the cross-functional coordination and integration in support of the production process across all activities. ERP also extends the planning scope from focusing on internal resources to schedule supplier resources based on dynamic customer demands and schedules (Chen, 2001).

In the mid-1990s, ERP expanded to include functions such as order management, financial management, distribution and warehousing, quality control, asset management and human resources management (Shehab et al., 2004). ERP, as a set of integrated, configurable information systems that can be bought 'off-the-shelf' and tailored by an organisation in order to integrate and share its information and related business processes within and across functional areas (Davenport, 2000a), became the promised magic wand for managers to overcome the so-called millennium bug and to integrate their scattered, separated systems. However, in many cases, the anticipated benefits in cost reduction and productivity improvements and integration were not realised. Many companies found that, by adopting ERP, their information technology expenditure had increased because of high maintenance costs and failure rates, and, furthermore, they failed to utilise the new systems to an optimum level. Numerous surveys, case studies and reports have highlighted implementation problems and failures (e.g., Bingi et al., 1999; Brynjolfsson and Hitt, 1996, 1998; Buckhout et al., 1999; Davenport, 1998b, 2000a).

ERP and other enterprise systems continue to be an important tool for operating manufacturing and services organisations. Enabling technologies such as the Internet, e-business and integration tools have enabled true integration between enterprise systems, which eventually leads to leveraging of strategic enterprise systems benefits, such as facilitating the decision-making process by utilising business intelligence, data warehousing and integration tools.

1.2 ERP in Australia

The ERP market in Australia comprises two tiers. The first tier consists of governmental departments and private enterprises that could not be regarded as small and medium size organisations (SMEs). These organisations are mostly customers of main multinational ERP vendors such as SAP and Oracle. The second tier is made up of SMEs that are customers of smaller ERP vendors with products made mainly for smaller organisations. This tier of the market is more accessible to Australian ERP vendors with local industry-specific knowledge and experience.

The first-tier ERP market in Australia, dominated by international vendors such as SAP and Oracle, is highly saturated; estimates suggest that 75–95% of potential ERP rollouts had been completed before the start of the new millennium in response to the Y2K bug (Industry Sector Analysis, 1998; Stein and Hawking, 2002; Woodhead, 2001). The Australian Government is the largest purchaser of information technology equipment in the local market and, inevitably, the state and federal government departments make up a good portion of the first-tier ERP market (Hawking et al., 2004). According to the ERP maturity model of Holland and Light (2001), most of these organisations should be in their maturity stage, meaning that they have normalised the ERP system into the organisation and are engaged in the process of obtaining strategic value from the system.

A lack of solutions for SMEs by the first-tier vendors and the importance of specific local industry knowledge for implementing ERPs have contributed to Australian ERP vendors being involved in the second-tier market. However, this started to change rapidly after the year 2000 as more and more first-tier companies started to provide solutions for SMEs and gain local industry knowledge by partnership with local consultant companies in order to overcome the difficult economic times immediately following the so-called Y2K spending spree. As a result, the number of Australian ERP vendors in the local market is declining; they make ideal acquisition targets for foreign firms, given their established client bases and their broad development and implementation skills.

Although the public sector makes up most of the local first-tier ERP market, Australian ERP customers are found in different sectors such as manufacturing, utilities, banking/finance and insurance, mining, defence, retail and human resources.

1.2.1 ERP future and trends in Australia

After the Y2K spending spree and the subsequent harsh economic climate and shrunken IT budget, ERP vendors struggled (Frost and Sullivan, 2004). Although the market bounced back after a few years, the impacts of this period, such as shrinking IT budgets and severe restrictions on capital expenditures, changed ERP vendors, strategies and products. These driving forces led to more consolidation and mergers among ERP vendors, second-tier market exploration, vertical market specialisation and ERP vendors going into partnership with consultants and integrators (Dharmasthira et al., 2004, 2005).

The first of these outcomes – acquisitions, mergers and consolidations – were the result of a difficult economic climate in the first few years of the 21st century that dramatically affected many ERP players. The merger/acquisition between JD Edwards, PeopleSoft and Oracle were the most important ones affecting many customers, consultants and end users. In addition, the disappearance of some vendors and the arrival of a few newcomers changed the landscape dramatically.

Another contributing factor to the changing ERP market landscape is the first-tier ERP vendors' efforts to gain control of the unsaturated second-tier market. This could be a result of the harsh economic climate and a highly saturated market for first-tier vendors in Australia. In addition, SMEs' awareness of the importance of gaining competitive advantage in order to survive in the e-business environment is an important factor for the flourishing ERP mid-market (Frost and Sullivan, 2004; Huin et al., 2003; IDC, April 2004).

Introduction of ERP in the mid-1970s was a response to the high failure rate and budget overruns in so-called integrated custom-made total systems. As an alternative to custom-made business software applications, ERP claimed to be able to provide a solution across all different industries and companies. However, this total system approach, which built specific systems for every company, was not successful. The answer to this problem lies in providing industry-specific packaged solutions to the vertical market. Vertical specialisation is one of the keys to product differentiation and competitive advantage among vendors of enterprise applications.

Finally, partnerships between ERP vendors and consultants/integrators firms with local and industry-specific knowledge have become more important in the new ERP market. Collaboration with these service providers is a key to reaching and penetrating certain industries (Zampetakis, 2004).

1.3 Research problem development

This section presents the research problem, scope and objectives, and the resulting research questions.

1.3.1 Research problem

The importance and need for timely decisions is widely recognised as a critical success factor for gaining competitive advantage, especially in complex supply chains. ERP provides the building blocks of data necessary for making such decisions. However, to facilitate the decision-making process, ERP data need to be transformed into information by using tools for data analysis and presentation, data communication, data access, assessing data context, synthesising data from other sources and assessing completeness of data (Davenport, 2000a). The importance of such additional decision support and information analysis features is considered a critical feature of enterprise systems (Jacobs and Bendoly, 2003).

Despite the importance of decision-support features in enterprise systems and their role in gaining and sustaining a competitive advantage in today's supply chains, the vast majority of the literature focuses on ERP operational issues such as evaluation, implementation and support. The literature investigating enterprise systems' decision-support features is limited to research recognising the importance of such features.

Most organisations acknowledge the importance of and need for research in this area. In particular, organisations who want to leverage their investments on ERP to more strategic benefits such as decision making, and vendors who are facing saturated markets, are looking for ways to add extra features and functionality to their products to keep or extend their market share and encourage more research on ERP utilisation beyond its transactional and operational capabilities.

The focus of this study is to reveal whether and, if so, how, the vast amount of data generated by ERP systems improves the decision-making process on strategic and tactical levels among Australian organisations.

1.3.2 Research questions

This research study investigated three distinct aspects of ERP decision-support features and capabilities and their impacts on decision making: (i) ERP adopters' expectations, (ii) the exhibition of such features and (iii) the realisation of possible impacts or benefits in practice. This section provides an overview of the rationale behind the three principal research questions. They are discussed in more detail in Chapter 3.

(i) Expectations

Decision support is not explicitly recognised as a major reason for implementing ERP systems (Holsapple and Sena, 2005). However, some researchers suggest that adopters' expectations of ERP decision-support features and benefits change after reaching a certain stage of maturity in their adaptation. Organisations that had initially implemented ERP to overcome operational and transactional problems subsequently tend to try to leverage their investment on ERP to more strategic benefits (Stein and Hawking, 2002; Woodhead, 2001). We investigated the following research question:

What are ERP adopters' expectations in regards to ERP decision-support features and capabilities?

(ii) Exhibition

The existence of decision-support features and capabilities in ERP systems was studied by investigating system characteristics and users' awareness of such features and capabilities. ERP could improve decision making by providing timely information, facilitating the decision-making process and providing facilities to encourage exploration and new approaches to the problem. We investigated these characteristics, along with the effectiveness of the user interface and the users' knowledge and training on utilising these features, by asking the following research question

What decision-support features and capabilities are exhibited in current ERP systems?

(iii) Realisation

If it is expected that ERP provides decision-support facilities, and if such features are exhibited in ERP systems, to what extent do organisations realise decision-support benefits from these systems? What decision-support benefits do users of current enterprise systems realise, and what decision-support benefits do they consider important? Previous studies of decision-support systems have identified the characteristics listed in Table 1.1 to measure the effectiveness of such systems (Holsapple and Whinston, 1996; Marakas, 1999; Turban and Aronson, 1998; Udo and Guimaraes, 1994).

We investigated the realisation of such features and their role as an objective of ERP implementation in the evaluation and acquisition process by asking the following research question:

What benefits and impacts are realised by ERP adopters as a result of utilising ERP decision-support features and capabilities?

To shorten the time and cost associated with making a decision
To enhance a decision maker's ability to process knowledge
To enhance a decision maker's ability to handle large-scale or complex problems
To improve the reliability of decision processes or outcomes
To encourage exploration or discovery by a decision maker
To reveal or stimulate new approaches to thinking about a problem space or decision context,
To furnish evidence in support of a decision or confirmation of existing assumptions, and create a strategic or competitive advantage over competing organisations

Table 1.1 Characteristics of decision-support systems

1.4 Research scope and objectives

The primary objective of this research was to provide insight into the current utilisation of ERP decision-making features and capabilities within Australian organisations, and to identify the major factors, their roles and interactions in the process of ERP utilisation in the decision-making process. Organisations investigated in this research are mainly categorised in the first tier of the ERP market from a wide range of industry sectors, and they had mostly completed their ERP rollout before 2000. The resulting insight and knowledge about the factors and their interactions will provide practical steps to help both customers and vendors maximise the benefits of ERP systems, such as improved decision making.

1.5 Research rationale

Timely decisions are critical for gaining competitive advantage, especially in complex supply chains. ERP systems provide the necessary building blocks of data for making such decisions. However, the vast amount of data produced by enterprise systems usually do not have the quality required for making decisions; these data need to be transformed to information in order to be used effectively for strategic and tactical decision making.

The process of transforming data into information should be supported by enterprise systems that provide tools for data analysis, presentation, communication and collaboration. Such additional decision-support and information analysis features and capabilities are a critical feature of enterprise systems (Jacobs and Bendoly, 2003).

Despite the need for decision-support features and capabilities in enterprise systems and their role and importance in gaining and sustaining competitive advantage in today's supply chains, the literature focuses mainly on operational issues such as enterprise systems evaluation/acquisition, adaptation and support. Studies investigating enterprise systems' decision-support features consist mostly of research that recognises the importance of such features. The groundbreaking research of Holsapple and Sena (2005) investigated how ERP adopters perceive decision-support benefits. Their findings indicate that benefits such as better knowledge processing, decision reliability, decisional substantiation, competitiveness, decision-making speed, and treatment of large-scale or complex problems are of significant importance to organisations adopting these systems.

Two groups, in particular, are urging the need for research on ERP beyond its transactional and operational capabilities. These are organisations looking for ways to leverage their investments on ERP to more strategic benefits, and vendors facing saturated markets, who are looking for ways to add extra features and functionality to their products to keep or extend their market share. However, this important topic with potential impact for both enterprise systems users and vendors remains under-researched.

1.6 Research design

This research was designed to address the research questions listed above by employing qualitative and quantitative methods. The research framework is illustrated schematically in Figure 1.1. Research started with iterative problem development and literature review, followed by two phases of data collection. Phase 1 involved exploratory interviews with main players in ERP implementation and operations in selected organisations, in order to cater for the lack of knowledge, theories and comprehensive studies on this topic in the Australian context. Phase 2 employed a survey instrument that was based on the findings from the exploratory interviews.

Results were analysed using open coding, and statistical descriptive analysis, t-test and correlation analysis techniques.

Finally, findings from the data analysis were used to develop a theoretical System Dynamics model of ERP and its utilisation in decision making in Australian organisations. Through simulation and sensitivity analysis, the model was used to provide insight and suggest practical guidance into better utilisation of ERP data towards decision making. The use of a System Dynamics approach provided key insights into the interactive behaviour of system elements over time that are normally not obvious through non-systematic approaches (Taylor, 2008; Wolstenholme, 2003).

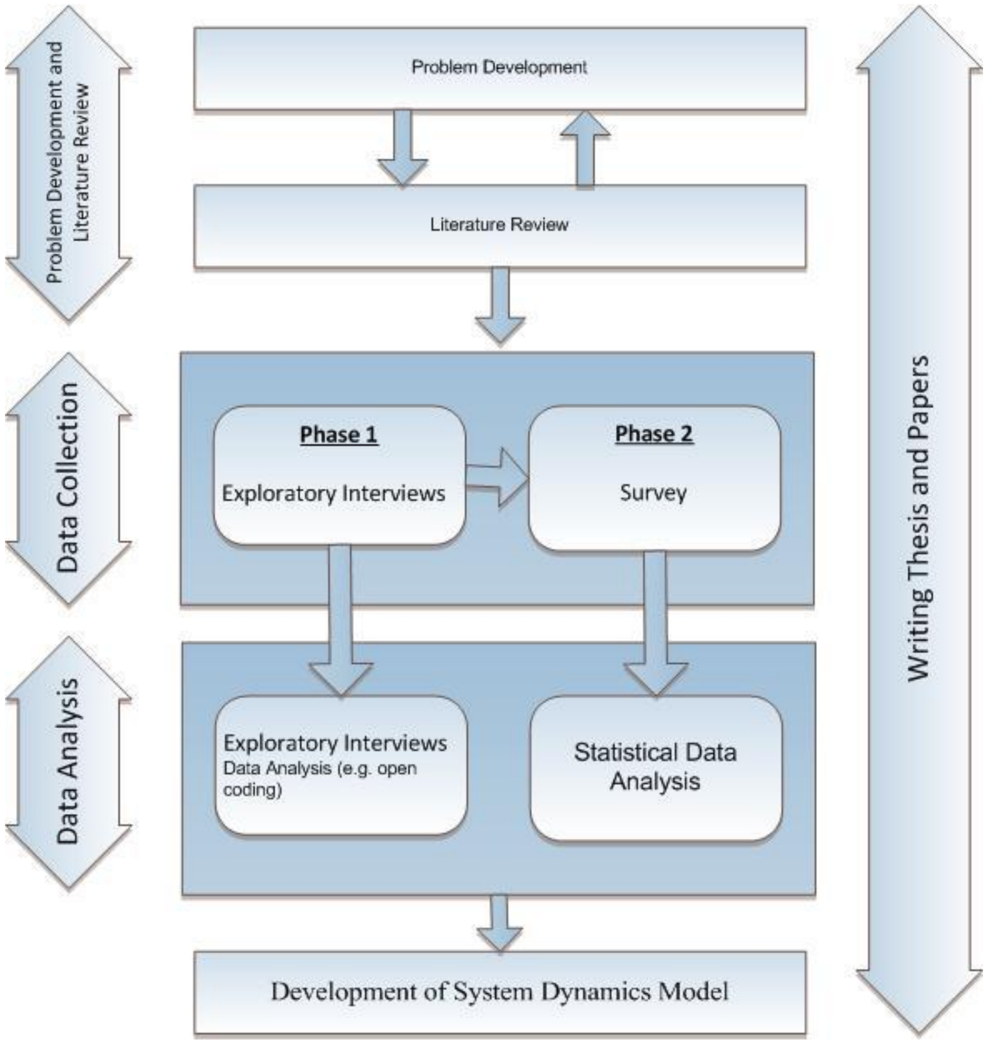

Figure 1.1 Research framework

1.7 Research limitations and constraints

This section first discusses the scope of the decision making situations addressed by this study, and then outlines some of the limitations.

Decision-support systems can support decision makers in various situations: (i) one person making an individual decision, (ii) multiple people jointly contributing to a decision, (iii) multiple people making inter-related decisions and (iv) multiple people from different organisations making cooperative and negotiated decisions (Holsapple and Sena, 2005).

By integrating processes and knowledge across different business units, and also by using recent technological advancements in communication and collaboration, ERP systems have the potential to provide substantial support for inter-related decision making in an organisation, that is, type (iii) above. However, no previous study has examined how ERP systems support this type of decision-making situation (Holsapple and Sena, 2005; Palaniswamy and Frank, 2000; Santhanam et al., 2000).

Intra-organisational decision making, type (iv), has also been made more feasible as a result of technological advances in global network proliferation. Organisations can connect to exchange transactional data and also to make collaborative and negotiated decisions. ERP could act as the necessary standard platform on which companies rely to collaborate with other organisations on transactional and decision-support levels (Ching et al., 1996; Kumar and Hillegersberg, 2000; Palaniswamy and Frank, 2000). Once again, no study has examined ERP systems support for this type of decision-making situation.

Much of the DSS literature focuses on types (i) and (ii) and recent technological advances have made types (iii) and (iv) increasingly feasible. However in this research I focussed mainly on type (i) decision making, one person making an individual decision.

This research utilised a purposefully selected population that was neither large nor fully random. Participants included Australian organisations from high technology, automotive, finance and consumer products industries that are mainly in their maturity stage of the ERP implementation. These organisations are categorised in the first tier of the ERP market, meaning that they had mostly completed their ERP rollout before 2000. Based on theory, these mature organisations are now looking for ways to leverage their investment to the next level by utilising ERP capabilities towards decision-making and information analysis activities (Hawking et al., 2004).

The findings of this research are relevant to Australian industries and, although a certain homogeneity between organisations in the same sector could be assumed, there are numerous other factors that can influence the adoption and implementation of any particular system. Therefore the findings cannot be generalised in the manner presumed by a quantitative study, although they could be used as practical guidance and recommendations.

Different enterprise system software may have a big impact on the organisation's experience during implementation and usage of such systems. ERP brands have not been considered as a factor in this study, although each participant's ERP system had to comply with certain attributes defined in this project.

1.8 Ethical considerations

I followed the university's ethical guidelines and obtained an approval from the ethics committee to conduct interviews and send survey. Respondents were informed that participation was voluntary and that they could leave particular questions unanswered if they so chose. Adequate measures were taken to protect respondents' confidentiality, with no public presentation of the results identifying individuals or providing any association with individual responses.

1.9 Thesis structure

This chapter has presented an overview of the research by discussing the research background, the research propositions, research questions, research scope and objectives, research design, and the expectations and limitations of this research.

Chapter 2 reviews the literature related to ERP and decision-making, decision-support characteristics of ERP systems and their related technologies such as Business Intelligence (BI), integration and data warehousing. Such studies are most commonly published in journals dealing with information systems, manufacturing and logistics, accounting information systems, decision-support systems and decision-making disciplines. This chapter also identifies gaps in the literature.

Chapter 3 discusses the research methodology and assumptions underpinning this research, and the approach, research strategy and research design. This chapter describes the methodology used to collect and analyse the data, and discusses how the appropriate research techniques were selected. It outlines the capabilities and limitations of these techniques and describes in detail the data collection and data analysis.

Chapter 4 presents the findings of the exploratory interviews and the survey.

Chapter 5 explains the System Dynamics model and presents simulation and sensitivity analysis results.

Chapter 6 summarises the research findings, discusses the study's contributions to practice and theory, and concludes with suggestions for future research. Published papers presenting the research findings are included after Chapter 6.

1.10 Future research

A common perception is that enterprise systems in general and ERPs specifically can help management to make better and timely decisions. However, this perception has not been rigorously investigated. In this research I have tried to identify factors which have an impact in this process by using semi-structured interviews and a survey. I have also tried to analyse basic behaviour and interactions between these factors over time using a system dynamics model. The findings could help both ERP customers to utilise their systems for more strategic benefits and ERP vendors to focus on those attributes in their product design which might contribute to better utilisation of such systems towards more strategic benefits such as decision making. However, this area of research is highly under-researched and there are many potential questions which could be the subject of further investigation, as mentioned in the final chapter.

CHAPTER 2

LITERATURE REVIEW AND RESEARCH CONTEXT

2.1 Introduction

This chapter reviews the literature related to ERP in the context of decision making. This includes the decision-support characteristics of ERP systems and related technologies such as Business Intelligence (BI), integration and data warehousing. Such studies are published mostly in journals dealing with information systems, manufacturing and logistics, accounting information systems, decision-support systems and decision-making disciplines. This chapter also reviews relevant works from management journals and conference proceedings.

The chapter first defines ERP and its evolution. It then explains the framework developed to better categorise previous research and more easily identify gaps in literature. The rest of the chapter reviews the literature within this framework.

2.2 Definition and evolution

In recent decades, the term 'ERP' has acquired a number of meanings. Divergent applications by practitioners and academics have produced much information on ERP, and also led to confusion regarding the meaning of the term. In fact, the term ERP itself could have contributed to the confusion, as 'Resource Planning' is not the main purpose of ERP systems. The fundamental capabilities of ERP systems come from transaction processing and structured record keeping of those transactions, and not 'planning' as the name suggests. In fact, although planning and decision support applications can be optional add-ons, they are not the core capabilities of the system (Jacobs and Bendoly, 2003).

ERP is a set of integrated, configurable information systems application software that can be bought 'off-the-shelf' and tailored by an organisation, in order to integrate and share its information and related business processes within and across functional areas (Davenport, 2000a). Such off-the-shelf packages (as opposed to applications built in-house) help organisations manage important aspects of their business, such as accounting, finance, manufacturing, distribution, human resources and sales (Kumar and Hillegersberg, 2000; Kumar et al., 2002) and may eventually allow organisations to achieve inter-organisational supply chains (Boonstra, 2005). The main purpose of the system is to facilitate the flow of information within and across all functional area based on standard processes inside the boundaries of an organisation[2] (Bidgoli, 2004).

2.4 Literature review framework

The ERP literature contains two distinct streams (Jacobs and Bendoly, 2003). The 'management concepts' stream focuses on the fundamental corporate capabilities driving ERP as a strategic concept, and considers the potential impacts of ERP on organisations' performance. In contrast, the 'system' stream is devoted mainly to details associated with implementation and its relative success and cost, focusing on intricacies of software, project management and process design. The framework for this literature review comprises the system and management concepts as presented by Jacobs and Bendoly (2003), and also includes the six-stage model presented by Kwon and Zmud (1987) (Figure 2.1).

Kwon and Zmud's stage model suggests that information systems implementation projects consist of six stages: initiation, adoption, adaptation, acceptance, routinisation and infusion. In the initiation phase, organisations identify their need for a system as a result of global competition, high volume of data, need for rapid decision making, incompatibility or need for connectivity. The initiation phase leads to the adoption phase, which concerns investment decisions, cost benefit analysis, choice of

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appropriate technology, choice of vendor/brand and assessing the suitability of innovation for the firm.

The adaptation phase is the vital step for reaching a balanced state between the organisation and the ERP. The implementation of the ERP system requires changes in the way the business is conducted. These changes in business processes are achieved by conducting a Business Process Review (BPR). At the same time, the ERP system needs to be customised to accommodate those business processes and characteristics that cannot be changed.

In the acceptance phase, systems become increasingly available for use in the organisation. In this stage of maturity, systems are modified in order to solve the problems reported by end-users and continuous improvements are made to make the system easy to use and to solve various problems.

In the routinisation phase, users are used to the new system and the organisation cannot revert to the old way of doing business before the enterprise system was implemented. In this stage various functional units can produce and access their required information and reports.

Infusion is the final stage, during which the system is used effectively to enhance the organisation's performance. Any information required for decision making is available, and informed, timely and high-quality decisions enhance the organisation's performance.

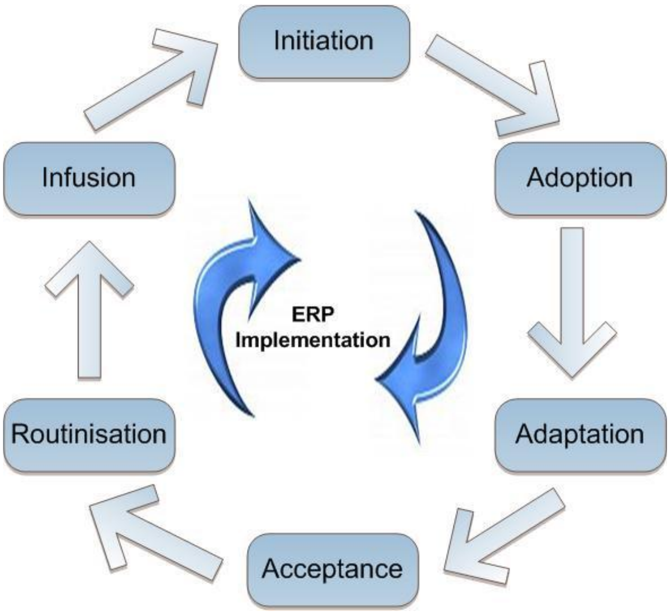

Figure 2.2 Six-stage model of Kwon and Zmud (1987)

The system stream in my framework comprises three categories from the Kwon and Zmud model: initiation, adaptation and acceptance. Initiation includes research during the period before adaptation, such as investment decisions, cost benefit analysis, readiness assessment, product evaluation and choice of appropriate technology, selection of product, and the acquisition and initiation processes. The adaptation stage incorporates Kwon and Zmud's adoption and adaptation stages, and involves research into implementation, defining success factors, project management, usage and maintenance, training, upgrade and extension, change management, socio-cultural factors and business process review. The acceptance stage incorporates Kwon and Zmud's acceptance, routinisation and infusion stages, and includes research into utilising a system to its full potential, enhancing compatibility, system expansion, integration realisation at enterprise level, and gaining strategic competitive advantage as a result of leveraging EPR to it full extent. The initiation, adaptation and acceptance stages of the system stream are discussed in more detail in Section 2.5.

The management concepts stream in my framework is broken down into more detailed research categories, such as impacts and benefits (e.g., return on investment), tactical or operational management decision support (e.g., inventory and supply chain management, quality control management, demand forecasting and yield management), and strategic decision support. The management concepts stream is discussed in Section 2.6.

This framework is depicted graphically in Figure 2.2. The figure shows how most research focuses on enterprise systems in the system stream, with decreasing attention as we move towards management concepts streams and areas such as tactical and strategic decision-making benefits.

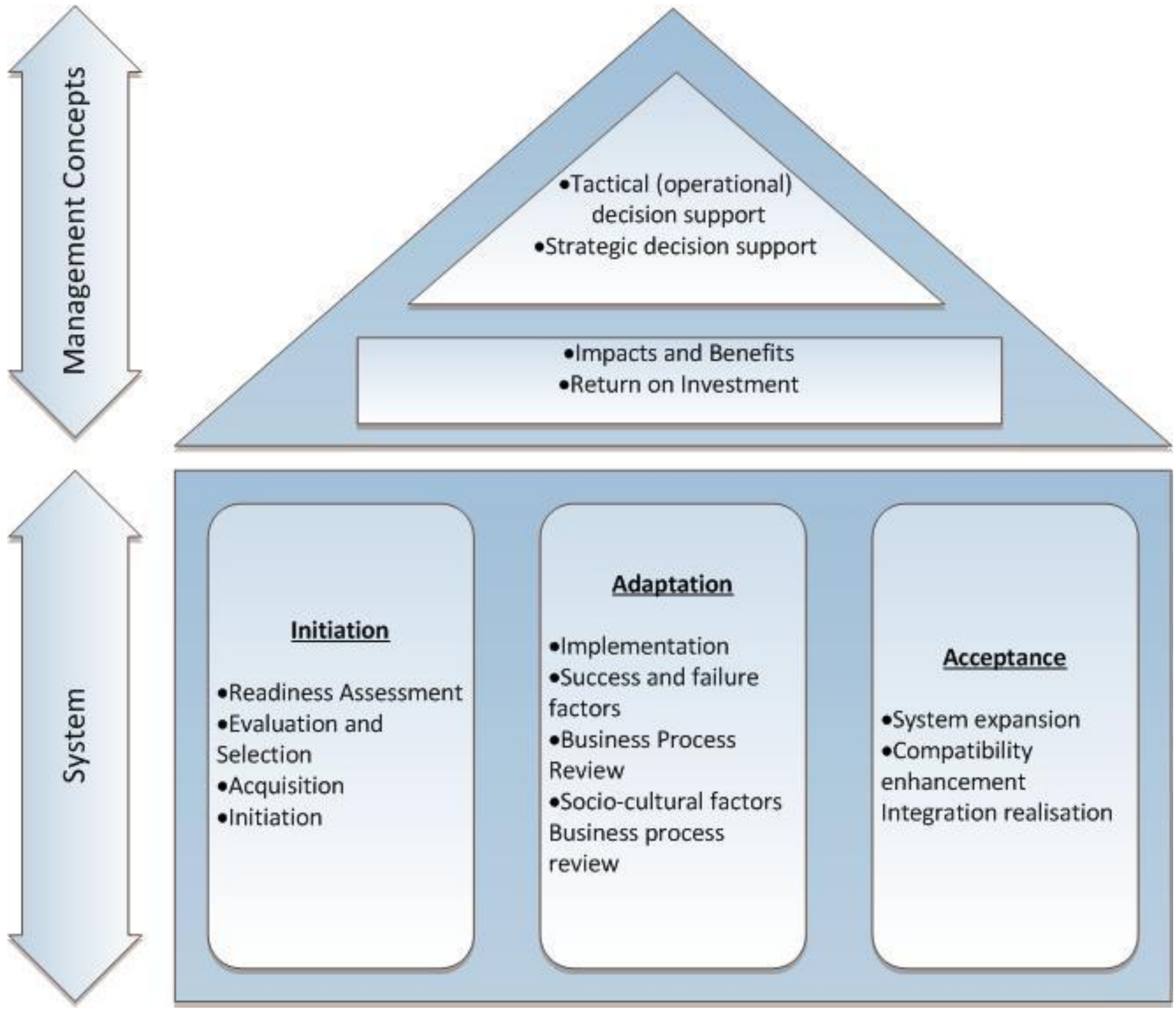

Figure 2.3 ERP literature framework

2.5 System stream

Based on the literature review framework, I categorised literature in the system stream under two categories: initiation, adaptation. Most of the literature dealing with acceptance category could be categorised under adaptation or one of the categories under management concept. This section discusses the two categories of the system stream: initiation and adaptation illustrated in Figure 2.2.

2.5.1 Initiation

Research in this category is concerned mainly with the decision-making processes leading to ERP acquisition. These processes include readiness assessment, planning, information search, selection, evaluation, choice, negotiations and acquisition (Verville and Halingten, 2003). Research in this area is important for two reasons: first, a well-planned initiation phase plays a major role in the success of overall implementation; second, while information systems expenditures represent a significant portion of ongoing capital expenditures for many organisations, little is known about how these expenditures are made or how best to maximise implementation success and investment returns (Berchet and Habchi, 2005; Verville and Halingten, 2001).

Despite the high volume and diversity of research in this category, most of the studies are mainly anecdotal theoretical frameworks or single case studies, rather than empirically supported investigations. Acquisition process models, evaluation/selection process frameworks and influential factors are common subjects in this category. (e.g., Brown et al., 2000; McQueen and Teh, 2000; Sammon and Adam, 2000; Shakir, 2000; Stefanou, 2000). Nevertheless, these theoretical frameworks based on case studies and practical experience can assist practitioners and managers in the ERP initiation phase, and can have a positive impact on the overall implementation of the project (Berchet and Habchi, 2005).

Contrary to the widely held belief that information technology acquisitions are a fairly simple and routine process, Verville and Halingten (2003) argue that acquisitions of the magnitude of ERP are complex, involved, demanding and intensive. Their model for ERP software acquisition comprises six distinctive yet interrelated processes: planning, information search, selection, evaluation, choice and negotiations.

Chun-Chin and Mao-Juin (2004) have presented a comprehensive framework for selecting suitable ERP by combining objective data obtained from external professional reports and subjective data obtained from internal interviews with vendors. As a result, a hierarchical attribute structure including project, software, and vendor factors can evaluate ERP projects.

Evaluation of ERP products was also suggested by Teltumbde (2000), who presented a framework based on the Nominal Group Technique (NGT) and the analytic hierarchy process (AHP) for making the final choice.

Lee and Kim (2000) combined the Analytic Network Process (ANP) and a 0–1 goal-programming model to model the process of selecting an information system. Santhanam and Kyparisis (1995, 1996) proposed a nonlinear programming model to optimise resource allocation and the interaction of factors; their model considers interdependencies of criteria in the information system selection process.

The acquisition process and its characteristics were investigated by Bernroider and Koch (2000) for small, medium, and large organisations, while Sistach et al. (1999) and Sistach and Pastor (2000) concentrated on the acquisition process and proposed methods for SMEs to optimise their acquisition process. Other studies have focused on requirements, risks and rewards, influential factors and the process of ERP adoption in different organisations (Fulford and Solanki, 2000; Hirt and Swanson, 1998, 1999; Oliver and Romm, 2000).

Many researchers consider that successful implementation depends on ensuring users have a positive perception and attitude towards the new information systems (Davis et al., 1989; Gattiker and Hlavka, 1991; Knights and Murray, 1992; Majchrzak et al., 1987; Parsons et al., 1991). However, Abdinnour-Helm et al. (2003) have argued that, contrary to conventional wisdom, extensive organisational investments in pre-implementation training and activities do not always achieve the desired effects.

The common acquisition literature mainly provides framework and guidance for buyers; however, some studies take a different point of view. For instance, the importance of correctly modelling the organisational culture before selecting and implementing a system was investigated by Rugg and Krumbholz (1999). Maiden et al. (1999) proposed using cases and scenarios to help vendors specify their products. O'Leary (2000) investigated the game-playing behaviour that can manifest itself in the requirements, analysis process, evaluation, and choice of ERP software. Stafyla and Stefanou (2000) found that managers' cognition about key factors affects the selection of ERP software.

Research in this category covers diverse topics, with varied findings. Most studies are single case studies, which provide useful information and insight for practitioners, but are not of great academic importance. Further academic research is needed in this category. The lack of empirical rigour has been noted by Oliver and Romm (1999), and Esteves and Pastor (2001) suggested several potential areas of research, such as readiness assessment processes and approaches, adoption decision process and mapping requirements to a particular ERP, contractual agreements analysis, different price models, analysis of returns on investments, and analysis of hardware and software needs associated with ERP system acquisitions.

2.5.2 Adaptation

The adaptation stage in the literature review framework consists of literature dealing with implementation, success factors, project management, usage and maintenance, training, upgrade, change management and business process review. This stage incorporates the adoption and adaptation stages of Kwon and Zmud's (1987) model. While adoption refers to acquiring resources and technology installation, adaptation is the process of adjustments and changes following the installation of such technology (Kwon and Zmud, 1987; Tyre and Orlikowski, 1994).

The majority of the ERP literature is categorised under adaptation. Relevant studies investigate implementation, project management, success and failure factors, usage and maintenance, upgrade and extension, change management, business process review and socio-cultural factors affecting ERP implementation and usage.

The term 'adaptation' signifies the importance and complexity of adaptation between the organisation and ERP, which include process, technical and cultural issues. While ERP vendors advocate that ERP embodies universally applicable best practices, in reality adaptation between a company and ERP involves a process of change in both the ERP and the company via customisation, BPR, process and cultural changes.

2.5.3 Implementation

ERP implementation is a complex and risky exercise which has led to numerous cases of failures, budget overruns, unrealised promised benefits, and systems being less than fully utilised. The high level of failure is often a result of companies failing to understand the real organisational needs, thus leading to poor implementation on their part, rather than being a consequence of poor software design or technical problems (Rajagopal, 2002). A good portion of literature on the subject, therefore, deals with implementation success and failure issues (see, for example, Bradford and Florin 2003; Buckhout et al., 1999; Donovan, 2000; Grabot, 2002; Kumar et al., 2003; Motwania et al., 2002; Umble et al., 2003; Yusuf et al., 2004).

Literature on implementation issues is diverse in both nature and subject. Studies range from anecdotally motivated theoretical frameworks (Cliffe, 1999; Markus et al., 2000a; Prasad et al., 1999) to empirically supported investigations (Holland and Light, 1999; Mabert et al., 2000, 2003b; Zhou et al., 2001).

Despite the diversity of research in this category, most studies agree that aspects of ERP implementation are significantly different from a software implementation project. For example, Davenport (1996, 1998b) distinguished between roles, responsibilities, and the necessary skill sets in an ERP implementation and those associated with a more traditional custom implementation. Gibson et al. (1999) and Scheer and Habermann (2000) differentiated ERP implementation from software implementation by placing emphasis on business process, software configuration, and project management aspects of implementation in the context of organisation strategy and structure. Also, Milford and Stewart (2000) argued that ERP implementations are qualitatively different from other large system implementations.

Case study is one of the most common research techniques for investigating ERP implementation projects. Implementation frameworks, methodologies and strategies as a result of practical cases are common. While most of these studies investigate routine implementation issues, some take different viewpoints that could potentially lead to further research. One example is the case study by Gattiker and Goodhue (2004), who argued that ERP's ability to coordinate activities and facilitate information flow is enhanced by the high interdependence among organisational sub-units. Naturally, however, differentiation among sub-units may incur ERP-related costs and difficulties in organisations.

Based on earlier research, Warda et al. (2005) synthesised a framework for analysing and understanding organisational and behavioural issues involved in ERP implementation. In a series of case studies, they investigated the interactions between a project team's management approach and stakeholder modes of behaviour. They argued that all three management approaches (top-down, coalition, negotiation) are probably needed at different stages of the project. Their results showed that successful ERP implementation depends on understanding whether to utilise existing trust-based relationships or create new coalitions of interest groups.

The in-depth case study of Nandhakumara et al. (2005) investigated the dynamics of contextual forces that lead to drift and control of ERP implementation. They argued that the triggers and consequences of the technology drift, unavoidably associated with ERP systems, can be explained by managers' intentions, the affordability of the technology, and the social structure of the organisation.

2.5.4 Success and failure

A large number of failures in ERP implementation projects have been reported, and many companies have experienced major difficulties with ERP projects. Not surprisingly, more research studies in ERP have focused on critical success factors than on any other topic. Unfortunately, however, much of this research consists of invalid and unreliable case studies, which often lack research methodology or precise definitions for investigated Critical Success Factors (CSFs), and have only a limited number of cases. In addition to validity and reliability problems, success and failure definitions and risks unique to ERP projects are often being sidelined, with few studies investigating these fundamental topics.

The study by Markus et al. (2000a) was one of the few to focus on ERP success definition. They argued that success depends on the point of view from which it is being measured: it has to be considered from technical, economical, operational and managerial aspects. Also important is when the success is being measured; it should be defined and measured at different phases of the ERP process (Markus et al., 2000a; Markus et al., 2000b). Olhager and Selldin (2003) related key-user satisfaction to the perceived success of the ERP system. They claimed key-user satisfaction results from the combination of ERP product, knowledge and involvement, and contractor service, and they developed an instrument that merges and measures these three factors.

Many researchers have attempted to define, develop and investigate CSFs at different stages of ERP implementation. Most have undertaken case studies that can be used as field data for further analysis. Esteves and Pastor (2000), for example, proposed a unified model for CSFs in ERP implementation, based on CSFs in the literature. While their efforts helped to categorise CSFs and to investigate their comparative importance, their unified model was possibly compromised by the small number of out-of-date articles on which it was based.

Because of the large number of research studies investigating CSFs and the variety of factors being investigated, this literature review groups CSFs into four categories: management/organisation, people, process, and planning and technology. Appendix 1 shows the identified CSFs in each study marked against each factor. The summarised data could be interpreted as a continuation of the work of Esteves and Pastor (2000) by the addition of 42 more up-to-date articles and by categorising CSFs for easier interpretation of results.

Based on the data in Appendix 1, the majority of authors consider CSFs associated with management, people and process to be more important than those related to technology (Botta-Genoulaz et al., 2005; Bradford and Florin, 2003; Brown, 1994; Buckhout et al., 1999; Cheung et al., 2001; Duchessi et al., 1998; Falkowski et al., 1998; Herb, 2000; Mainthou et al., 1996; Sarker and Lee, 2003; Stefanou, 1999; Thite, 2000; Wang et al., 2005). Factors identified as crucial to the success or failure of ERP project implementation include top management support, strong and committed leadership, project management principles, empowered project team, end users' training, business process review, communication, monitoring and performance evaluation, upfront planning, and change management. Those authors who investigated mainly technological aspects of CSFs tended to focus on IT infrastructure, consulting services, vendor support and integration; however, this does not indicate that they regard the other factors as less important (Scheer and Habermann, 2000; Sum et al., 1997).

Overall, the most frequently mentioned CFSs in the literature are top management support, and team and user training. These CSFs are considered by most investigators to have the greatest influence on the success or failure of implementation.

Top management support; strong and committed leadership; project management principles
End users' training
Empowered project team; cohesiveness; HR development; people – user characteristics and participation
Company-wide support
Cultural fit
Charismatic leadership
Sustained management support
Steering committee
Leaders' effectiveness

Confidence and knowledge

Table 2.1 Management/organisation and people CSFs

It could be argued that the CSFs considered more important to ERP implementation are likely to appear more frequently in the literature. Based on this review, management/organisation and people together are considered the most important critical success factors for ERP implementation. Table 2.1 lists the management/organisation and people CSFs, in order of importance.

After people and management, the next most frequent category is process and planning. Table 2.2 lists the CSFs identified in this category, again in order of importance.

Process; Business Process Review (BPR)
Open and honest communication; visibility of implementation
Clear goal and objectives
Careful software and vendor selection
Upfront planning
Inter-departmental cooperation and communications
Performance indicators
Detailed documentation
Feasibility and critical evaluation
Confidence and knowledge

Table 2.2 Process and planning CSFs

The least important group of CSFs are technology-related (Table 2.3). Once again, this shows that ERP projects are not similar to ordinary software projects; the vital importance of people and process in implementation project is much higher than technological issues.

Results from empirical studies investigating CSFs support these findings from the literature that people and process in ERP implementation projects are much more important than technological issues. Somers and Nelson (2004) investigated the key players, important activities and the prevalence of their effects in ERP implementation stages. Using an information theory approach, they analysed the fit between the current literature and the experience reported by a cross-section of organisations that completed an ERP implementation. They based their analysis on the six-stage model of Kwon and Zmud (1987), and found that early literature and case-based research on ERP did not take into account the importance of several key variables. For example, they found that the steering committee, interdepartmental cooperation and communication, consultants, and users' training all continue to be important during the first five stages, instead of just in the early phases, as previously thought.

IT infrastructure
Vendor support
Data accuracy and integrity
Consulting services; use of people with technical and business experience
Integration with other systems
Technology
Perceived usefulness, learnability and user interface
Lack of customisation
Leaders' effectiveness
Confidence and knowledge

Table 2.3 Technology-related CSFs

The literature indicates that three key social enablers are necessary conditions for successful ERP implementation are a strong and committed leadership, open and honest communication, and a balanced and empowered implementation team. While all three may contribute to ERP implementation success, the longitudinal positivist case study of Sarker and Lee (2003) highlighted that only strong and committed leadership can be empirically established as a necessary condition.

Bradford and Florin (2003) based their study on the Diffusion of Innovation theory (DOI) of Rogers (1983) and the Information Systems Success theory (IS) of Delone and McLean (1992). They tested a model of ERP implementation success that is measured by user satisfaction and perceived organisational performance. Their results revealed that top management support and training are positively related to user satisfaction, while perceived complexity of ERP and competitive pressure show a negative association. In addition, consensus in organisational objectives and competitive pressure are positively associated with perceived organisational performance.

Some authors have used CSFs for a qualitative research. Sun et al. (2004) defined a framework for CSF assessment, and offered SMEs a structured approach to implementing an ERP system. They converted CSFs into quantitative information that reflects the cost, schedule and goal achievement that must be addressed during implementation. Their simulation model provided a balance between schedule, cost and achievement that is reached at low cost and within a reasonably short time.

2.5.5 Other implementation issues

Other implementation issues consist of a range of topics, such as the role of consultants and the importance of mediation by consultants in ERP implementation project (Westrup and Knight, 2000), examining the issues associated with multi-site implementation (Markus et al. 2000b), using knowledge-based decision support systems to minimise the integration and migration efforts (Umar and Missier, 1999), and deciding whether to implement ERP with or without BPR (Bernroider and Koch, 1999).

Hong and Kim (2002) explored the high failure rate of ERP implementation. They considered it stems from the difference in interests between customer organisations, who desire unique business solutions, and ERP vendors, who prefer generic solutions applicable to a broad market. Based on this assumption, they argued that an important criterion in selecting an ERP system is the ERP fit with the current business processes. From their quantitative research, they found that organisational fit of ERP has a significant effect on the success of ERP implementation.

2.5.6 Socio-cultural factors

Investigation of ERP implementation issues has been extended beyond management, process, and resources to include the importance of culture (national and organisational) and socio-technical view of organisations. Researchers from various disciplines have recognised and studied the impacts of sociological and cultural factors on EPR success or failure, and the realisation of true ERP values following successful implementation. These studies include human behavioural, organisational, sociological and cultural studies (Lee et al., 2002; Shanks et al., 2000).

At a national level, similar cultures and shared believes are recognised to have positive impacts on implementation through better communications and a better trust-building mechanism between team members and other personnel (Jones et al., 2006; Kwasi and Salam, 2004; Lander et al., 2004). Huang and Palvia (2001) investigated other factors with negative impacts on ERP implementation, such as challenges faced in developing countries by their economic and cultural environment and their basic infrastructure. Huang and Palvia proposed a framework for examining ERP implementation in developing countries that assists potential vendors in foreign markets to better understand global ERP markets and develop more appropriate strategies.

Consideration of cultural factors is highly important and critical for successful ERP implementation, especially in multi-national organisations (Sheu et al., 2003). The impacts of national culture on ERP implementation CSFs has been investigated by Shanks et al. (2000). They defined a set of CSFs and performed a comparative analysis on their importance in each phase of ERP implementation in Australia and China. They also analysed the differences using national cultural characteristics.

On an organisational level, Yusuf et al. (2004) considered that organisational culture is a key dimension of the implementation process. Southwick and Sawyer (1999) argued for the importance of analysing managerial and social issues surrounding ERP implementation by applying critical social theory. Krumbholz et al. (2000) used several cultural social science theories to model and predict the impact of culture on ERP implementations.

2.5.7 Business Process Review (BPR)

Business Process Review (BPR) re-defines ineffective business processes and obliterates non-value adding steps in order to maximise customer value while minimising required resources (Hammer, 1990). Without proper BPR, the introduction of information technology might not lead to improved customer values, and excessive expenses for running the technology in order to automate non-value added steps can actually decrease the customer values (Davenport and Short, 1990).

In an ERP implementation, BPR is the alignment between business and ERP standard processes, which are usually claimed by ERP vendors to be based on best practices. As a result, ERP could transform the business processes both by enforcing the standard practices and by changing functional-based operations into process-based operations. In fact, one of the major benefits of implementing ERP is claimed to be its role in re-engineering existing business processes (Al-Mashari et al., 2003).

In general, most research regards BPR as an important factor in the success or failure of ERP. Many researchers have argued that BPR also has an important influence on the post-implementation benefits. They consider BPR a good explanation for Brynjolfsson's (1993) 'productivity paradox', which is the apparent absence of increased performance despite increased expenditure on information technology (Grover et al., 1998; Harris 1994; Hunton et al., 2003; Pinsonneault, 1998; Quinn and Baily, 1994).

Most researchers regard BPR as one of the most important critical success factors in ERP implementation, and even post-implementation (Al-Mashari et al., 2003; Berchet and Habchi, 2005; Hong and Kim, 2002; Ike et al., 2005; Mabert et al., 2003a, 2003b; Mandal and Gunasekaran, 2002; Motwania et al., 2002; Rosario, 2000; Somers and Nelson, 2004; Sun et al., 2004; Umble et al., 2003, Yusuf et al., 2004). However, opinions on BPR implementation and the alignment between business processes and ERP systems are diverse.

Some practitioners and academics regard BPR as a preliminary step required before ERP implementation (van der Aalst and Weijters, 2004), while others consider BPR a parallel process to ERP implementation projects (Chiplunkar et al., 2003).

Alignment between business processes and ERP systems is the subject of debate. Some researchers and practitioners have suggested that conforming to ERP processes and less customisation is vital for success (Gibson et al., 1999; Holland and Light, 1999; Rosario, 2000), while others see the alignment as customisation of the standard ERP processes (Luo and Strong, 2004). However, the majority of researchers fall between these two extreme views. For instance, Soffer et al. (2003) have suggested a reverse engineering process for obtaining an ERP model that can be aligned with the needs of the enterprise. Daneva (2003) defined the problem of process alignment in terms of composition and reconciliation: a general set of business processes and data requirements is established, then standard ERP functionalities are explored to see how closely they match the organisation's process and data needs. Kato et al. (2003) suggested an elicitation-based method for comparing user requirements with existing packages.

2.6 Management concepts stream

Based on the literature review framework explained above, in this section the literature classified under the Management Concepts Stream is broken down into more detailed research categories, such as benefits and impacts (e.g., return on investment), tactical or operational management decision support (e.g., inventory and supply chain management, quality control management, demand forecasting and yield management), strategic decision support and business intelligence.

2.6.1 Benefits and impacts

In contrast to the large number of studies investigating ERP implementation, few researchers have focused on ERP benefits and impacts at the organisational, technological or business level, and the number of studies are insufficient to have yet created a substantial body of knowledge on the subject. Studies investigating benefits and impacts of ERP systems on organisations are diverse in both their research domain and findings. Reported benefits from ERP vendors, and also from the industry and academic studies, are mainly categorised as operational or strategic benefits (Shang and Seddon, 2002; Spathis and Constantinides, 2003; Wieder et al., 2005). However, in the majority of those studies the main benefits revolve around the production of real-time data shared across the organisation, which leads to the integration and automation of business processes.

Potential operational benefits identified in the literature are cost reduction, cycle time reduction, improved delivery time, reduction of stock level, increase in stock turn over, quality improvements, customer service improvements, reduction in total operating and administration costs, reduction of time for transaction processing, easier maintenance and increased user-friendliness (Akkermans et al., 2003; Connolly, 1999; Gattiker and Goodhue, 2004;).

Potential strategic benefits identified in the literature are standardised company processes, integrated operations or data, re-engineered business processes, improved decision-making processes, improved quality and flexibility of information generation, improved performance, support for business growth and alliance, increased business flexibility, building of external linkages (customers and suppliers), support of globalisation strategy, increased internal communications, improved coordination between departments and keeping pace with competitors (Cooke and Peterson, 1998; Lonzinsky, 1998; Shang and Seddon, 2000).

Gaining any of the above benefits for an organisation is highly dependent on factors such as ERP implementation and its maturity stage, implemented modules and numerous other contextual factors. The main benefit expected from any ERP implementation is the reduced cost of information technology infrastructure and human resources (Gattiker and Goodhue, 2004; Holsapple and Sena, 2005). However, it is interesting to note that these two areas have the greatest disparity between expected and actual benefits.

2.6.2 Operational benefits and impacts

Despite similarities in their approaches, studies investigating the impacts of ERP implementation on performance differ substantially in their findings (Bharadwaj, 2000; Brynjolfsson and Yang, 1997; Wieder et al., 2005). Some studies report improved performance, although most find that implementing ERP makes no significant difference on performance, the 'productivity paradox' described earlier.

Poston and Grabski (2001) investigated the impacts of ERP implementation on companies' performance on four financial characteristics before and after ERP adoption. They had predicted that ERP systems would improve firms' performance through cost reduction and by providing a better platform for efficient decision making. Their results indicated no significant improvement associated with residual income or the ratio of selling, general and administrative expenses in each of the three years following the implementation of the ERP system. However, a significant increase in the firm's performance, resulting from a decrease in the ration of cost of goods sold to revenues, was found three years after the ERP system implementation.

Wieder et al. (2005) investigated the impacts of ERP adoption on organisational performance. Based on their findings, they challenged ERP vendors' claim that ERP has a significant impact on performance. They concluded that there are no significant performance differences between ERP adopters and non-adopters, at either the business process level or the overall firm level. However, they confirmed that the longer the experience of firms with ERP, the higher their overall performance.

In an attempt to solve the productivity paradox, Robertson and Gatignon (1986) and Brynjolfsson and Hitt (1996) suggested that increased spending on information technology improves efficiency and effectiveness, which in turn passes financial gains on to consumers through decreased prices, and this process leads to competitive advantage. This is in line with the analytical modelling of Eliashberg and Jeuland (1986) and Eliashberg and Chatterjee (1985, 1986), which demonstrated that prices drop immediately after adoption of innovative technologies and demand increases as a result of price sensitivity. They further indicated that the financial performance might or might not improve significantly; however, the performance of non-adopters would be expected to deteriorate in a competitive marketplace. To test this hypothesis, Hunton et al. (2003), examined the longitudinal impact of ERP adoption on firms by comparing the financial performance of adopters and non-adopters. They reported no pre- to post-adoption improvement in financial performance of ERP firms. However, they found significant differences between adopters non-adopters, due primarily to the decreased financial performance of non-adopters.

Some studies have found that ERP adopters benefit from ERP implementation in the form of improved performance. Through comparing financial data of ERP adopters to their matched control group, Nicolaou et al. (2003) found that adopters have significantly higher differential performance in their second year after the completion of the system than the control group. Also, Matolcsy et al. (2005) found that adoption of ERP systems leads to sustained operational efficiencies and improved overall liquidity. In addition, some support was found for increased profitability some time after implementation.

2.6.3 Strategic benefits and impacts

One of the perceived benefits of implementing ERP systems is increased efficiency and effectiveness in business processes permeating managerial processes, such as planning and decision-making at all levels. Benefits such as real-time data availability and integration have apparent implications for organisational decision support (Shang and Seddon, 2000; Spathis and Constantinides, 2003); however, decision support is not explicitly recognised as a major reason for implementing ERP systems (Cook and Peterson, 1998; Davenport, 2000a; Holsapple and Sena, 2005).

ERP impact on management processes is one of the intangible benefits of ERP implementation which have not been investigated rigorously (Duff and Jain, 1998; Hayes et al., 2001; Shang and Seddon, 2000; Spathis and Constantinides, 2003). ERP implementation and support activities incur substantial operational challenges, providing a possible explanation for the increasing volume of research on implementation issues and less focus on crucial managerial concepts such as decision-making, return on investment and strategic benefits.

Davenport (1998b) and Jacobs and Bendoly (2003) have argued that operational complexity, and the tedious job to get the system to work, have contributed to less focus on such crucial issues such as improved decision making at tactical and strategic levels, return on investment and gaining competitive advantage, although such issues represent potential long-term rationales for ERP acquisition.

Operational challenges become less important as companies become more mature in their adaptation and vendors gain more experience and awareness about design and implementation of ERP systems. As a result, companies who initially implemented ERP to overcome operational and transactional problems tend to subsequently leverage their expectations to more strategic benefits. Hawking et al. (2004) argued that these companies could achieve these benefits by implementing 'second wave' functionality, which is the process of achieving additional benefits from an ERP implementation. In other words, although benefits gained from ERP projects include elimination of conflicting information, reduction in data redundancy, standardisation of business processes across business units and efficiency in managing transactions, today increasing numbers of companies who have already achieved these aims are using the ERP systems for decision support and information analysis activities. It is at this stage that the anticipated benefits from the investment in ERP will eventually be realised.

ERP decision-support functionality

Although there has been little examination of the extent to which decision support benefits accrue to ERP adopters, or the extent to which they relate to various objectives in an ERP implementation (Holsapple and Sena, 2005), the importance of additional decision support and information analysis features is recognised as a critical feature of enterprise systems (Jacobs and Bendoly, 2003).

Davenport (1998b, p.8) identified the need 'to make sound and timely business decisions' as a major reason for adopting ERP systems. White (1999) claimed that 'although organisations have found that ERP packages offer benefits supporting transaction processing, they haven't been so successful in using them for decision processing'. Also, in a study focused on the need to link ERP systems with both external and internal data, Palaniswamy and Frank (2000, p.11) described the need for organisations 'to digest the vast amount of information from the environment and make fast decisions' and the need to 'work together and sometimes with other organisations' to make strategic decisions. Davenport (1998a, 1998b) pointed out that organisations spend millions of dollars to implement enterprise systems without being able to use the data in the system to their advantage.

Overall, the need for decision support functionality in ERP systems is widely recognised and, in principle, ERP should at least support decision-making processes in operation management areas. However, there is no consensus on the exhibition of any such functionality to support either tactical or strategic decision-making processes (Gupta and Kohli, 2004). Some studies consider decision support functionality is part of ERP systems; others disagree. Examples from the literature expressing both points of view are outlined below.

Literature supporting the exhibition of decision-support functionality

Davenport (2000a) described several elements of an ERP system that provide both decision support functionality and transactional functionality. These elements are tools for data communications, data access, data analysis and presentation, assessing data context, synthesising data from other sources, and assessing completeness of data.

In a survey of 15 ERP adopters, Holsapple and Sena (2003) examined the extent to which 16 decision support characteristics are exhibited by their ERP systems. They found that adopters consider their ERP systems exhibit a moderate level of decision-support characteristics, most noticeably the provision of a repository of knowledge for solving problems and mechanisms to facilitate communication within an organisation.

In order to explore the importance of decision-support objectives during ERP planning, Holsapple and Sena (2005) surveyed the importance of 13 identified objectives in the planning of ERP. Eight objectives were based on findings from Cooke and Peterson (1998), while five others explicitly referred to decision support. However, in contrast to studies by Lonzinsky (1998) and Cooke and Peterson (1998), which did not identify support for decision making as a reason for adopting ERP systems, Holsapple and Sena (2005) found that organisations consider the decision support objectives important when planning their ERP projects, particularly in some situations, as listed in Table 2.4.

One person making an individual decision
Multiple people contributing to making a decision
Multiple people involved in making inter-related decisions
De-centralised decision-making process

Table 2.4 Different situations in decision making

The only decision support objective which was found to have no significant importance was the objective of supporting trans-organisational decision making.

In what claimed to be the first research to investigate this issue in the field of ERP and Decision Support System (DSS) research, Holsapple and Sena (2005) examined the perceived impacts of ERP on decision-support by ERP adopters. They compiled a ranked list of perceived decision-support benefits by ERP adopters. The six highest-rated benefits, each with a median of 5 on a 7-point scale are: better knowledge processing, decision reliability, decisional substantiation, competitiveness, decision-making speed, and treatment of large-scale or complex problems. These findings are similar to the results of DeSanctis and Gallupe (1987), Udo and Guimaraes (1994), Holsapple and Whinston (1996), Marakas (1999), Turban and Aronson (1998) and Murphy and Simon (2003).

Literature rejecting the exhibition of decision-support functionality

In an attempt to investigate impacts of ERP system on accounting practices in Australia, Booth et al. (2000) suggested that ERP systems are quite effective in transaction processing but less effective in reporting and decision support.

Akkermans et al. (2003) investigated the impacts of ERP systems on Supply Chain Management (SCM) performance, with their results contradicting the claim that ERP functionality goes beyond transactional. Their study of 23 Dutch supply chain executives of European multi-nationals indicated that there is only a moderate role for ERP in improving future supply chain effectiveness, and there is a clear risk of ERP actually limiting SCM progress. The researchers identified 'lack of functionality beyond managing transactions', as one of four key limitations to current ERP systems providing effective SCM support. However, they conceded that concepts such as ATP (available-to-promise) within ERP circles, and that these are moving system functionality beyond transactional and more towards tactical decision support functionality.

Chou and Tripuramalu (2005) argued that, although ERP systems can integrate all business transaction data into one master database for organisational planning, it is not a system for data analysis and decision support processes. They explained that introduction of business intelligence tools by ERP vendors is a response to address such deficiency.

Despite contrasting findings in the literature regarding the exhibition of ERP decision support capabilities, using enterprise data in an efficient way for decision making is recognised as an important benefit of ERP systems. Vendors' responses to such a need have been diverse. Some vendors have provided report writers that can access data from multiple ERP modules and create a consolidated report. Others have introduced business intelligent (BI) tools to access data directly from ERP modules. An alternative is to congregate all needed data from enterprise systems, load them to a data warehouse or a data mart and then use BI tools to provide necessary information for the decision-making process.

To justify their return-on-investment, more organisations are turning to BI tools that make data, collected by ERP and other data-intensive enterprise applications, meaningful for decision makers (Chou and Tripuramalu, 2005). While ERP systems are designed to capture transactional data, BI tools in contrast provide analytical features to examine large volumes of data and generate essential information for decision making. Chou and Tripuramalu (2005) concluded that integration of BI and ERP systems contributes additional value by providing meaningful analysis, such as online analytical processes (OLAP) and data mining tools to discover trends and patterns. Such capabilities increase decision-making effectiveness and quality through utilising analytical capability of BI on ERP data, which ultimately helps organisations to gain a competitive advantage.

2.6.4 Business intelligence

The growth of evolving enterprise systems has led to a new challenge for organisations: integration between enterprise systems and making use of vast amount of data generated by these systems for decision-making purposes. In fact, more and more organisations seek a consolidated picture of business operations across multiple enterprise systems and a variety of data sources.

BI is the industry answer to this challenge. BI was introduced by Howard Dresner from the Garthner Group in 1989 to explain a set of concepts and methodologies designed to improve decision making via the use of facts and fact-based systems (Hashmi, 2004). BI provides access to data, tools to make it meaningful and the necessary infrastructure to deliver it to stakeholders inside and outside the organisation.

Integration as the main obstacle for BI implementation

BI has four major components: operational data, data integration, data storage and BI software. Achieving data integration is the most challenging task facing organisations that attempt to implement BI in both inter and intra-organisational levels.

Although ERP systems consist of a set of internally integrated modules to support generic business processes, they are not designed for collaboration with other enterprise systems. Other enterprise systems such as Customer Relationship Management (CRM) lack such a capability. As a result, integration between enterprise systems becomes vital in order to utilise enterprise system data for decision making (Kalakota and Robinson, 2001).

The need for intra and inter-organisational integration has existed since applications moved from central processors to distributed environments and networks. The introduction of ERP as a new alternative resolved some of the integration issues at the operational level and within ERP integrated modules. However, the introduction of other enterprise systems such as CRM and emerging e-business environments dictated the need for another level of intra-organisational integration between enterprise systems in a maintainable and flexible way (Themistocleous et al., 2001). At the same time, increasing inter-dependency between supply chain organisations and their transformation from individual organisations to virtual entities of the supply chain, which compete against other supply chains, requires inter-organisational integration between supply chain partners (Sutton, 2006; Wieder et al., 2005).

Electronic data interchange (EDI) was the first attempt to provide limited integration between disparate systems. EDI is a complex and invasive technology that provides limited date integration across limited applications. It does not provide inter- or intra-organisational integration, process integration or the necessary maintainability and flexibility which are required by today's dynamic organisations (Kim and Umanath, 1999; Nissen, 2000).

The industry response to the need for integration has been to introduce different integration approaches, ranging from a single application which captures all business data and handles all business processes through one big application (Big I), to the very sophisticated service-oriented architecture which provides integrity with business data and processes under web-services technology (Little I). It is reasonable to assume that most organisations find their integration solution somewhere between totally integrated "Big I" and totally distributed integration "Little I".

Given the current state of technology, most organisations have to adopt a solution that lies between Big I and Little I. Such solutions include EDI, Data Warehousing (DW), Enterprise Application Integration (EAI) and Point-to-point integration.

Enterprise Application Integration (EAI)

There is no single integration solution technology that solves all types of integration problems. EAI, which can be provided by ERP vendors or third party solution providers, facilitates a wide range of technologies to build a centralised integration infrastructure in order to share data and business process logic across hetero/homogeneous applications (Ring and Ward-Dutton, 1999; Themistocleous, 2004).

EAI integrates multiple systems at the application or database level using a form of middleware known as Enterprise Service Bus (ESB). ESB is a hub-spoke model that allows sharing data and business processes across different systems through message-oriented-middleware (MOM). Using MOM means that individual applications can publish messages to the bus, and subscribe to receive certain messages from the bus, using pre-designed interfaces or connectors. This model requires one single interface or connector between middleware and each application, in contrast to the point-to-point model, which requires interfaces between each application and all others (Gulledge, 2006).

2.7 Discussion

The importance and need for timely decisions is widely recognised as a critical success factor for gaining competitive advantage, especially in complex supply chains. EPR provides the necessary building blocks of data that are required for making such decisions. However, to facilitate the decision-making process, ERP data need to be transformed into information by using tools for data analysis and presentation, data communications, data access, assessing data context, synthesising data from other sources and assessing completeness of data (Davenport, 2000a). The importance of such additional decision support and information analysis features is considered a critical feature of enterprise systems (Jacobs and Bendoly, 2003).

Despite the need for decision-support features in enterprise systems and their importance in gaining and sustaining competitive advantage in today's supply chains, the vast majority of the literature focuses on operational issues such as initiation, adaptation and support. Studies investigating the decision-support features of enterprise systems are mostly limited to recognising the importance of such features.

Organisations looking for ways to leverage their investments on ERP to more strategic benefits and vendors who are facing saturated markets are both looking for ways to add extra features and functionality to their products to keep or extend their market share. However, the utilisation of ERP beyond its transactional and operational capabilities remains highly under-researched, considering the importance of the topic and its impact on both enterprise systems users and vendors. From this literature review, there is clearly a need for research that provides insight into tactical and strategic decision-support features and functionality, in terms of expectation, exhibition and realisation.

2.7.1 Expectation

Decision support is not explicitly recognised in the literature as a major reason for implementing ERP systems (Holsapple and Sena, 2005). However, adopters' expectations of ERP decision-support features and benefits after reaching a certain stage of maturity in their adaptation have not been investigated. Organisations who initially implemented ERP to overcome operational and transactional problems subsequently tend to try to leverage their investment on ERP to more strategic benefits. The majority of potential ERP rollouts in Australia are already completed or are underway. This includes organisations which could be categorised under the first-tier ERP market, most of whom completed their ERP rollouts before 2000. This community of mature ERP users who are entering the final stage of their evolutionary process are now looking for ways to leverage their investment in ERP to the next level, by utilising ERP capabilities towards decision-making and information analysis activities (Industry Sector Analysis, 1998; Stein and Hawking, 2002; Woodhead, 2001).

This research investigated adopters' expectations of ERP decision-support features as they reach a different stage of maturity in ERP adaptation process, and the priority of such features compare to other objectives, by asking the following questions:

- To what extent utilising ERP decision-support features for making decisions is one of the objectives for ERP implementation?
- To what extent ERP decision-support features of ERP system considered as an important factor in the evaluation and requisition process?
- To what extent ERP adopters expect that ERP should provide tools to enhance decision makers' ability to process information (OLAP analysis, knowledge repository)?
- To what extent ERP adopters expect that ERP should provide tools for better facilitation of the decision-making process (e.g., collaboration, communication)?
- To what extent ERP adopters expect that ERP should provide facilities to encourage exploration and new approaches to the problem (e.g., sensitivity analysis, simulation tools)?
- To what extent ERP adopters expect that ERP should provide a user-friendly interface, which improves the decision-making process?
- To what extent adopters expectations change based on their maturity state?

2.7.2 Exhibition

Previous studies have not investigated the existence of decision-support features in ERP systems. In their research into the impacts of ERP systems on supply chain management (SCM) performance, Akkermans et al. (2003) identified 'lack of functionality beyond managing transactions', as one of four key limitations to current ERP systems providing effective SCM support. However, neither this nor similar studies (e.g., Holsapple and Sena, 2005) have investigated the existence of specific characteristics of decision-support features in ERP systems and their impacts on the decision-making process. In this research I investigated the exhibition of ERP decision-making features and capabilities by asking the following questions:

- To what extent ERP provide tools to enhance decision makers' ability to process information? (OLAP analysis, knowledge repository)
- To what extent ERP provide tools for better facilitation of the decision-making process? (e.g., collaboration, communication)
- To what extent ERP provide facilities to encourage exploration and new approaches to the problem? (e.g., sensitivity analysis, simulation tools)
- To what extent ERP provide a good user interface? (e.g., simple and convenient format, customised queries, customised results, scheduling queries, customised user interface)
- To what extent user knowledge and decision-making training have a positive impact on utilising ERP for decision making?

2.7.3 Realisation

If it is expected that ERP provide decision support facilities and if such features are exhibited in ERP systems, to what extent do organisations realise decision-support benefits from these systems? What decision-support benefits do users of current enterprise systems realise, and what decision-support benefits do they consider important? Studies investigating decision-support systems have identified several characteristics to measure the effectiveness of such systems (Holsapple and Whinston, 1996; Marakas, 1999; Turban and Aronson, 1998; Udo and Guimaraes, 1994) (Table 2.5).

To shorten the time and cost associated with making a decision
To enhance a decision maker's ability to process knowledge
To enhance a decision maker's ability to handle large-scale or complex problems
To improve the reliability of decision processes or outcomes
To encourage exploration or discovery by a decision maker
To reveal or stimulate new approaches to thinking about a problem space or decision context,
To furnish evidence in support of a decision or confirmation of existing assumptions, and create a strategic or competitive advantage over competing organisations

Table 2.5 Characteristics of decision support systems

Using these characteristics, we investigated the realisation of such features and their role as an objective of ERP implementation, and in the evaluation and acquisition process, by asking the following questions:

- To what extent ERP improves the quality of decisions?
- To what extent ERP helps reducing the cost of decision making?
- To what extent ERP shortens the decision-making time?
- To what extent ERP improves the reliability of the decision-making process?
- To what extent ERP improves decision makers' abilities to tackle complex problems?
- To what extent ERP increases satisfaction with the decision-making process?

This research was designed based on the structure presented in this section. We investigated adopters' expectations from ERP as a decision-support tool, the exhibition of decision-support features and capabilities in ERP systems and, finally, realisation of such potential benefits in practice.

2.8 Chapter summary

This chapter has reviewed the ERP literature in general and in relation to decision making. We developed a framework and categorised literature based on two main streams of system and management concepts. The literature review was conducted as the first step in this research in order to identify the gaps in research and to initiate data collection. More recent research has been reviewed and is referred to in the final chapter, in order to provide a recent context for the findings of this research.

CHAPTER 3

RESEARCH METHODOLOGY

3.1 Introduction

This chapter describes the research objectives and methodology, and discusses the process by which the most appropriate research techniques were selected. The capabilities and limitations are briefly outlined. Finally, the chapter provides details of the data collection and subsequent data analysis.

3.2 Research objectives

The previous chapter discussed the importance and need for research on the decision support characteristics of ERP systems. Such research is encouraged by organisations looking for ways to leverage their investments on ERP to more strategic benefits. It is also encouraged by vendors, facing saturated markets, looking for ways to add extra features and functionality to their products to keep or extend their market share.

The focus of this study was to reveal if, and how, the vast amount of data generated by ERP systems can improve the decision-making processes of Australian organisations on strategic and tactical levels. I studied ERP decision support features and capabilities and their impacts on decision making by investigating ERP adopters' expectations, the exhibition of such features in ERP systems and the realisation of possible impacts or benefits in practice. As briefly outlined in Chapter 1, this research aimed to answer three main questions:

What are ERP adopters' expectations in regards to ERP decision support features and capabilities?

What decision-support features and capabilities are exhibited in current ERP systems?

What benefits and impacts are realised by ERP adopters as a result of utilising ERP decision support features and capabilities?

3.2.1 Expectations

Decision support is not explicitly recognised as a major reason for implementing ERP systems (Holsapple and Sena, 2005) and it could be concluded that ERP adopters do not have high expectations that ERP systems will increase decision support in their organisations. However, some researchers suggest that adopters' expectations of ERP decision support features and benefits change after reaching a certain stage of maturity in their adaptation. They argue that organisations who initially implemented ERP to overcome operational and transactional problems tend subsequently to try to leverage their investment on ERP to more strategic benefits such as decision making (Stein and Hawking, 2002; Woodhead, 2001).

This study investigated adopters' expectations of ERP decision support features during different phases of ERP adaptation, including defining objectives and the evaluation/requisition stage, by asking the following questions:

- Is utilising ERP decision support features for making decisions one of the objectives for ERP implementation?
- Are ERP decision support features of ERP systems considered an important factor in the evaluation and requisition process?
- Do ERP adopters expect that ERP should provide tools to enhance decision makers' ability to process information (OLAP analysis, knowledge repository)?
- Do ERP adopters expect that ERP should provide tools for better facilitation of decision-making process (e.g., collaboration, communication)?
- Do ERP adopters expect that ERP should provide facilities to encourage exploration and new approaches to the problem (e.g., sensitivity analysis, simulation tools)?

- Do ERP adopters expect that ERP should provide a user-friendly interface, which improves the decision-making process?
- Do adopters' expectations change, based on their maturity state?

3.2.2 Exhibition

I studied the existence of decision support features and capabilities in ERP systems by investigating system characteristics and users' awareness of such features and capabilities in the system. I needed to identify decision support characteristics in order to examine the exhibition of ERP decision support features, and I assumed that these characteristics are similar to those exhibited in Decision Support Systems (DSS).

Decision support systems provide a comprehensive framework which enhances and facilitates decision making process by (i) enhancing communication, (ii) providing necessary knowledge which reduces uncertainty and (iii) providing better decision making processes (Desanctis and Gallupe, 1987). A decision support system has accurate data, an effective interface, a reliable knowledge base and a good inference mechanism, which can be categorised into four main components: knowledge base, user interface, inference engine and collaboration tools. The knowledge base is the repository which contains well established facts, guidelines, risk and cost of operations. The user interface requests from the system and presents the outputs. The inference engine is set of complex computer algorithms that use the data in the knowledge base to obtain solutions to problems. These algorithms can be designed to deal with decision making in two ways: under certainty, which utilises mathematical models, and under uncertainty, which utilises statistical approaches (Hogue and Watson, 1983; Holsapple and Whinston, 1996; Turban and Aronson, 1998). Finally, collaboration and coordination tools facilitate communication and collaboration between decision makers within or across organisations.

This research builds upon the work of Holsapple and Sena (2003), who studied the decision support characteristics of ERP and identified 16 characteristics for DSS components (Table 3.1). Holsapple and Sena (2003) examined these characteristics along the four dimensions of individual, joint, inter-related and inter-organisational decision making. In this study I used a modified list of these characteristics to design the survey instrument.

DSS Components	***Characteristics***
Knowledge base	*Identify problem* *Provide solution (Relevant: immediately applicable)* *Facilitate interaction (Timely: brings research results more quickly into practice, reduces learning time, reduces variations in quality)* *Define, document and regulate actions* *Private repository* *Public repository*
Inference engine	*Infer new knowledge using calculations, analysis, reasoning* *Knowledge for unanticipated needs (Adaptable: captures many situations: wide range of possibilities)*
User Interface	*Customised request* *Customised results* *User friendliness (Simple: compact, convenient format)* *Scheduling requests*
Collaboration and coordination	*Facilitate communication:* *- Within organisation* *- Across organisations boundaries* *Structure, regulate tasks:* *- Individuals* *- Joint* *- Inter-related* *- Inter-organisational*

Table 3.1 Characteristics of DSS components (from Holsapple and Sena, 2003)

ERP can improve decision making by providing timely information, facilitating the decision-making process and providing facilities to encourage exploration and new approaches to the problem. These characteristics, along with the effectiveness of user interface and users' knowledge and training on utilising these features, come under the category of the exhibition of ERP decision-making features and capabilities, and were investigated by asking the following questions:

- Does ERP provide tools to enhance decision makers' ability to process information? (OLAP analysis, knowledge repository)
- Does ERP provide tools for better facilitation of decision-making process? (e.g., collaboration, communication)
- Does ERP provide facilities to encourage exploration and new approaches to the problem? (e.g., sensitivity analysis, simulation tools)
- Does ERP provide a good user interface? (e.g., simple and convenient format, customised queries, customised results, scheduling queries, customised user interface)
- Do user knowledge and training on decision making have a positive impact on utilising ERP towards decision making?

3.2.3 Realisation

Granted that it is expected that ERP provides decision support facilities and that such features are exhibited in ERP systems, to what extent do organisations realise decision support benefits from these systems? What decision support benefits do users of current enterprise systems realise, and what decision support benefits do they consider important?

I used the recognised benefits in the DSS literature to investigate the realised decision support benefits of ERP systems. Holsapple and Whinston (1996) compiled a list of such benefits, which include the capacity of a DSS to enhance a decision maker's ability to process knowledge, enhance a decision maker's ability to handle large-scale or complex problems, shorten the time and cost associated with making a decision, improve the reliability of decision processes or outcomes, encourage exploration or discovery by a decision maker, reveal or stimulate new approaches to thinking about a problem space or decision context, furnish evidence in support of a decision or confirmation of existing assumptions, and create a strategic or competitive advantage over competing organisations (DeSanctis and Gallupe, 1987; Holsapple and Whinston, 1996; Marakas, 1999; Turban and Aronson, 1998; Udo and Guimaraes, 1994). These benefits are summarised in Table 3.2.

DDS Benefits
Better knowledge processing
Better cope with large/complex problems
Reduced decision time
Reduced decision costs
Greater exploration/discovery
Stimulates fresh perspective
Substantiation (furnish evidence in support of a decision or confirmation of existing assumptions)
Greater reliability
Better communication
Better coordination
Greater satisfaction
Decisional empowerment
Competitive advantage
Reducing communication barriers
Reducing uncertainty and noise
Regulating decision process
Facilitating individual decision making
Facilitating joint decision making
Facilitating inter-related decision making
Facilitating intra-organisational decision making

Table 3.2 Decision support benefits (from Holsapple and Whinston, 1996)

Based on the DSS benefits identified in the literature, I investigated the potential benefits of ERP decision support features, as listed in Table 3.3.

To shorten the time and cost associated with making a decision
To enhance a decision maker's ability to process knowledge
To enhance a decision maker's ability to handle large-scale or complex problems
To improve the reliability of decision processes or outcomes
To encourage exploration or discovery by a decision maker
To reveal or stimulate new approaches to thinking about a problem space or decision context,
To furnish evidence in support of a decision or confirmation of existing assumptions, and create a strategic or competitive advantage over competing organisations

Table 3.3 Benefits of ERP decision support features

I investigated the realisation of identified benefits by asking the following questions:

- Does ERP improve the quality of decisions?
- Does ERP help reduce the cost of decision making?
- Does ERP shorten the decision-making time?
- Does ERP improve the reliability of the decision-making process?
- Does ERP improve decision makers' abilities to tackle complex problems?
- Does ERP increase satisfaction with the decision-making process?

3.3. Research paradigm and methodology

Few notable studies, in either industry or academia, have investigated the decision support characteristics of ERP systems and their utilisation in practice. To redress this lack of knowledge and theory, I conducted this study in two phases, using qualitative techniques in the first phase to gain insight into the problem in order to design and conduct the second phase, which utilised qualitative techniques.

I adopted an interpretivist paradigm in the first phase to cater for the scarcity of underlying knowledge, theory and comprehensive studies in the Australian context. Interpretivism assumes that reality is subjective and multiple, and the world can be best understood from the point of view of the individuals directly involved in the activities in question. The emphasis is on understanding features of the phenomenon in subjective reality rather than its totality in objective reality.

The insight gained from the first phase provided the foundation for employing qualitative methods in the second phase. This phase examined the extent to which adopters of ERP systems perceive the characteristics usually associated with decision support systems. It also investigated the exhibition of such characteristics in ERP products and the realised benefits of using such features. To this end, the researcher assumed the role of an objective analyst, making detached interpretations about those data that had been collected in an apparently value-free manner, with an emphasis on a highly structured methodology to facilitate quantifiable observations that lead to statistical analysis (Gill and Johnson, 1997). The main methodology in this second phase was a survey targeting professionals, as described in Section 3.4 below.

3.3.1 Methodological strategy

The two most commonly used research approaches are deductive and inductive reasoning (Babbie, 1993), and positivistic research may be conducted using either approach (Saunders and Lewis, 2003). Deductive reasoning is essential for working within the positivist paradigms, while inductive reasoning begins with detailed observations of the world and moves toward more abstract generalisations, ideas, relationships, and developing theory from observable facts (Neuman and Kreuger, 2003; Sekaran, 2000). Inductive reasoning is used within the interpretivist paradigm; however, both approaches can be used in combination in a research project if the research question directs such an approach (Saunders and Lewis, 2003). Table 3.4 summarises deductive and inductive approaches.

Deductive approach
Identifies relevant theory, developing hypotheses, making observations relevant to testing the hypotheses and comparing the hypotheses and observations
Inductive approach
Begins by making observations about a set of relevant data and then seeks to discover patterns that may point to more general theories

Table 3.4 Research approaches

Because of the lack of previous work on the subject, one of the main objectives of this study was to provide a better understanding of the problem and to identify major factors and parameters involved. I achieved this aim by conducting exploratory interviews in the first phase of the research, which provided preliminary insights for developing the survey instrument used in the second phase. However, both phases were designed to increase understanding and insight into the problem, and in both phases I adopted an inductive approach. In both phases, data analysis was inductive, searching for themes and patterns and finally developing a model to explain system behaviour.

3.3.2 Research population and sampling frame

Decision support is not explicitly recognised in the literature as a major reason for implementing ERP systems (Holsapple and Sena, 2005). However, adopters' expectations of ERP decision support features and benefits can change after reaching a certain stage of maturity in their adaptation. Organisations who initially implement ERP to overcome operational and transactional problems tend to subsequently try to leverage their investment on ERP to more strategic benefits. This includes organisations which can be categorised as first-tier ERP market, most of whom completed their ERP rollouts before 2000. This community of mature ERP users who are entering the final stage of their evolutionary process are now looking for ways to leverage their investment in ERP to the next level, by utilising ERP capabilities towards decision making and information analysis activities (Industry Sector Analysis, 1998; Stein and Hawking, 2002; Woodhead, 2001). The research population was therefore defined as:

Professionals who are involved with the implementation, operation and day to day use of ERP systems in Australian organisations in the first tier ERP market (with approximately 500+ employees) who have been using at least two of the main ERP modules (manufacturing, financials, and human resources) for the last five years.

Potential respondents were identified from the user groups of major ERP vendors in Australia.

3.3.3 Sample design

As defined in Chapter 1, respondents were chosen from organisations in the first tier of the ERP market and were familiar with both the objectives and benefits of their organisation's enterprise systems. These included senior managers, operational managers and project managers. Possible titles of survey respondents were Managing Director, Human Resources Manager, CEO, CFO, Production and Inventory Control Manager, Materials Manager, Master Scheduler and Production Manager.

Research participants for the first phase, the exploratory interviews, were purposefully selected from Australian organisations in technology, defence, financials, logistics and telecommunications. All of these organisations were in the first-tier ERP market and had been using at least two of the main ERP modules (manufacturing, financials, and human resources) for the preceding five years. Participants were senior managers, middle managers and professionals who could potentially benefit from ERP decision-making capabilities or had been involved with the implementation and day-to-day use of ERP systems in those organisations. Fifteen individuals were identified using referrals, professional connections and a direct approach.

For the second phase, the survey, I did not follow the traditional approach of ERP researchers who focus mainly on information systems and ERP practitioners as their primarily informants. Instead I targeted high-level managers who could potentially benefit from ERP decision-making features and capabilities. For this phase, most of the participants were purposely selected from top managers in executive positions. Respondents were sought mainly from the first tier of the ERP market across different industry sectors and functional areas. Defence, technology, telecommunication and service providers such as financial and insurance were the most common industry sectors.

3.4 Phase 1: Exploratory interviews

In the first phase of the research, semi-structured interviews with open-ended questions were utilised to collect data that consisted of real stories, experiences and insights. Such exploratory interviews are ideal for gaining the insight necessary for designing the survey instrument and constructs (Sieber, 1973), and the process was enhanced by the researcher's personal experience with ERP systems (Nightingale and Cromby, 1999). Appendix 2 contains the interview instrument that was used as a guide for exploring the main topics, and questions that could be used to initiate discussion on each topic. With participants' consent, interviews were audio taped and subsequently transcribed.

The data collected during this first phase consisted of the transcribed semi-structured interviews, the researcher's notes taken during interviews and the researcher's personal experience with ERP systems. A few pilot interviews were conducted first with colleagues to refine the interview process and to improve the interviewer's skills. The interviews with participants were conducted in the participants' offices and, in two cases, by phone.

Prior to each interview, interviewees were briefed on the study objectives, presented with an information statement and requested to sign a consent form. Interviews were digitally recorded and transcribed, the interviewer's reflection notes were attached to the file as an appendix, and final transcripts were emailed to participants for their review and approval.

I analysed interview transcripts using an open coding technique (Strauss and Corbin, 1990). Data were first broken down by taking apart sentences, paragraphs, reflection notes and observations. I gave each separate idea or event a name, and regrouped the data into subcategories of similar ideas and events. Axial coding then identified main categories and made connections between them and their subcategories, based on the researcher's personal experience.

3.5 Phase 2: Survey

Insight gained from the qualitative first stage provided a foundation for the qualitative methods used in the second stage to investigate the subject in more depth and detail. In this phase I designed a survey instrument to identify the major factors and their potential relationships.

3.5.1 Survey development

The first draft of the survey instrument was based on the work of Holsapple and Sena (2005), and the final version of the survey also incorporated the findings from the exploratory interviews. The survey comprised a 10-page questionnaire that took approximately 40 minutes to complete. It was divided into five parts: (i) mostly multiple choice questions describing the organisation's characteristics and the type of system it used; (ii) questions that further addressed the characteristics of the ERP computer system and how it was used by both the organisation and the participant; (iii) questions about expectations and objectives relating to decision support features; (iv) questions exploring the decision support characteristics exhibited in the ERP product; and (v) finally questions exploring the realisation of these characteristics in practice.

I developed the content and presentation of the questionnaire with the aim of minimising sampling and non-response errors. I considered the number of questions, minimised 'open-ended' questions, and ensured the wording was simple, specific and sufficiently well defined that respondents interpreted the questions in the same way (Fowler, 1995; Salant and Dillman, 1994). In addition, I took into account the fact that the look and feel of a questionnaire affects the response rate: people are more likely to participate if they feel the topic is important and the survey is easy to complete (Salant and Dillman, 1994).

I pre-tested the survey with a representative sample of respondents who were interviewed either after each question or at the end of the survey to find out what they were thinking while answering the questions. This identified problems such as confusing terms or phrases or difficult questions, and verified that respondents were interpreting questions in the same way. This process also tested whether questions were biased; I asked respondents to guess what I was predicting or expecting the survey results to show, and if substantially more respondents than would be expected by random chance could guess my hypothesis, it was highly likely that the survey contained biased or leading questions.

3.5.2 Survey implementation

The most important prerequisite for implementing the survey involved compiling the list of potential survey recipients. Survey participants were targeted by identifying individuals and by identifying potential positions in selected organisations. Sources for identifying potential individual participants included personal contacts in the professional and academic environments, membership lists for organisations such as APICS, and user group lists for ERP products. Sources for identifying organisations falling into the research population were ERP vendors' web sites that list selected customers, and ERP periodicals which summarise specific implementations.

The survey I sent by email to potential participants included a cover letter to explain the research objectives. One week after sending the survey, I sent a second email to all respondents to remind those who had not already responded. A few weeks later, I sent to those who had not yet responded a third email that included another copy of the survey. All these communications were professional in appearance and showed evidence of personal attention (Dillman, 1978; Salant and Dillman, 1994).

The survey was successfully emailed to around 650 potential participants across 150 organisations. The 82 valid responses represented a 12% response rate.

3.5.3 Survey data collection and analysis

The survey instrument is presented in Appendix 3. The introductory section gathered demographic information. The main body of the questionnaire contained multiple-choice questions addressing the research question in terms of expectations, exhibition and realisation, as discussed above in Section 3.2. These questions used a 5-point Likert scale, with 1 representing “not at all” and 5 representing “to a great extent”.

3.6 The conceptual System Dynamics model

Users’ expectations of the strategic benefits of ERP change as organisations adapt their systems. Investigating this behaviour and the interactions and impacts of other factors requires techniques beyond statistical analysis and the usual qualitative techniques. In addition, the interactions and impacts of major factors and parameters do not follow a simple linear flow, but are part of a dynamic system with complex feedback loops that can change with time. Examining the ongoing dynamic behaviour of this system provides a deeper and richer understanding of the factors and their relationships.

I used the findings from the exploratory interviews and survey, together with my personal experience and knowledge, to build a conceptual model using a System Dynamics methodology. This model provided the means for experimenting with various proposed scenarios, with the aim of enhancing our understanding of system behaviour in order to define strategies and policies towards the better utilisation of ERP systems in decision making. A detailed discussion of the model is provided in Chapter 5.

Model building is an iterative process of creating a model, testing model behaviour, comparing this behaviour with knowledge about the real world being represented, and reconsidering the model (Forrester, 1975). The researcher should always be alert to new discoveries about behaviour during the modelling process. New discoveries could be a surprise to the researcher or they could provide insights into general characteristics of system.

Surprising behaviour (behaviour that was not expected in terms of what was previously known about the behaviour of the actual system) usually points to model defects. My first response to surprise discoveries was to assume a major error in the model. However, the researcher must be always alert to the possibility that the unexpected behaviour of the model is revealing a new insight about the real system. As I improved the model and removed errors, I examined the behaviour to see if it revealed new insight about the real system.

Even more important than finding unexpected behaviour of a specific system is the discovery of general characteristics that are applicable to the system. In complex nonlinear systems, such generalising must be interpreted with caution, but, even so, rules of thumb can be identified that are usually valid and give a useful basis for thinking about systems (Forrester, 1991). Chapter 5 provides a full discussion of these various aspects of the model.

3.7 Chapter summary

This chapter has provided details of the research objectives and questions. It discussed the use of an interpretivist paradigm to underpin the two-phase research design, and outlined the sampling procedures used to select the participants. The qualitative first phase of the study comprised exploratory interviews; the quantitative second phase, a survey questionnaire. Both phases were described in detail. Finally, the chapter introduced the Systems Dynamics model developed as part of this study. The model is discussed in detail in Chapter 5.

CHAPTER 4

DATA ANALYSIS

4.1 Introduction

This chapter presents the data analysis and discusses the findings from the exploratory interviews and the survey. Data were collected in two phases. The interviews in the first phase provided preliminary insights for developing the survey instrument used in the second phase. The data collected in both phases were analysed inductively in order to identify themes and patterns and ultimately develop a model which could be used to explain system behaviour.

The focus of the first phase was to reveal if and how ERP systems could improve the decision-making process at strategic and tactical levels. Information was collected from 15 semi-structured interviews, and observations of medium-sized organisations in Australia who had been using ERP systems for at least five years. The data collected from the second phase of research were based on the 82 valid responses to the mail-out survey.

The research utilised a purposefully selected sample that was neither large nor random; thus, the findings cannot be generalised in the manner presumed by a quantitative study. In addition, the researcher's knowledge and experience have influenced the way the findings have been presented.

4.2 First phase: Exploratory interviews

This research set out to examine the extent to which adopters of ERP systems benefit from potential decision-support characteristics of such systems. The first phase utilised qualitative methods to investigate the current use of ERP systems in Australian organisations, and in industry generally, as part of the decision-making process. This phase comprised semi-structured exploratory interviews with purposefully selected participants, in order to redress the lack of underlying knowledge and theory, and the lack also of comprehensive studies in the Australian context. This phase incorporated a qualitative paradigm, which assumes that reality is subjective and multiple, and the world can be understood best from the point of view of the individuals directly involved in the activities in question. As the emphasis was on understanding the unique features of the phenomenon in subjective reality rather than its totality in objective reality, managers and senior managers involved with ERP systems in Australian organisations were regarded as the most appropriate informants. The semi-structured interviews contained open-ended questions that elicited the interviewees' real stories, experiences and insights. The researcher's personal experience with ERP systems also contributed to the construction of meaning throughout the research process (Nightingale and Cromby, 1999).

4.2.1 Participants

Research participants were purposefully selected from Australian organisations in technology, defence, finance, logistics and telecommunications. All organisations were in the first-tier ERP market and had been using at least two of the main ERP modules (manufacturing, finance and human resources) for the preceding five years. Participants were senior managers, middle managers and professionals who could potentially benefit from ERP decision-making capabilities or who had been involved with the implementation and day-to-day use of ERP systems in those organisations.

4.2.2 Data collection

The data collected in the first phase consisted of material collected from the 15 semi-structured interviews, the researcher's reflection notes taken during the interviews, and the researcher's personal experience with ERP systems. The researcher initially conducted a few pilot interviews with colleagues to refine both the interview process and the questions. Interview participants were provided with the study objectives and information statement before the interview, and signed a consent form. The main interviews were conducted in the participants' offices or, in two cases, by phone. With participants' permission, all interviews were digitally recorded and interview transcripts were produced after each interview. Reflection notes were attached to each interview transcript as an appendix. Final transcripts were emailed to participants for their review and approval.

4.2.3 Data analysis

Interview transcripts were analysed using an open coding technique (Strauss and Corbin, 1990). Data were first broken down by taking apart sentences, paragraphs, reflection notes and observations. Each separate idea or event was given a name. Data were then regrouped into categories of similar groups of ideas and events, which become subcategories. The next step was axial coding to identify main categories and to make connections between them and their subcategories. At this stage of coding the researcher's personal experience influenced the choice of categories and the relationships between them.

4.2.4 Interviews: Emerging themes

Several main themes emerged from the interviews, covering widely diverse aspects of ERP implementation and use, not all directly related to the main research question. However, documenting these themes, identifying key parameters and establishing relationships between them provided valuable fundamental data for designing the survey and also for building a Systems Dynamic model, the accepted methodology for studying the behaviour of complex feedback systems over time. Both qualitative and quantitative data collected from the first and second phases were used to build the System Dynamics model. The model, quantification and simulation of this system are presented in Chapter 5.

A summary of emerged themes was sent to interviewees via email to validate the findings. This validation process raised some discussion and feedback, which enhanced the validity and reliability of the findings and increased the researcher's confidence that these themes are major factors in ERP implementation and its effects on the decision-making process within Australian organisations.

Decision support as an objective for ERP adoption

The literature contains different opinions on whether decision support should be an objective for ERP adoption. For instance, Davenport (1998b) identifies the 'need to make sound and timely business decisions' as a major reason for adopting ERP systems. However, this view is not widely supported; overall, decision support is not recognised as a major reason for implementing ERP systems (Holsapple and Sena, 2005). The literature suggests that expectations will change as organisations reach a certain stage of maturity in their adaptation process. Hawking et al. (2004) argue that companies who are becoming mature in their ERP implementation, by achieving operational objectives, start exploring the possibility of leveraging their investment in ERP towards more strategic benefits, such as supporting decision-making and information-analysis activities. It is only at this stage that anticipated benefits from the investment in ERP will eventually be realised (Cook and Peterson, 1998; Davenport, 2000a; Holsapple and Sena, 2005; Stein and Hawking, 2002; Woodhead, 2001). The interview participants were mainly from this category of organisations.

In line with the literature, an emerging theme from the interviews was that decision support is not an objective for implementing ERP, as illustrated by the following interview extract:

> *My expectations in terms of [ERP] as a decision support tool is pretty low. I think it [ERP] efficiently does the transactions processing and it is integrated, so you can have high degree of confidence in any reports you looking at because it is integrated. (Extracted from interview with subject 3, page 1)*

Despite discussion in the literature, my findings indicate that stakeholders' and decision makers' expectations do not change towards strategic benefits by their organisation going through a maturity process. In fact, respondents questioned and rejected the notion of a maturity process. The interviewees' responses suggest that organisations do not become more mature in their ERP implementation as assumed in the literature. Many factors – operational obstacles, upgrade spirals and integration complexity – affect the maturity process, preventing organisations exploiting the use of ERP for more strategic benefits such as decision making, data analysis and business intelligence (BI). These factors are discussed below in more detail, and are reflected in the following interview extracts:

> *I have had BI layer in my wish list for almost five years and [I know] for the next five years, I know other things that are in front of that. You know it just would not get up. It wouldn't get up because, because of so many things that we still need to do on the basic fabric of the business before that would…*

> *I think the other thing you have to keep in mind is always a few extraneous things: one is the need to replace stuff or substantially re-implement; two is vendors that change stuff like PeopleSoft dropping out, Oracle coming in; there is a number of big companies who have done and also acquired other companies – they have got all sorts of legacy systems that other companies within the group are using and a lot of their time probably tends to get focused trying to standardise that so you wind up taking them off BAAN or something and putting them on Oracle or whatever, and that takes up quite a bit of time for a number of companies. (Extracted from interview with subject 7, page 1)*

> *Probably, all things being equal, you would imagine that someone who is in steady-state business that nothing being acquired, nothing is changed on the outside environment, they have fully implemented ERP for seven years; logically you would say they would be exploring more functionality and maybe there are some companies out there that are in steady state that could fall into that profile. (Extracted from interview with subject 5, page 2)*

My guess is when you take the core modules that people need to run the business, by the time you get to implementing those five, six, whatever core modules you probably then are into a major upgrade of one of the earlier ones, and it is major to the extent that it is almost a re-implementation. And you are in that sort of spiral just to keep you core machinery going, let alone getting beyond that. (Extracted from interview with subject 4, page 2)

Decision-making features not important factors in evaluation process

An emerging theme from the data analysis was that decision-support features are not considered an important factor in the ERP evaluation and selection process. This finding came as no surprise; I also found that these features were not objectives for ERP implementation and, as a result, they have no role to play in the evaluation and selection process. This is in line with the findings of the few studies that have investigated the subject (Cook and Peterson, 1998; Davenport, 2000a; Holsapple and Sena, 2005).

Stakeholders' low expectation of ERP decision-support features could partly explain why existing features and capabilities are under-utilised and also why vendors fail to improve such features.

Perceived importance of ERP for the decision-making process

Participants did not consider decision making either an objective for implementing ERP or an important factor in the evaluation and selection process, although they said that they placed substantial importance on using ERP data for decision making. In practice, though, this strong perception that ERP could potentially improve decision quality and timing by providing required data and process failed to materialise, as explained in the following paragraphs.

The role of decision-support features of ERP in strategic and operational decision-making process

One of the perceived benefits of implementing ERP systems is increased efficiency and effectiveness as business processes permeate managerial processes such as planning and decision making at all levels. Benefits such as availability and integration of real-time data are thought to have a positive impact on the decision-support process (Shang and Seddon, 2000; Spathis and Constantinides, 2003). However, most of these propositions are based on the assumption that integration, data availability and data accuracy – which are immediate benefits of a successful ERP implementation – should automatically lead to better decision-making processes across an organisation. In fact, few of the above propositions are based on empirical research.

An emerging theme in the data analysis was that the information provided by ERP and the decision-support features of ERP do not play an important role in strategic decision making. However, in some instances operational decision makers benefit from features such as standard and ad-hoc reports and queries. In neither strategic nor operation decision-making processes did I observe ERP decision-making features being utilised to facilitate the process.

Participants, who were senior managers in their organisations, indicated that their boardroom and day-to-day decisions are not directly affected by information extracted from their ERP system, and even less do they utilise ERP to facilitate decision making. This finding is reflected in its strongest form in the following statement from the finance director of one these companies:

> *In fact, in my many years as finance director I cannot remember even in one instance walking into the boardroom with a bunch of ERP reports to help us make decisions. We might have referred to reports and figures as supporting materials for our arguments, but to formalise or shape a decision purely based on this information never happens. (Extracted from interview with subject 3, page 3)*

Integration and Business Intelligence (BI)

Chou and Tripuramalu (2005) argue that increasing numbers of organisations are turning to BI tools that make data collected by ERP and other data-intensive enterprise applications meaningful for decision makers, in order to justify their return-on-investment. The term Business Intelligence (BI) was coined by Howard Dresner of Gartner Group in 1989 to describe a set of concepts and methodologies designed to improve decision making by providing easier and faster access to corporate data across ERP and other enterprise systems. They argue that, while ERP systems are designed to capture transactional data, BI tools provide analytical features to examine large volumes of data and generate essential information for decision making. Integration of BI and

ERP systems increases value by providing meaningful analysis such as online analytical processes (OLAP) and data-mining tools to discover trends and patterns. Such capabilities increase the effectiveness and quality of decision making through utilising the analytical capability of BI on ERP data, which ultimately helps organisations to gain a competitive advantage (Chou and Tripuramallu, 2005).

Despite the literature and marketing materials indicating the rise of BI as a decision-support tool and its acceptance at all levels of organisations, I found that BI is not utilised effectively in first-tier ERP organisations and is not one of management's priorities in their ERP program. This view is reflected in the following comment from the chief executive of operations of one of the big defence companies:

> *If anyone says that we are getting any ROI around BI soon, I don't believe we are. I believe, what'll happen is as we implement every tactical solution toward tactical need and we manage to drive that tactical solution in through the ERP and add yet another foundation building block, then people will start to see some benefits of integration. (Extracted from interview with subject 7, page 1)*

Many reasons were identified as contributing factors preventing organisations from gaining potential strategic benefits by using BI. Operational difficulties with implementation and integration, spiral upgrades as a result of technology enhancements, and rapid waves of merger acquisitions among ERP vendors are some of these obstacles. These obstacles constantly consume available resources and, as one participant noted, take first priority over 'non-critical' features such as BI.

One of the emerging themes was that the main obstacle to BI utilisation is the integration between ERP modules and between ERP and other enterprise systems. BI can provide real strategic benefits and decision-making support when used at the enterprise level across all departments and functions, and this is only achievable if ERP modules are integrated, with sufficient links between ERP and other enterprise systems. I found that none the organisations achieve an acceptable level of integration between ERP modules and between ERP and other enterprise systems, as illustrated by the following comments by the financial director of a logistic organisation:

However, it's more about the fact that you cannot have good BI if you do not have the foundation to call on; at the moment we just building the foundation. Integration is the key to BI and this is the only way which BI could be differentiated from reports.

Most people seem to struggle with the cost of implementing and supporting these core modules to be reasonably current with half a dozen modules to use this to run the business. As I said we would like to have four or five to put in before we even put the BI on the list and that's just around the core business.

It is fair to say that there is a lot of what I would call basic functionality that we are not using in a number of these things. Around commitment reporting and things I call fundamental to the basic integrity of transaction processing that we are not using, and I am far more worried about not using that at the moment than the added layer BI. So BI – I sort of look at it like a lost opportunity but when we are not using the basic functionality it is a risk. (Extracted from interview with subject 9, page 2)

Decoupled ERP modules

Achieving integration at the enterprise level is considered one of the main justifications for investing in ERP. In different ERP-related studies, integration has been directly linked to gaining strategic competitive advantage as a result of leveraging EPR to its full extent (Shang and Seddon, 2000; Spathis and Constantinides, 2003; Wieder et al., 2006). However, integration at the enterprise data and process levels is proving challenging for most organisations.

The complexity of integration has forced many organisations to answer such a complex question with a simple answer: decoupled ERP. When companies who invest millions of dollars to integrate their processes and data across the whole organisation find themselves in an integration battlefield, they tend to compromise integrated systems for the sake of functional decoupled modules in different departments. The degree of decoupling differs in different organisations: in some cases there is no real-time connection between any two ERP modules, while in other instances vital links exist and only hard-to-achieve integration goals are compromised.

As an emerging theme, I observed that ERP systems have been implemented and are being used in decoupled models in Australian organisations in the first-tier ERP market. In these cases implementation complications have forced management to accept a decoupled model as a compromise to provide at least operational and transactional functionality across different functions.

Such decoupled ERP modules provide the minimum core transaction functionality across different departments. Usually these departments develop procedures and mechanisms to pass information between decoupled modules to establish the necessary data flow. However, with such a compromised setup, one of the main objectives of ERP implementation – integrated real-time data availability across the organisation (Shang and Seddon, 2000; Spathis and Constantinides, 2003) – never materialises. Because integration between ERP modules is vital for utilising enterprise system data for decision making (Kalakota and Robinson, 2001), decoupled ERP systems do not provide the necessary platform for either decision making or utilising BI modules of ERP.

Decoupled ERP systems are not the only reason that ERP data are not used in organisation-level strategic decision making or day-to-day operations. A department-centric mentality also contributes to the downgrading of ERP data, as highlighted by the following statements from two participants:

> *In the ERP evaluation process, if you go back to the debate, everybody in the HR world wanted to have a dedicated tool which was HR exclusive and my view was that it would address the tactical issue. Well, [HR] will be always be fundamentally concerned about HR issues; they have the responsibility to deliver a service…(Extracted from interview with subject 11, page 1)*

I do not believe people here have yet got the context – although it is changing – that we are actually implementing both foundation building boxes to give us a full ERP. I do not think that people were thinking outside their tactical needs. (Extracted from interview with subject 8, page 2)

Adaptation process

The majority of the ERP literature is concerned with ERP adaptation, a term borrowed from the six-stages model of Kwon and Zmud (1987). In this model adoption refers to acquiring resources, technology and installation, and adaptation refers to the process of adjustments and changes following the installation of such technology (Kwon and Zmud, 1987; Tyre and Orlikowski, 1994). Adaptation between the organisation and ERP is important and complex, and includes process, technical and cultural issues. While ERP vendors advocate that ERP embodies universally applicable best practices, in reality adaptation between a company and ERP involves a process of change in both the ERP and the company via customisation, business process review and cultural changes. Numerous studies have investigated aspects of adaptation, including evaluation, implementation, project management, success and failure factors, usage and maintenance, upgrade and extension, change management, business process review and socio-cultural factors affecting ERP implementation and usage.

An emerging theme in the data was that adaptation is one of the main obstacles preventing the utilisation of ERP towards decision making. Various problems with implementation discourage ERP program managers from utilising ERP for more strategic benefits, and potential costs mean that top level management are reluctant to support spending on decision-making features when the main objectives of ERP have not yet been met. The finance manager of a telecommunication company expressed this view:

> *I think we still in transactional issues. Even each module that we have is probably under-utilised in terms of its functionality. That's even in the module level. We have just deployed HR. OK, so we would not give ourselves a fantastic score. We would say we survived the transition with the skin of our teeth. But I look at it now and I think, OK, we have now the ability to operate HR at a transacting level in an integrated way across the company. Before, we would ever able to do that. So, I look forward to seeing more and more coherence as we develop … at the moment I would say we just survived, people just got paid, we just managed to maintain the integrity of our data. But it's a survival proposition. (Extracted from interview with subject 6, page 1)*

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Implementation and operational processes are diverse and cover a broad spectrum from evaluation to business and cultural practices. In this research I investigated these issues only in the context of their role in the decision-making process. The financial director of an aerospace company summarised this impact on decision making:

> *I think most companies struggle just to implement the basic stuff and then it becomes an affordability issue and … you have less paper and things accelerated and so on, and it winds out actually costing you much more than you think to implement, much more than you think to run, you don't tend to get the saving you assumed you would at the time of implementing it.*
>
> *You know our customer is [a governmental department] and they struggle to produce their basic accounts. They have been under-qualified for the last five years and that's around their basic accounting modules and so on. So there are lots of, assumingly most organisations, whether they be in commercial world or NGOs, are also affected a lot by outside factors and will have a bearing on whether their priorities in IT spender and the affordability and the rate that they can bring this on, the rate in which their people can assimilate the change and so on. I am not sure if you find a high percentage of companies who fit the profile.*
>
> *I am reasonably happy if we get all of our transactions in every area of the business optimised through using an ERP with its speed, accuracy and timeliness. Three very important building blocks to have. If you can get that done and if can do that cost effectively, I would say that's achieved. Probably 80% of what we want from an ERP system and then the other 20% of what would be nice to have from it if we ever could devote the time to getting it an using it, would be some sort of BI layer. (Extracted from interview with subject 3, page 1)*

Upgrade spiral

Many ERP users face an upgrade spiral, caused by technological advancements, the ever-increasing rate of merger-consolidations and acquisitions among ERP vendors, and the increasing rate of mergers and consolidations among organisations that use ERP systems.

This upgrade spiral prevents ERP users achieving a reasonable level of maturity in their adaptation process.

An emerging theme in this study was that a never-ending upgrade spiral consumes most of the budget allocated to enterprise systems programs, thus preventing program managers being able to plan to use ERP in the decision-making process. The CEO of a defence company explained this problem:

> *There's this perpetual sort of upgrade path which costs you an arm and a leg, licensing and everything else. So, it is a very expensive investment, ERP for us, and it has been for many companies.... To my mind it has very good transaction processing capabilities and assurance around the output of that, which is a good start for any decision making. But I've never really seen it being used much beyond that, in my experience…(Extracted from interview with subject 10, page 1)*

Other emerging themes

The data analysis highlighted several other factors that can prevent the utilisation of ERP systems in the decision-making process:

- Selective use of information. In the absence of uniform and standard decision-making and BI tools that provide unbiased visibility to organisational data, decision makers and managers can favour information that supports their preferred ideas and actions and ignore other information. Such a practice can undermine the importance of ERP data for decision making among managers and stakeholders.
- Training. All participants acknowledged the potential importance of ERP data for decision making. However, the majority of managers and decision makers had no official training in using EPR, interpreting data or recognising the potential benefits gained by using BI modules.
- User-friendliness. While many ERP vendors have now made their systems more user-friendly with intuitive report writers and BI modules, the older versions of enterprise systems used by most first-tier ERP adapters suffer from a lack of user-friendliness, intuitive report and query generators or any BI modules.

4.3 Second phase: Survey

The second phase of this research used insight gained from the qualitative first stage as a foundation to investigating the subject in more depth and detail using qualitative methods. I designed a survey instrument to identify major factors and their potential relationships. The results of the survey data analysis are presented in this section. The findings from the data analysis in this phase were then used to build a System Dynamics model to provide better understanding of the impacting factors and their relationships. This model is discussed in Chapter 5.

4.3.1 Survey development

Questions in the survey were based on the findings from the exploratory interviews with managers and practitioners. The survey incorporated the ERP decision-support characteristics and benefits developed by Holsapple and Sena (2005), who investigated the decision-support benefits of ERP systems by examining relationships between the importance of various objectives in ERP planning and the subsequent realisation of decision-support benefits from an ERP system.

The survey questionnaire was ten pages long and took approximately 40 minutes to complete. The questions in the survey covered five areas: (i) the characteristics of the organisation and the type of system it uses, (ii) the characteristics of the ERP computer system and how it is used by both the organisation and the participant, (iii) expectations and objectives of the decision-support features, (iv) the decision-support characteristics exhibited in the ERP product, and (v) realisation of these characteristics in practice. All except the demographic questions were multiple-choice and used a 5-point Likert scale, with 1 representing 'not at all' and 5 representing 'to a great extent'.

I minimised sampling and non-response errors by including an adequate number of questions that were carefully worded, specific and clearly defined so that all respondents would interpret them the same way, and by minimising the number of 'open-ended' questions (Salant and Dillman, 1994; Fowler, 1995). I attempted to increase the response rate by organising the survey and presenting questions so that participants were immediately convinced that the survey was both important and easy to complete (Salant and Dillman, 1994).

I pre-tested the survey by asking a representative sample of respondents to complete the questions and provide feedback. This identified any problems such as confusing terms or phrases or questions that were too difficult to answer, and allowed me to verify that respondents were interpreting questions in the same way. I also tested the questions for bias by asking respondents to guess what I was predicting or expecting the survey results to show. If substantially more respondents than would be expected by random chance could guess the my hypothesis, it was highly likely that the survey contained biased or leading questions.

4.3.2 Survey implementation

Potential survey participants – either individuals or positions in selected organisations – were chosen from several sources:

- personal contacts in the professional and academic environments
- membership lists for organisations such as APICS
- user group lists for ERP products

Potential organisations were chosen from ERP vendors web sites that list selected customers, or ERP periodicals that summarise specific implementations.

In order to minimise the non-respondent and sampling errors and achieve a reasonable response rate, I included with the survey a covering letter explaining the research objectives; one week after sending the survey I sent a second email to those who had not already responded to the survey, and a few weeks later sent a third email including another copy of the survey to those people who still had not responded. All these communications were professional in appearance and showed evidence of personal attention (Salant and Dillman, 1994; Dillman, 1978). Respondents were able to fill the survey in electronic form (Microsoft Word) and send via email.

The survey was successfully emailed to around 650 potential participants across 150 organisations. The 82 valid responses yielded a response rate of 12%. The survey instrument and the cover letter are presented in Appendix 3.

4.3.3 Survey data analysis

I analysed the survey data using SPSS software. First, I examined the sample characteristics, using a sample t-test to evaluate mean of the variables. A paired-sample t-test was utilised in some instances to examine the difference between the variables' means. I used factor analysis to extract 12 factors and examine the correlation between them in order to identify potential relationships. These factors and the relationships between them were used to build the system dynamics model (explained in Chapter 5). The rest of this chapter presents the data analysis and findings.

Sample characteristics

The primary source of information for research studies into ERP systems is usually practitioners in Information Systems and ERP, who have the required knowledge and background. However, in this research I targeted high-level managers who potentially could benefit from ERP decision-making features and capabilities. Participants were purposely selected from top managers in executive positions from the first tier of the ERP market across different industry sectors and functional areas. Defence, technology, telecommunication and service providers such as financial and insurance institutions were the most common industry sectors. Respondents' demographics are displayed in tables 4.1 (industry sector) and 4.2 (functional area).

Industry Sector	Per cent
Defence	7.3
High technology	14.6
Logistic	12.2
Services	14.6
Telecom	14.6
Other/not specified	36.6
Total	**100.0**

Table 4.1 Survey participants by industry sector

Functional Area	Per cent
Executives/board	7.3
Finance	14.6
Human resources	14.6
Information systems	36.6
Other/not specified	14.6
Total	**100.0**

Table 4.2 Survey participants by functional area

Participants came from organisations with a mean of six years' experience with ERP systems, and more than 90% of them had implemented their system more than five years before their participation in the survey. Based on the ERP literature, organisations with this level of experience with ERP should start to realise real strategic benefits, such as decision making, as they should have reached maturity stage in their adaptation process. Figure 4.1 illustrates participants' experience with ERP and the time since their organisations' implementation of ERP. Sixty per cent of participants, who were mainly senior executives in their organisations, had had more than four years' experience with such systems. Participants' experience and organisations' maturity both increase the credibility of their input to the survey results.

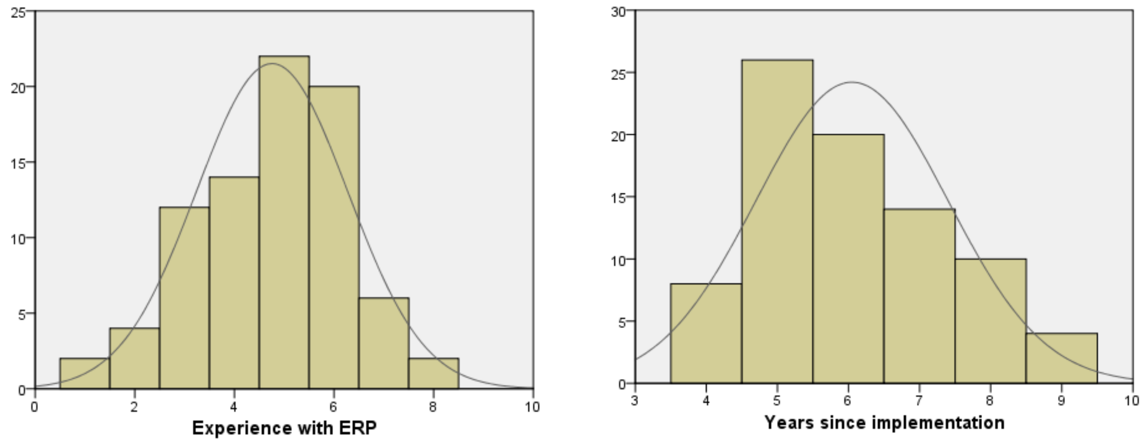

Figure 4.4 Frequency graphs showing participants' experience with ERP (in years) and the number of years since ERP implementation in their organisation

Although participants and their organisations were experienced and mature with their ERP implementations, three other variables about management knowledge and training with ERP decision-making features in general, and decision-making tools specifically, did not support this experience and maturity. On a 5-point Likert scale (1 = 'not at all'; 5 = 'to a great extent'), participants scored a mean of 2.10 on 'knowledge of using ERP for decision making', 1.12 on 'training on utilising ERP in decision making' and 1.27 on 'training towards the decision-making process and potential tools to utilise the process'. These data are presented in Table 4.3.

Survey item	N	Minimum	Maximum	Mean	Std. Deviation
Knowledge of using ERP for decision making	82	1	4	2.10	.826
Training on utilising ERP in decision making	82	1	2	1.12	.329
Training towards the decision-making process and potential tools to utilise the process	82	1	3	1.27	.498

Table 4.3 Participants' knowledge and training

I investigated whether the population mean for these three variables was around the centre, a value of 3 (moderately). Based on a one-sample t-test with a confidence interval of 98% I concluded that the population mean for management knowledge and training in the areas of ERP and decision making was below average. In addition, although all three variables were significantly below average, there was a significant difference between the first variable (Knowledge of using ERP towards decision making: mean of 2.1) and the two other variables related to training (means of 1.12 and 1.27). This result could indicate that managers' knowledge about using ERP for decision making is probably acquired via other means, such as experience and common sense rather than training.

In this research I did not investigate whether providing this extra training – in utilising ERP in decision making, in the decision-making process, or in potential tools for utilising these processes – could lead to improved decision making in terms of cost, duration and quality. However, I conclude that providing relevant training on these subjects could potentially improve management knowledge. This could finally manifest in better use of existing tools such as ERP and the introduction of new tools and techniques which could facilitate quicker, cheaper and higher quality decision making.

Descriptive analysis

(i) Expectations

To investigate managers' expectations in regards to ERP decision-making features, I asked the following questions:

Q1 Should decision support features of ERP be one of the objectives for ERP implementation?

Q2 Should decision support features of ERP to be considered in the evaluation and requisition process?

Q3 Should ERP provide tools to enhance decision makers' ability to process information?

Q4 Should ERP provide tools for better facilitation of the decision-making process?

Q5 Should ERP provide facilities to encourage exploration and new approaches to problem solving (e.g., sensitivity analysis, simulation tools)?

Q6 Should ERP provide a user-friendly interface?

All questions started with 'should' to encourage participants to separate themselves from their current situation and think instead about the ideal situation, thus giving an indication of their expectation.

Based on the literature, adopters do not consider decision support a major objective for implementing ERP, although their expectations of ERP decision-support features and benefits could change after reaching a certain stage of maturity in their adaptation process. These mature ERP users could be looking for ways to leverage their investment in ERP to the next level, by utilising ERP capabilities towards decision-making and information-analysis activities (Holsapple and Sena, 2005; Industry Sector Analysis, 1998; Stein and Hawking, 2002; Woodhead, 2001).

The data analysis showed that managers and executives generally have high expectations that ERP will provide decision-support features and capabilities. This finding is in line with the literature, as participants were mostly in their maturity stage and were looking for ways to leverage their investment on strategic benefits. Based on the descriptive statistics (Table 4.4), participants considered decision-support features one of the objectives for ERP implementation (mean 3.51). They also thought that these features should be considered during the evaluation and acquisition process (mean 3.66); they ranked highly the importance of decision-making tools in ERP (mean 3.85). The highest score was for 'providing user-friendly interface' (mean 4.27) and the lowest was for 'providing facilities to encourage exploration and new approaches to problem solving' (mean 2.37)

The data in Table 4.4 show that in general managers and executives generally expect that ERP should provide tools to (i) enhance decision makers' ability to process information and (ii) better facilitate the decision-making process. On the other hand, organisations should make such features an objective for their ERP implementation and should consider this in their evaluation and acquisition process. Above all, the findings show that executives and managers place high importance on the user friendliness of such systems.

High expectations on ERP to provide tools for better decision-making and to facilitate the process were also expressed in the semi-structured interviews by managers and executives, however the statistical results show stronger emphasis on expectations in comparison to what was expressed in those interviews.

	N	Minimum	Maximum	Mean	Std. Deviation
Q1 Objective	82	2	5	3.51	.997
Q2 Evaluation	82	2	5	3.66	.878
Q3 DM tools	82	2	5	3.85	.788
Q4 DM process	80	1	5	3.45	.926
Q5 DM exploration	82	1	4	2.37	.854
Q6 User-friendliness	82	3	5	4.27	.668

Table 4.4 Participants' expectations of decision-support features in ERP systems

(ii) Exhibition

The term 'exhibition' refers to the existence of decision-support features in ERP systems, and the importance of these features as an objective for ERP implementation and in the evaluation and acquisition process, as shown by the participants' experience. To date this subject has not been investigated vigorously (Holsapple and Sena, 2005). The survey therefore asked the following questions:

Q7 Have decision-support features of ERP been one of the objectives for your ERP implementation?

Q8 Have decision-support features of ERP been considered in the evaluation and requisition process of your ERP?

Q9 Does ERP provide tools to enhance decision makers' ability to process information?

Q10 Does ERP provide tools for better facilitation of the decision-making process?

Q11 Does ERP provide facilities to encourage exploration and new approaches to the problem?

Q12 Does ERP provide a good user interface?

Based on the descriptive statistics presented in Table 4.5, most managers and executives did not see ERP decision-support features as one of the objectives of their ERP implementation (mean 1.78), and such features were not even moderately considered during their evaluation and requisition process (mean 1.51). The existence of such features in their ERP systems was also regarded as of minor importance (decision-making tools, mean 1.66; decision-making process, mean 1.34; decision-making exploration, mean 1.27). The only variable with a score marginally higher than moderately was the ERP user interface (mean 3.07).

In order to examine the difference between expectations and exhibition variables, I compared the variables' means. Based on a paired-sample t-test with confidence interval of 98%, the population means for all paired variables between expectations and exhibition were significantly different (refer to paired-sample t-test results in Appendix 4). The significant gap between participants' expectations and exhibition indicates an opportunity for both ERP vendors and ERP adopters. ERP vendors could capitalise on such high expectations and build products which reduce this gap. ERP adopters could realise management expectations by utilising ERP systems beyond their transactional capabilities to provide management support.

	N	Minimum	Maximum	Mean	Std. Deviation
Q7 Objective	82	1	3	1.78	.721
Q8 Evaluation	82	1	3	1.51	.633
Q9 DM tools	82	1	4	1.66	.724
Q10 DM process	82	1	3	1.34	.526
Q11 DM exploration	82	1	2	1.27	.446
Q12 User-friendliness	82	1	5	3.07	.979

Table 4.5 Participants' exhibition of decision-support features in ERP systems

(iii) Realisation

If it is expected that ERP will provide decision-support facilities and if such features are exhibited in ERP systems, to what extent do organisations realise the decision-support benefits from these systems? The third series of survey questions concerned the extent of the realised benefits. What decision-support benefits do users of current enterprise systems realise, and what decision-support benefits do they consider important?

Previous studies have highlighted several features of effective decision-support systems (Holsapple and Whinston, 1996; Marakas, 1999; Turban and Aronson, 1998; Udo and Guimaraes, 1994). They:

- shorten the time and cost associated with making a decision
- enhance a decision maker's ability to process knowledge
- enhance a decision maker's ability to handle large-scale or complex problems

- improve the reliability of decision processes or outcomes
- encourage exploration or discovery by a decision maker
- reveal or stimulate new ways of thinking about a problem space or decision context
- furnish evidence in support of a decision or confirmation of existing assumptions, and create a strategic or competitive advantage over competing organisations.

Using these characteristics, I investigated the realisation of such features by asking the following questions:

Q13 Has ERP improved the quality of decisions?

Q14 Has ERP helped to reduce the cost of decision making?

Q15 Has ERP shortened decision-making time?

Q16 Has ERP improved the reliability of the decision-making process?

Q17 Has ERP improved decision makers' abilities to tackle complex problems?

Q18 Has ERP increased satisfaction with the decision-making process?

Based on descriptive statistics presented in Table 4.6, participants considered these benefits had been realised in their organisations at a very low level. Despite finding that managers and executives expect that ERP should provide tools to both enhance decision makers' ability to process information and better facilitate the decision-making process, in practice the participants have not experienced these benefits.

I then evaluated whether the population means for these variables fell around the middle of the range (a value of 3, 'moderately'). The results from a one-sample t-test with a confidence interval of 98% showed that the population means for all realisation variables were well below average, with a significant deference between the first variable (Decision Quality), with a mean of 2.66, and the other variables. This finding indicates that managers and executives generally believe that ERP has improved the quality of decisions more than it has decreased the cost or time, and it has increased reliability by helping complex decision making and supporting decision-making processes.

	N	Minimum	Maximum	Mean	Std. Deviation
Q13- DM Quality	82	1	5	2.66	.959
Q14- DM Cost	82	1	3	1.39	.583
Q15- DM Time	82	1	3	1.32	.518
Q16- DM Reliability	82	1	2	1.32	.468
Q17- DM Complex	82	1	4	1.49	.707
Q18- DM Process	82	1	4	1.78	.786

Table 4.6 Participants' realisation of decision-support features in ERP systems

(iv) Evaluation and selection process

The evaluation and selection process is one of the crucial factors impacting the success or failure of ERP implementation. The most frequently identified factors influencing the success or failure of ERP are the involvement of all stakeholders and well defined and documented requirements during the evaluation and selection phase (Botta-Genoulaz et al., 2005; Bradford and Florin, 2003; Brown, 1994; Buckhout et al., 1999; Cheung et al., 2001; Duchessi et al., 1988; Falkowski et al., 1998; Herb, 2000; Mainthou et al., 1996; Sarker and Lee, 2003; Stefanou, 1999; Thite, 2000; Wang et al., 2005).

Other factors, such as system match and considering all possible options, are also important. System match refers to certain elements and characteristics in ERP systems, which make one system more appropriate than others for an industry sector. Although there is no perfect match between any business and ERP systems, it is important that these factors are considered during the evaluation phase.

Questions in the survey that referred to considering all possible options also included all feasible solutions in the evaluation process. This approach incorporates what is known as 'Best of Breed' (BoB) vs. single-vendor integrated ERP system. Technological advances in Enterprise Application Integration (EAI) that reduce the complexity and cost of implementation and maintenance could make BoB a more viable option than a single-vendor integrated enterprise system. In response to this trend, some single-vendor ERP systems are currently being componentised to allow them to be more readily integrated into this form of strategy (Olson, 2007).

I asked the following questions to investigate which factors in the evaluation and selection process can play a potential role in the success and failure of ERP:

Q19 Were all requirements defined and documented in your ERP evaluation/selection process?

Q20 Were all stakeholders involved in the ERP evaluation/selection process?

Q21 Were possible options (e.g., BoB) considered in the ERP evaluation/selection process?

Q22 Do you think your ERP system is a good match for your business?

Q23 Do you think your evaluation/selection process could have been improved?

Based on descriptive statistics presented in Table 4.7, most participants thought the evaluation and process could have been improved (mean 3.93). They also considered that requirements were moderately defined and documented (mean 3.12) and agreed that main stakeholders were involved in the process (mean 3.51). However, they thought all possible options were not considered (mean 1.98) and the selected ERP system was less than moderately matched to the business (mean 2.93).

	N	Minimum	Maximum	Mean	Std. Deviation
Q19 Requirements	82	1	5	3.12	.948
Q20 Involvement	82	2	5	3.51	.864
Q21 Options	82	1	4	1.98	.875
Q22 System match	82	1	5	2.93	.813
Q23 Improvement	82	2	5	3.93	1.003

Table 4.7 Evaluation and selection process

The results presented in Table 4.7 show that, although defining requirements and the involvement of stakeholders seem to be part of the evaluation process for the majority of ERP adopters, other important factors such as system match and considering all possible options, such as BoB, are less popular. One reason could be that enterprise integrated systems have long been advertised by vendors as the IT 'magic wand' for achieving competitive advantage. As such, organisations who want to leverage IST to their advantage do not look beyond integrated systems (e.g., ERP), even though technological advances in integration methods make integration between different systems (e.g., BoB) much easier now than it was in the past. This situation could change in time with successful BoB implementations, training, improved integration techniques and introduction of componentised ERPs that allow them to be more readily integrated into this architecture.

(v) Implementation

Numerous cases of failures, budget overruns, unrealised promised benefits, and systems being less than fully utilised have resulted in much of the literature focusing on factors that impact the success or failure of ERP implementation (see, for example, Bradford and Florin 2003; Buckhout et al., 1999; Donovan, 2000; Grabot, 2002; Kumar et al., 2003; Motwania et al., 2002; Umble et al., 2003; Yusuf et al., 2004).

In this study I investigated implementation factors in the context of the main research objective only, and therefore the survey questions did not cover all aspects of the complex task of implementing ERP. I asked:

Q24 Were all stakeholders and users engaged in ERP implementation?

Q25 Was the executive team informed and supportive of the ERP program?

Q26 Was your ERP implementation over budget?

Q27 Was your ERP implementation over time?

Q28 Were process and data integration the most challenging tasks?

Q29 Is your ERP system well integrated and are most modules working harmoniously?

Q30 Does your ERP system seems to be mature now?

Q31 Do ERP processes cover different functions or are they mainly function-centric with interfaces linking different modules?

The descriptive statistics (Table 4.8) show that implementation was over budget and over time for most participants (means 4.37, 4.05). However, the statistics on integration are rather surprising.

Integration realisation at the enterprise level is considered one of the main justifications for investing in ERP, and in different studies it has been directly linked to gaining strategic competitive advantage as a result of leveraging EPR to its full extent (Shang and Seddon, 2000; Spathis and Constantinides, 2003; Wieder et al., 2006). However, the majority of participants considered process and data integration the most challenging tasks (mean 4.24) and to the question 'Is your ERP system well integrated and are most modules are working harmoniously' the mean response was 2.15.

The challenging task of achieving process and data integration at an enterprise level has forced many organisations to answer such a complex question with a simple answer: decoupled ERP. When companies who have invested millions of dollars to integrate their processes and data across the whole organisation find themselves on an integration battlefield, they tend to compromise integrated systems for the sake of functional decoupled modules in different departments. The degree of decoupling can differ among organisations: sometimes there is no real-time connection between any two ERP modules and in some instances vital links exist and only hard-to-achieve integration goals are compromised. Based on the survey results (mean 3.39), ERP systems have been implemented and are being used in decoupled models in the first-tier ERP market in Australian organisations, and one of the main objectives of ERP implementation, integrated real-time data availability across the organisation (Shang and Seddon, 2000; Spathis and Constantinides, 2003), never materialises.

	N	Minimum	Maximum	Mean	Std. Deviation
Q24 Involvement	82	1	5	2.78	.930
Q25 Executive support	82	1	4	2.54	.919
Q26 Over budget	82	3	5	4.37	.658
Q27 Over time	82	2	5	4.05	.830
Q28 Integration challenge	82	2	5	4.24	.825
Q29 Integrated	82	1	4	2.15	.788
Q30 Maturity	82	1	5	2.12	.974
Q31 Decoupled	82	2.00	4.00	3.39	.53877

Table 4.8 Implementation

Although stakeholders' involvement in the evaluation and selection process was ranked above average (3.51), in the implementation phase it had dropped to 2.78. The reason could be that implementation is a much more complex task than evaluation, and schedule pressure and the enormity of the implementation task possibly overshadow the importance of user and management involvement during implementation.

(vi) Maintenance and upgrade

Maintenance and upgrade cycles start immediately after implementation. One of the emerging themes from the exploratory interviews was that technological advancements, the ever-increasing rate of merger-consolidation and acquisition among ERP vendors and the increasing rate of merger and consolidation among organisations that use ERP systems have all contributed to create an upgrade spiral which prevents ERP users achieving a reasonable level of maturity in their adaptation process. To verify these findings I included the following questions in the survey:

Q32 Has your ERP been fairly stable and has there been any need to patch/upgrade?

Q33 Has your ERP been upgraded (or migrated) multiple times due to changes in technology?

Q34 Has your ERP been upgraded (or migrated) multiple times due to ERP vendors' mergers or consolidation?

Q35 Has your ERP been upgraded (or migrated) multiple times due to your company merging or consolidating with other companies?

The descriptive analysis (Table 4.9) shows that technology advancements, ERP vendors and customers' mergers or acquisitions have forced most organisations to upgrade or change their ERP systems multiple times (means 3.88, 3.83, 3.93). This has caused instability and never-ending upgrade spirals (mean 2.15), preventing organisations reaching the maturity stage in their adaptation (mean 2.12) and eventually, therefore, planning to utilise ERP in the decision-making process.

	N	Minimum	Maximum	Mean	Std. Deviation
Q32 Stable system	82	1	4	2.15	.957
Q33 Upgrade/change technology	82	2	5	3.88	.921
Q34 Upgrade/change vendor merger	82	2	5	3.83	.858
Q35 Upgrade/change company merger	82	2	5	3.93	.843

Table 4.9 Maintenance and upgrade

Factor analysis

Factor analysis is a set of techniques for determining the extent to which related variables can be grouped together so that they can be treated as one combined variable or factor rather than as a series of separate variables (Cramer, 2003). By using Exploratory Factor Analysis (EFA) we try to combine variables that investigate different aspects of a phenomenon in order to investigate the relationships between them in a comprehensive way. These relationships between different components were used to build the System Dynamics model. I focused mainly on variables in the same category; for instance, I performed factor analysis on variables related to the evaluation and selection process, or variables related to implementation, and so on.

In the EFA I used the principal components extraction method. I employed the Kaiser-Guttman criterion to identify the number of principal components to be retained, and factors with eigenvalues of 1 or less were ignored.

(i) Evaluation and selection process

EFA was conducted on five variables in the evaluation and selection process category of variables (Table 4.10). Question 5 in this group had a different direction and so I reverse-scored this question in the factor analysis.

Variables	Question represented by variable
Evaluation Requirements	Were all requirements defined and documented in your ERP evaluation/selection process?
Evaluation Involvement	Were all stakeholders involved in the ERP evaluation/selection process?
Evaluation Options	Were possible options (e.g., BoB) considered in the ERP evaluation/selection process?
Evaluation Match	Do you think your ERP system is a good match for your business?
Evaluation Improve	Do you think your evaluation/selection process could have been improved?

Table 4.10 Evaluation variables

In the principal components analysis, two components were extracted which explained 58% of the variance (for detailed calculation please refer to Appendix 5).

	Component	
	1	2
Evaluation Requirements	.702	
Evaluation Involvement	.403	-.417
Evaluation Options		.838
Evaluation Match	.702	.452
Evaluation Improve (Reversed)	.809	

Table 4.11 Component matrix with all variables

'Evaluation Involvement' loaded to two components (Table 4.11), which justified the removal of this variable. Table 4.12 shows the result after removing this variable. Based on this result three variables then loaded to component 1.

	Component	
	1	2
Evaluation Requirements	.707	
Evaluation Options		.961
Evaluation Match	.766	.305
Evaluation Improve-(Reversed)	.799	

Table 4.12 Component matrix with one variable removed from EFA

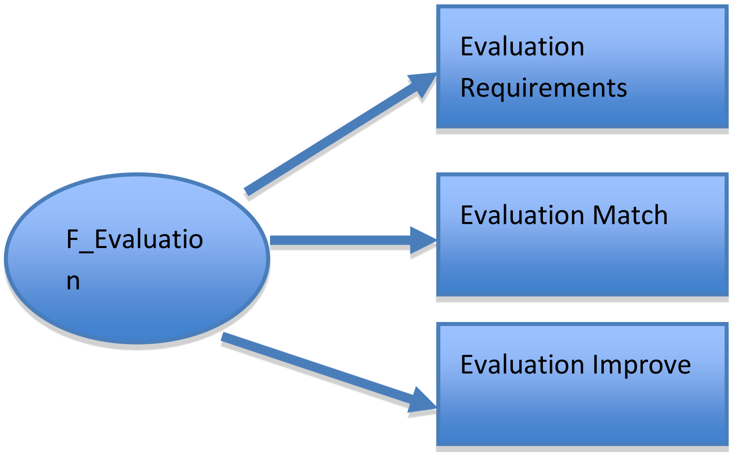

Figure 4.2 Evaluation loading

Based on the above analysis, component variable F_Evaluation was identified as representing "Evaluation Requirements", "Evaluation Match" and "Evaluation Improve" (Figure 4.2). In order to construct a score for the extracted factor I simply calculated it based on the mean values of these three variables. The following formula shows how component (F_Evaluation) was calculated:

F_Evaluation =MEAN (EvaluationRequirments, EvaluationImprove, EvaluationMatch)

(ii) Expectation

Using the same EFA technique explained above, six variables in the expectation category of variables (Table 4.13) were analysed to extract latent factors.

Variable	Question represented by variable
Perceived Objective	Should the decision-support features of ERP be one of the objectives of ERP implementation?
Perceived Evaluation	Should the decision-support features of ERP be considered in the evaluation and requisition process?
Perceived DM Tools	Should ERP provide tools to enhance decision makers' ability to process information?
Perceived DM Process	Should ERP provide tools for better facilitation of the decision-making process?
Perceived DM Exploration	Should ERP provide facilities to encourage exploration and new approaches to problem solving (e.g., sensitivity analysis, simulation tools)?
Perceived User Friendliness	Should ERP provide a user-friendly interface?

Table 4.13 Expectation variables

Based on principal component analysis and varimax rotation with Kaiser normalisation, two components were extracted which explained 59% of the variance (Table 4.14) (for detailed calculation please refer to Appendix 5).

	Component	
	1	2
Perceived Objective	.235	.814
Perceived Evaluation	.309	.683
Perceived DM Tools	.780	
Perceived DM Process	.847	
Perceived DM Exploration	.531	.213
Perceived User Friendliness	-.326	.692

Table 4.14 Perception component matrix

Based on EFA, ‘Perceived Objective’, ‘Perceived Evaluation’ and ‘Perceived UI’ loaded to a component, which I called F_Perception_General, indicating that these variables represent general perceptions towards ERP decision-making support in terms of objectives and the evaluation process. These variables loaded to the identified factor with .814, .683 and .692, respectively (Figure 4.3).

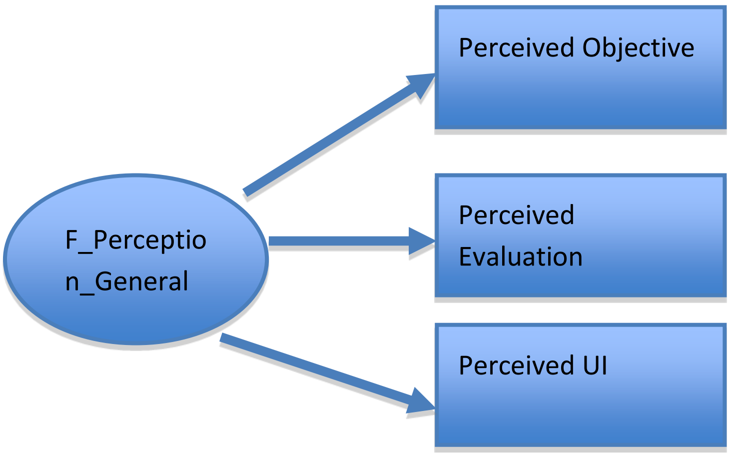

Figure 4.3 General perception

‘Perceived DM Tools’, ‘Perceived DM Process’ and ‘Perceived DM Expl’ loaded to a component called F_Perception_DM, indicating that these variables represent managers’ and practitioners’ perceptions towards ERP decision-making tools, processes and techniques specifically. These variables loaded to this component with .78, .847 and .531, respectively. The loading for Perceived DM Expl was slightly lower than the acceptable threshold of 0.6; however, because the difference with loading of 0.213 to F_Perception_General was more than 0.2, and also because of the variable nature which fits with variables loading to F_Perception_DM, I loaded this variable into F_Perception_DM (Figure 4.4).

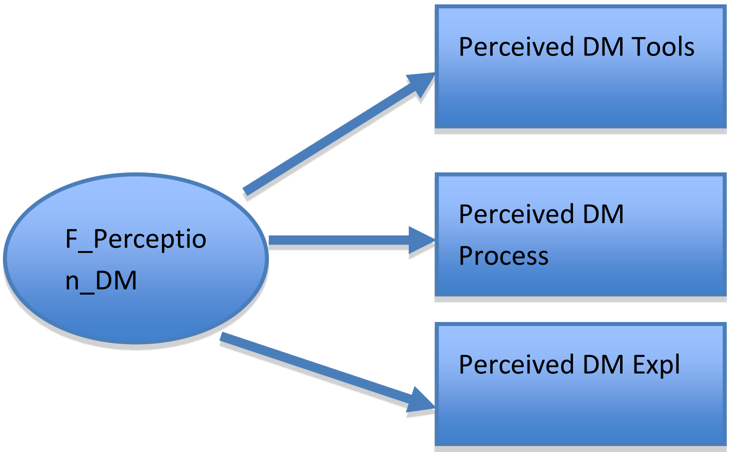

Figure 4.4 Perception of decision-making tools

To construct the score for extracted factors I simply calculated them based on mean values of loaded variables.

(iii) Exhibition

Using the EFA technique explained above, I analysed six variables in the exhibition category of variables (Table 4.15) to extract latent factors.

Variable	Question represented by variable
Exhibit Objective	Have the decision-support features of ERP been one of the objectives of your ERP implementation?
Exhibit Evaluation	Have the decision-support features of ERP been considered in the evaluation and requisition process of your ERP?
Exhibit DM Tools	Does ERP provide tools to enhance decision makers' ability to process information?
Exhibit DM Process	Does ERP provide tools for better facilitation of decision-making process?
Exhibit DM Expl	Does ERP provide facilities to encourage exploration and new approaches to the problem
Exhibit UI	Does ERP provide a good user interface?

Table 4.15 Exhibition variables

Based on principal component analysis and varimax rotation with Kaiser normalisation, two components were extracted which explained 60% of the variance (Table 4.16) (for detailed calculation please refer to Appendix 5).

	Component	
	1	2
Exhibit Objective		.779
Exhibit Evaluation	.412	.532
Exhibit DM Tools	.800	.296
Exhibit DM Process	.860	
Exhibit DM Expl	.853	
Exhibit UI		-.587

Table 4.16 Exhibition component matrix

Based on EFA, 'Exhibit Objective', 'Exhibit Evaluation' and 'Exhibit UI' loaded to a component which I called F_Exhibition_General, indicating that these variables represent exhibition of ERP decision-making support in terms of objectives, evaluation process and user interface in general. Although the loading of 'Exhibit Evaluation' and 'Exhibit UI' was below .6, I accepted these two variables to be loaded to F_F_Exhibition_General, considering the nature of these variables and the similarity between these factors and two factors extracted in the perceptions section of the questionnaire (discussed above). A similarity between these factors provides a good opportunity for paired analysis. Figure 4.5 shows the extracted factor and loaded variables.

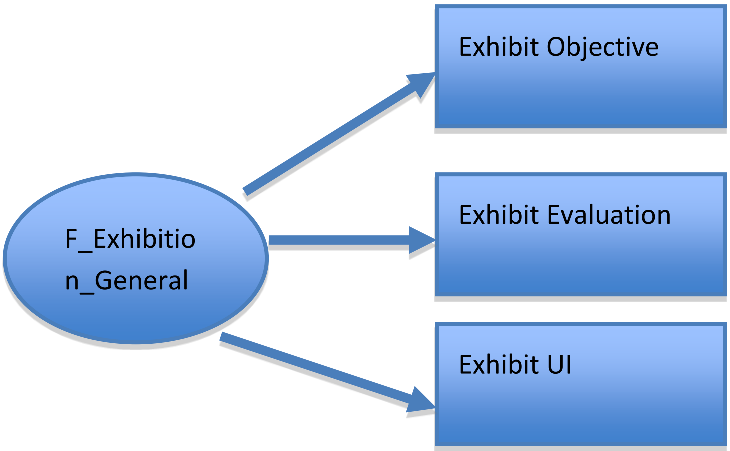

Figure 4.5 General exhibition of decision-making features

'Exhibit DM Tools', 'Exhibit DM Process' and 'Exhibit DM Expl' loaded to a component I called F_Exhibition_DM, indicating that these variables represent managers' and practitioners' views on exhibited ERP decision-making tools, processes and techniques specifically. These variables loaded to this component with strong loadings of .8, .86 and .853, respectively. Figure 4.6 shows the extracted factor and loaded variables.

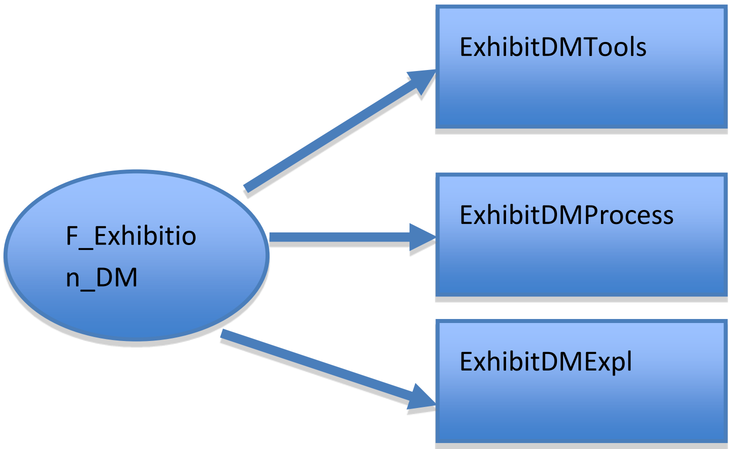

Figure 4.6 Exhibition of decision-making tools and features

To construct the score for extracted factors I simply calculated them based on mean values of the loaded variables.

(iv) Realisation

I used EFA to analyse the six variables in the realisation category of variables (Table 4.17) and extract latent factors.

Variable	Question represented by variable
Realised DM Quality	Has ERP improved the quality of decisions?
Realised DM Cost	Has ERP helped to reduce the cost of decision-making?
Realised DM Time	Has ERP shortened the decision-making time?
Realised DM Reliability	Has ERP improved the reliability of the decision-making process?
Realised DM Complex	Has ERP improved decision makers' abilities to tackle complex problems?
Realised DM Process	Has ERP increased satisfaction with the decision-making process?

Table 4.17 Realisation variables

Based on principal component analysis and Varimax rotation with Kaiser normalisation, three components were extracted which explain 68% of the variance (Table 4.18) (for detailed calculations please refer to Appendix 5).

	Component		
	1	2	3
Realised DM Quality	.720		-.413
Realised DM Cost		.837	.219
Realised DM Time	.668		.496
Realised DM Reliability			.855
Realised DM Complex		.854	
Realised DM Process	-.680		

Table 4.18 Realisation component matrix

‘Realised DM Quality’, ‘Realised DM Time’ and ‘Realised DM Process’ loaded to a component I called F_Realisation_Quality_Time_Process, indicating that this component shows the impact of ERP decision-making features and functionality on improving decision-making quality, reducing the time to make decisions and to improve the decision-making process in practice. Figure 4.7 shows the extracted factor and loaded variables.

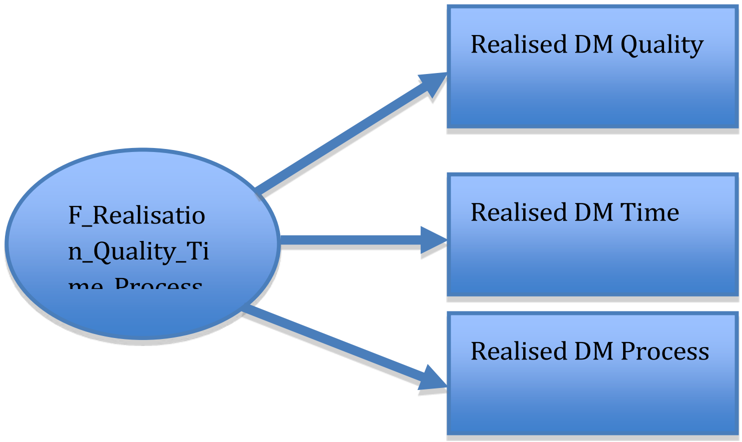

Figure 4.7 Realisation Quality-Time-Process

Two variables, 'Realised DM Cost' and 'Realised DM Complex' strongly loaded to another component I called F_Realisation_Cost_Complex, which represents the impact of ERP decision-making features and functionality on reducing the cost of decision making and enhances decision makers' ability to perform better when making more complex decisions. The third component loaded only with 'Realised DM Reliability' and I used the variable as itself in my calculations instead of creating a new component. Figure 4.8 shows the extracted factor and loaded variables.

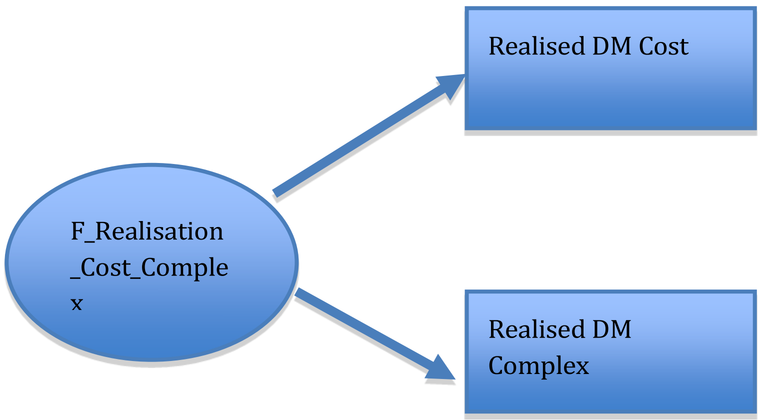

Figure 4.8 Realisation of decision-making cost and its complexity

Values for both extracted factors were calculated based on the mean of their loaded variables.

(v) Implementation

I used EFA to analyse eight variables in the implementation category of variables (Table 4.19) and extract their latent factors.

Variable	Question represented by variable
Imp Involvement	Were all stakeholders and users engaged in the ERP implementation?
Imp Executive Support	Was executive team informed and supportive of the ERP program?
Imp OverBudget	Was your ERP implementation over budget?
Imp OverTime	Was your ERP implementation over time?
Imp Integration Challenge	Were process and data integration the most challenging tasks?
Imp Integration	Is your ERP system well integrated and are most modules working harmoniously?
Imp Maturity	Does your ERP system seem to be mature now?
Imp Decoupled	Do ERP processes cover different functions or are they mainly function-centric with interfaces linking different modules?

Table 4.19 Implementation variables

Questions 3, 4, 5 and 8 in this group had different directions and so I included reversed-scored values of these four variables in the factor analysis.

Based on principal component analysis and Promax rotation with Kaiser normalisation, three components were extracted which explain 70% of the variance (Table 4.20) (for detailed calculations please refer to Appendix 5).

	Component			
	1	2	3	4
Imp Involvement	.835			.275
Imp Executive Support	.858			
Imp Integration		-.810		
Imp Maturity			.779	.406
Imp OverBudget	-.509	.235	-.242	.368
Imp OverTime				.914
Imp IntegrationChallenge			.793	-.222
Imp Decoupled		.820		

Table 4.20 Implementation component matrix

'Imp Involvement' and 'Imp Executive Support' loaded to a component I called F_Imp_Involvement_Support, indicating that this component represents management's and executives' involvement in and support of ERP implementation. Figure 4.9 shows the extracted factor and loaded variables.

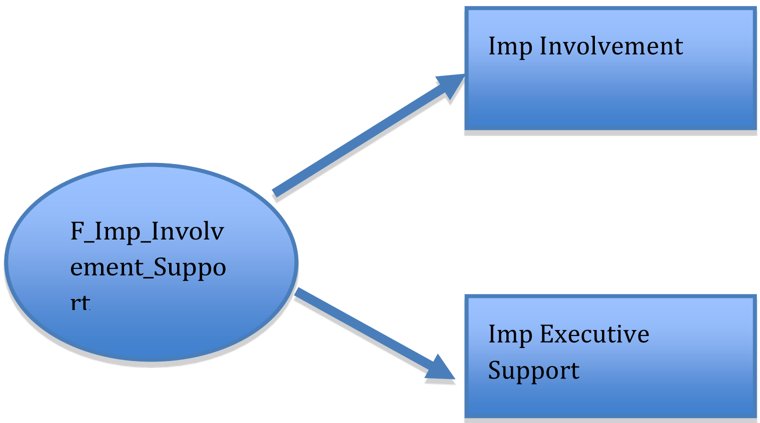

Figure 4.9 Implementation involvement and executive support

Another factor called F_Imp_Integration was extracted, loaded by 'Imp_Integration' and 'Imp_Decoupled'. This factor represents the degree of integration achieved during implementation. Figure 4.10 shows the extracted factor and loaded variables.

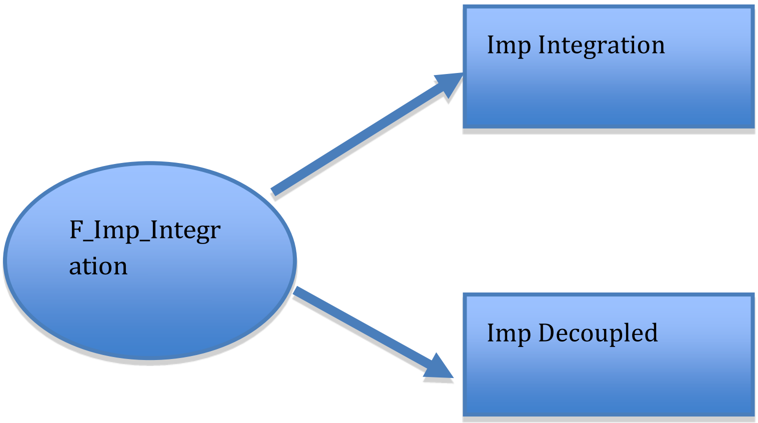

Figure 4.10 Implementation integration and decoupled systems

The third extracted factor was F_Imp_Maturity and it was loaded by 'Imp_Maturity' and 'Imp_IntegrationChallenge'. This factor represents organisations' maturity in their ERP adaptation process. Based on the findings in the first phase of this research, overcoming the challenge of achieving a high degree of integration in data and process is one of the contributing factors that prevents organisations becoming mature in their ERP adaptation process. A direct question about maturity and an indirect question about integration were taken into account in this factor. Figure 4.11 shows the extracted factor and loaded variables.

'Imp OverBudget' did not load to any component and the variable 'Imp OverTime' was the only variable that loaded to factor four; therefore I used these two variables without any change.

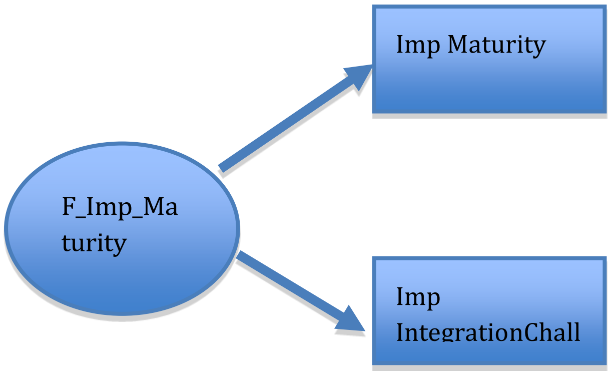

Figure 4.11 Implementation maturity and integration challenge

(vi) Maintenance

I used EFA to analyse four variables in the maintenance category of variables (Table 4.21) to extract latent factors.

Variable	Question represented by variable
Maintenance Stable	Has your ERP been fairly stable and there been no need to patch/upgrade?
Maintenance Technology	Has your ERP been upgraded (or migrated) multiple times due to change in technology?
Maintenance VendorMerger	Has your ERP been upgraded (or migrated) multiple times due to ERP vendors' mergers and consolidation?
Maintenance CompanyMerger	Has our ERP been upgraded (or migrated) multiple times due to your company merger and consolidation with other companies?

Table 4.21 Maintenance variables

Question 1 in this group had a different direction and so I included reverse-scored values of this variable in the factor analysis.

Based on principal component analysis and no rotation, one component was extracted which explained 70% of the variance (Table 4.22) (for detailed calculations please refer to Appendix 5).

	Component
	1
Maintenance Technology	.914
Maintenance VendorMerger	.939
Maintenance CompanyMerger	.913
Maintenance Stable	-.502

Table 4.22 Maintenance component matrix

Based on EFA, 'Maintenance Technology', 'Maintenance VendorMerger' and 'Maintenance CompanyMerger' loaded to component F_Maintenance, which represents upgrade and maintenance activities due to technology improvements and merger/consolidation of both ERP vendors and customers. Figure 4.12 shows the extracted factor and loaded variables.

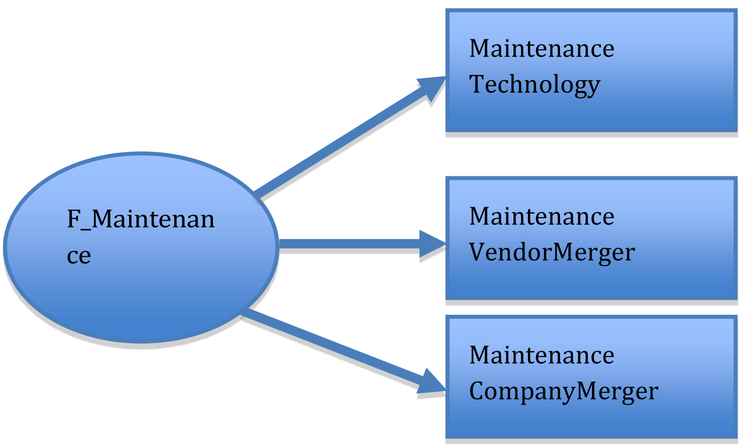

Figure 4.12 Maintenance technology and merger

(vii) Management knowledge and training

I used EFA to analyse three variables on management knowledge and training on using ERP features for decision making and decision-making in general (Table 4.23) to extract latent factors.

Variable	Question represented by variable
Management knowledge	How would you rank your knowledge about using enterprise systems towards decision making?
Management Training ERP	Have you had any training in utilising ERP in decision making?
Management Training DM	Have you had any training in the decision-making process and potential tools which could be utilised in this process?

Table 4.23 Management knowledge and training variables

Based on principal component analysis and no rotation, one components was extracted which explained 59% of the variance (Table 4.24) (for detailed calculations please refer to Appendix 5).

	Component
	1
Management knowledge	-.351
Management Training ERP	.923
Management Training DM	.884

Table 4.24 Management knowledge and training component matrix

Based on EFA, 'Management Training ERP' and 'Management Training DM' loaded to component F_Management_Training, which represented management training in using ERP features and functionality for decision making, and also their training in decision making in general. The 'Management Knowledge' variable was not loaded to any component and was used unchanged in the calculation. Figure 4.13 shows the extracted factor and loaded variables.

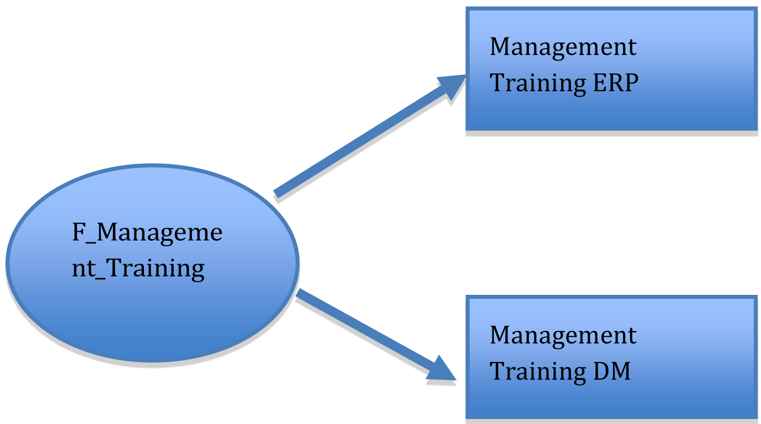

Figure 4.13 Management training in ERP and decision making

Pair analysis between perception, exhibition and realisation

I used a paired-samples t-test to test for any significant difference between perception, what is exhibited in ERP systems and what happens in real life. The paired-samples t-test compares the means of two variables, computes the difference between the two variables for each case and tests to see if the average difference is significantly different from zero.

(i) Comparison between perception and exhibition

First I tested the relationship between perception and exhibition by utilising the paired-samples t-test to investigate the following hypothesis:

Hypothesis: There is no significant difference between the means of perception and exhibition

The comparisons of (i) the means of perception in general (F_Perception_General) and exhibition in general (F_exhibition_General), and (ii) the means of perception towards decision-making tools (F_Perception_DM) and exhibition of decision-making tools (F_Exhibition_DM) revealed that both pairs of means had a significant difference. Therefore I rejected the null hypothesis, meaning that there is a significance difference between managers' perceptions of ERP systems' decision-making capabilities and features and what is actually exhibited in such systems. For detailed calculations please refer to Appendix 6.

The significant difference between F_Perception_General and F_exhibition_General shows that, although managers perceive that (i) decision-support features should be one of the objectives of ERP implementation, (ii) such features should be considered in the evaluation and requisition process and (iii) ERP has to provide a user-friendly interface, in practice none of these expectations are fully realised. This gap between expectations and outcomes is a strong indication that managers do not consider decision-support features necessary as implementation objectives or part of the evaluation and requisition process, despite managers' awareness of the importance of these features. The failure to emphasise decision-support features in the implementation objectives and in the evaluation and requisition process could contribute to the significant gap seen between F_Perception_DM and F_exhibition_DM. As customers do not care much for such features, vendors do not invest in them or improve them.

The significant difference between F_Perception_DM and F_exhibition_DM shows that, although managers think ERP should provide tools to enhance decision makers' ability to process information, facilitate the decision-making process and encourage new approaches to problem solving (e.g., sensitivity analysis, simulation tools), in practice none of these materialises. This gap between perception and exhibition in terms of decision-making tools is an opportunity for ERP vendors to capitalise on such high expectations, and improve their systems to meet some of their customers' expectations by providing tools and features to support decision making and facilitate the decision-making process. On the other hand, ERP adopters should find ways to meet management expectations by utilising ERP systems beyond their transactional capabilities to incorporate potential management support, which could be a result of their expectations.

(ii) *Comparison between exhibition and realisation*

In the second comparison I tested the significance between the exhibition of decision-making tools and features and the realisation of the benefits of using these features. I compared the mean of F_Exhibition_DM with F_Realisation_Quality_Time_Process and F_Realisation_Cost_Complex by utilising a paired-samples t-test. In this test I investigated two hypotheses:

A) ***Hypothesis:*** *There is no significant difference between the means of exhibited decision-making tools and realisation of benefits in terms of quality, time and process*

B) ***Hypothesis:*** *There is no significant difference between the means of exhibited decision-making tools and realisation of benefits in terms of cost reduction and ability to tackle complex decision-making scenarios*

Although both variables had a mean less than 3, the result of the paired-samples t-test showed a significance difference between F_Exhibition_DM and F_Realisation_Quality_Time_Process. Therefore null hypothesis A could be rejected. However, participants scored realised benefits in terms of quality, time and process (F_Realisation_Quality_Time_Process) significantly higher than exhibition of decision making tools and features (F_Exhibition_DM). For detailed calculations please refer to Appendix 6.

These findings are another indication of the low level of decision-making capabilities exhibited in ERP systems. In another words, participants' high expectations and their efforts to materialise some of the benefits do not match with ERP vendors' efforts to provide necessary tools and features in their systems. It seems that among expectation, exhibition and realisation, the weakest link is the exhibition of decision-making capabilities and features in ERP systems.

The paired-samples t-test also showed no significance difference between F_Exhibition_DM and F_Realisation_Cost_Complex, and therefore null hypothesis B was not rejected. Both variables were significantly below average, indicating a low level of exhibition and realisation in terms of cost and ability to tackle complex decision-making scenarios. This finding indicates that managers and executives generally believe that ERP could be more effective in improving the quality of decisions than other more tangible variables such as cost.

Correlation analysis

The previous section described the use of factor analysis to combine variables to make up 12 factors. Identified factors describe management knowledge and training, user expectations towards ERP decision-making capabilities, evaluation, implementation, exhibition of decision-making features in ERP systems, realisation of decision-making benefits in real life and finally ERP maintenance and upgrade. This section describes how I used correlation analysis to show whether, and how strongly, these variables are related. The relationship between these variables was subsequently used to build a conceptual model to gain a deeper understanding of important factors and their roles (discussed in Chapter 5).

Like any other statistical technique, correlation analysis is most appropriate for quantifiable data in which numbers are meaningful; it cannot be used for purely categorical data, such as gender, brands purchased, or favourite colour. The variables in this analysis were all of rating scales. Some statisticians believe that correlations should not be used with rating scales, because the mathematics of the technique assumes the differences between numbers are exactly equal. Many survey researchers use correlations with rating scales; however, results should be interpreted with care. In fact, when working with quantities, correlations could provide precise measurements and, when working with rating scales, correlations could provide general indications. I utilised the Pearson or product-moment correlation technique with the objective of finding general indications of relations between these factors.

It is true that correlation can tell us just how much of the variation in one variable is related to another one, and therefore finding a correlation between two variables does not mean changes in one variable cause a change in another. In other words, I did not aim to find causality. I am also aware that the Pearson correlation technique works best with linear relationships and does not work well with curvilinear relationships. As I utilised this technique as a general indication of potential relations between variables, which could be building blocks for the System Dynamics model, I assumed a linear relationship between these variables.

Table 4.25 shows significant correlation between variables from the correlation analysis. In this table, blue represents that the correlation is significant at the 0.05 level (two-tailed) and red that the correlation is significant at the 0.01 level (two-tailed).

The results presented in Table 4.25 indicate a significant correlation between five of the investigated variables, discussed below.

	Years since implementation	Experience with ERP	F_Evaluation	F_Perception_General	F_Perception_DM	F_Exhibition_General	F_Exhibition_DM	F_Realisation_Quality_Time_Process	F_Realisation_Cost_Complex	F_Imp_Involvement_Support	F_Imp_Integration	F_Imp_Maturity	F_Maintenance	F_Management_Training
Years since implementation	1	.451**	-0.05	-.331**	-0.14	-0.04	-.337**	0.037	-0.06	-0.18	0.06	-0.11	-0.14	0.053
Experience with ERP		1	0.009	-0.22	-0.06	-.289**	-.263*	-0.05	0.101	-0.09	0.076	0.065	-.256*	-0.02
F_Evaluation			1	-0.05	-0.04	0.199	-0.09	.374**	0.168	.310**	0.158	-.223*	-0.21	-0.05
F_Perception_General				1	0.187	0.161	0.197	-0.07	.249*	0.018	-0.11	0.046	.437**	-0.15
F_Perception_DM					1	-0.21	0.024	-0.02	-0.02	0.194	-0.02	-0.08	0.083	-0.18
F_Exhibition_General						1	.261*	.316**	0.204	0.073	.239*	-0.12	-0.04	0.053
F_Exhibition_DM							1	-0.12	.460**	-0.02	-.322**	.230*	.315**	-0.01
F_Realisation_Quality_Time_Process								1	0.014	.487**	0.015	-.281*	-0.1	-0.06
F_Realisation_Cost_Complex									1	0.022	-0.21	0.037	0.121	-0
F_Imp_Involvement_Support										1	0.003	-0.03	0.192	-0.06
F_Imp_Integration											1	-0.16	-.286**	0.165
F_Imp_Maturity												1	.427**	-0.02
F_Maintenance													1	0.09
F_Management_Training														1

Table 4.25 Correlation between variables

(i) Good practices in evaluation process (F_Evaluation)

Good practice in evaluation process is correlated with management support and involvement in the implementation process, realised benefits in terms of time/quality/process and degree of achieved maturity in adaptation process. The correlation of good practices in evaluation with management support and involvement could be interpreted as executive support and stakeholders' involvement having a positive impact on better practices in evaluation processes. The correlation with realised benefits and maturity could be interpreted as good practices in evaluation with possible positive impacts on adopting a suitable system which eventually helps to achieve higher degrees of maturity and improved quality, reducing the time for making decisions and improving the process of decision making.

(ii) *Managers' and executives' positive perception of ERP decision-making features and capabilities*

Managers' and executives' positive perception of ERP decision-making features and capabilities correlates with a realised reduction in decision-making costs and also an increased chance of attempting more complex decision-making scenarios. This correlation could be interpreted as perceived managerial views impacting final outcomes, which are realised benefits in terms of cost reduction and increased confidence and ability to approach more complex decisions. However, the same correlation also could be interpreted as realised benefits – such as decision-making cost reduction and increased ability to tackle more complex decision-making scenarios – could generate a positive perception by managers and executives who have benefited from such features. Managers' and executives' positive perception of ERP decision-making features and capabilities in general correlates with maintenance and upgrade activities.

(iii) *Exhibition of decision-making features and capabilities in ERP systems*

The F_Exhibition_General component represents the situation that if decision-support features of ERP had been one of the objectives for the implementation stage, whether they had also been considered during evaluation and requisition. The component also covers whether the ERP provides a suitable user interface for decision making. This variable correlates with realised benefits in terms of time/quality/process and degree of achieved integration in the adaptation process. This means that organisations considering such features as their objectives and including these factors in their evaluation and requisition process could increase their chance of realising benefits such as reducing the time and increasing the quality of decision making and achieving better processes. These companies could also achieve a better degree of integration, as a result of understanding the importance of integration in terms of providing meaningful information for decision making.

The F_Exhibition_DM component represents the situation where an ERP system provides tools and facilities to enhance decision makers' ability to process information, thus facilitating the decision-making process and encouraging exploration and new approaches to the problem. This variable correlates with a realised reduction of decision-making cost and also an increased chance of attempting more complex decision-making scenarios. It also correlates with the degree of achieved integration, maturity and maintenance/upgrade activities. This finding could be interpreted as meaning that, if an organisation has the system to provide tools and facilities to process information, to facilitate the decision-making process and to explore new approaches to the problem, that organisation is more likely to enjoy realised benefits such as reduced decision-making costs and the ability to tackle more complex issues. The organisation is also more likely to achieve better maturity and integration in its implementation.

(iv) *Realisation of decision-making features and capabilities in ERP systems*

The F_Realisation_Quality_Time_Process variable represents the situation where ERP has improved the quality of decisions and has consequently helped reduce the cost of decision making and shorten the decision-making time. This variable correlates with management support and involvement in implementation process, and correlates negatively with the level of maturity achieved by adopters. Correlation with F_Imp_Involvement_Support could be interpreted as the importance of management support and involvement during implementation in achieving the final objectives of reducing time, increasing the quality and facilitating the process of decision making.

(v) *Level of Integration*

The F_Imp_Integration variable represents the level of integration achieved by ERP adopters. This variable is negatively correlated with the variable representing frequency and amount of maintenance and upgrade to the system. This finding means that frequent upgrades and maintenance to the system prevent achieving an acceptable level of integration, and vice versa.

4.4 Findings and discussion

There has been little examination of the extent to which decision-support benefits accrue to ERP adopters, or the extent to which they relate to various objectives in an ERP implementation (Holsapple and Sena, 2005). Such a study in the context of Australian organisations is particularly rare. In this research I utilised semi-structured interviews and a survey to gain insight into the current status of Australian organisations and industry practitioners in regard to utilising ERP systems towards the decision-making process. Most participants were from the first-tier ERP market, had had more than six years of experience with ERP and had completed their implementation at least five years before the study. Based on the data analysis, ERP stakeholders and users perceive ERP's strong potential for improving the decision-making process at the strategic and operational levels. However, this potential is not among the main objectives for investment in ERP. I also found that these potential benefits do not materialise in practice. This section discusses some of the main reasons for this lack of materialisation, and suggests some correctional strategies which could benefit both customers and vendors of ERP systems.

Based on the findings, ERP adapters perceive substantial importance of and potential for utilising ERP data to improve the decision-making process at both strategic and tactical levels. Previous studies have also identified the perceived importance of decision-support features (Holsapple and Sena, 2005; Jacobs and Bendoly, 2003).

I also found that decision-support features of ERP systems do not play an important role in the evaluation process, and this could contribute to decreased materialisation of such benefits in practice. In this regard the findings support those of some previous studies. As supporting the decision-making process is not an objective, it is then not part of evaluation process.

I found that, although ERP is perceived to have an important potential role in supporting the decision-making process, these benefits do not materialise among first-tier Australian ERP adopters. Participants' high expectations and their efforts to achieve some of the benefits do not match ERP vendors' effort to provide the necessary tools and features in their systems. It seems that among expectation, exhibition and realisation, the weakest link is the exhibition of decision-making capabilities and features in ERP systems. This chapter has discussed some of the barriers and contributing factors preventing materialisation of these benefits; however, identification of all contributing factors or cause-and-effect relationships has not been an objective of this research.

I found that the ERP adaptation process, with its numerous obstacles and difficulties, is among the main factors preventing utilisation of ERP towards more strategic benefits. Probably the greatest obstacle is achieving a reasonable level of integration across enterprise processes and data, which in many cases can lead to decoupled or semi-integrated ERP implementation. Such implementation is a major compromise on one of the main objectives of investing in ERP. Decoupled modules, along with a department-centric mentality, contribute to the downgrade of valuable ERP data from being utilised in organisation-level strategic decision making to being treated as departmental data used for day-to-day operations.

I found that ERP vendors and customers' mergers and acquisitions consume most of the resources allocated to the ERP program and prevent top management and operational teams taking BI implementation seriously. This outcome occurs as a result of the adaptation process and integration, and also because of upgrade spirals due to advances in technology. In the absence of uniform and standard decision-making and BI tools, the selective use of information to support or reject individual actions and ideas leads to increased mistrust of ERP data and lack of confidence that ERP can provide vital information and the necessary processes for better decision making.

Other contributing factors identified were management training and systems' user-friendliness. I found that, although all participants recognised the potential importance of ERP data for decision making, the majority of managers and decision makers had had no official training on using EPR, interpreting data or the potential benefits gained by using BI modules. In addition, although many ERP vendors have already invested in making their systems user-friendly and equipped with intuitive report writers and BI modules, most legacy systems and older versions of enterprise systems in use in first-tier ERP adapters suffer from a lack of user-friendliness, intuitive report and query generators or any BI modules.

4.4.1 Practical guides

Overall, the need for decision-support functionality in ERP systems is widely recognised and, in principle, ERP should support decision-making processes. However, operational issues, and especially integration complexity, prevent organisations achieving any of the above. In this situation, organisations should consider more manageable implementation scenarios which are suitable for their requirements and could minimise their risk of being trapped in an integration battleground. New technological advancements in integration techniques mean that integrating separate systems is becoming less difficult and building interfaces between these systems does not require huge investment. In addition, I found that many ERPs are being implemented in a decoupled fashion and, as such, the real benefits of highly priced integration are never gained.

As a result, despite the perception that integration is achievable only through native modular integration which is available in ERP, I argue that Best of Breed (BoB) solutions could be a viable option for many organisations, and they should certainly consider BoB as an option in their evaluation process. By considering BoB, these organisations could minimise their implementation risk and cost. They could also distribute implementation cost and effort over a period of time suitable for their business. By taking advantage of BoB, organisations could integrate their current system into the new system, rather than scrapping it altogether. The end result could be a cheaper system with a higher degree of integration than a decoupled ERP.

The significant gap between expectation and exhibition, both in general and in terms of decision-making tools, is an opportunity for ERP vendors to consider such high expectations from their customers and incorporate the expected features, tools and capabilities in their systems. On the other hand, ERP project managers should consider management and executives' high expectations as an opportunity to find ways of materialising management expectations.

For most organisations struggling to overcome their operational issues, BI implementation seems highly idealistic. However, available data can be utilised in ERP without requiring a complex BI implementation. Practical steps towards utilising ERP data for decision making include using new integration, web and programming techniques, and building data marts based on ERP and other disparate systems which eventually lead to data warehouse and, potentially, BI.

Management commitment and support is one of the main success factors for any BI program. By providing necessary training on using EPR, interpreting data and recognising the potential benefits of BI, organisations could increase their chance of utilising valuable ERP data to gain competitive advantage. Increased management knowledge could contribute to high expectations of ERP decision-support features, which could have a positive impact on using existing features and capabilities within the organisation. ERP vendors, therefore, should consider investing in integration techniques and building intuitive BI modules.

4.5 Chapter summary

This chapter has presented the analysis of the data from the exploratory interviews and survey, discussing the themes emerging from the interviews and the statistical data analysis. These observations led to discussions and practical guides for managers and practitioners to utilise their investment on ERP more effectively towards more strategic benefits such as decision making.

Quantitative and qualitative data analysis techniques used in this chapter provide insight into factors, their impacts and behaviour as observed in the collected data. However, these techniques do not provide a holistic systematic view of the phenomena in which factors, their interactions and their changes could be studied over a period of time. For instance, maturity in ERP adaptation is one of the variables that has been thoroughly investigated using statistical analysis; however, its behaviour, which is highly time dependent, could not be investigated using these techniques.

In order to understand the behaviour of all involved factors from a systemic point of view, their interactions and their changes over time, a theoretical System Dynamics (SD) model was built and used to understand behaviours that are not obvious through non-systematic approaches. The SD model was built based on findings from this research, the literature and personal experience, and it helped researcher to understand the phenomenon in its entirety. This model was also used to simulate different scenarios and their impacts on system outputs. This model, its theoretical foundations and simulating scenarios are explained in detail in Chapter 5, which investigates the subject of this research from a different point of view, confirming some of the findings of Chapter 4 and providing insight into interactions between factors and their changing behaviour over a period of time.

CHAPTER 5

MODELLING

5.1 Introduction

This chapter uses a System Dynamics (SD) approach to analyse a theoretical model of Enterprise Resource Planning (ERP) and its utilisation in decision making in Australian organisations. The theoretical SD model was based on both the findings presented in Chapter 4 and the literature. Experimenting with the model suggests possible policies and offers insights into the better use of ERP data in decision making. An SD approach also provides key insights into the interactive behaviour of system elements over a period of time that are normally not obvious through non-systematic approaches.

Section 5.2 briefly discusses SD and the rationale for using this modelling technique. Section 5.3 outlines the building blocks of the model, its working elements and their interactions as a system. The rest of the chapter describes experimental simulations to test real life scenarios and possible outcomes. Section 5.4 introduces causal loop modelling. Section 5.5 builds on the discussion by examining the system structure and discussing the constructs and their relationships. The constructs are implementation issues, cost of ownership, maintenance, maturity, perception, management knowledge and training, and management and executives' involvement and support. Finally, Section 5.6 explains the structure of the SD model, providing details of the reference mode and the scenarios run to test the model, and outlining its limitations and assumptions. By using the model I suggest management policies that may improve the utilisation of ERP and its associated data in decision making and other related processes.

5.2 System thinking and modelling methodology

The systems thinking and modelling methodology used in this study was based on the SD methodology initially developed by Jay Forrester and others at the Massachusetts Institute of Technology in the late 1950s. Such an approach aims to understand the behaviour of complex systems over time and deals with internal feedback loops and time delays that affect the behaviour of the entire system (Taylor, 2008). This method has been applied successfully in information systems (IS) research focusing on the complexity of IS requirements analysis and software development project management (Wolstenholme, 2003).

A systems thinking and modelling methodology involves five distinct but interrelated stages: problem structuring, causal loop modelling, dynamic modelling, scenario planning and modelling, implementation and organisational learning (Figure 5.1).

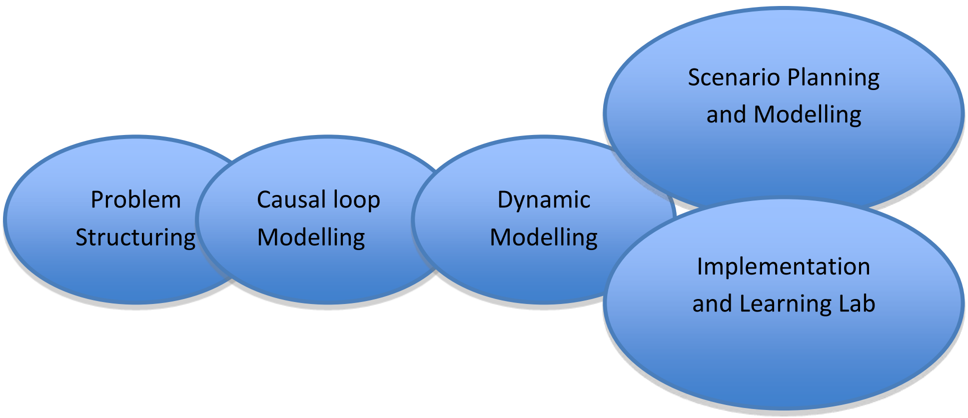

Figure 5.1 Stages of the systems thinking and modelling methodology

The findings from the first and second phases of this study indicated a complex system, with major factors interacting and changing their behaviour over time. One could argue that major parameters do not follow a linear flow and are part of a dynamic system with complex feedback loops that change with time. Consequently, examining the dynamic behaviour of the system over time can provide a deeper and richer understanding of impacting factors and their inter-relationships. Using the findings from the exploratory interview and survey phases of this research, together with information from the literature, I built a conceptual model and used it to experiment with various proposed scenarios and behaviours. The purpose of this experimentation was to enhance our understanding of a system's behaviour over time and of the roles and interactions of major parameters, in order to define strategies and policies towards better utilisation of ERP systems in decision making.

Phases one and two of this study, the exploratory interviews and survey (see Figure 1.1 in Chapter 1), were described and discussed in chapters 3 and 4. These two phases identified the scope and boundaries of the study and collected the data to help model the system. This chapter focuses on the structure of the causal loop models, the dynamic model itself, and experimentation and sensitivity analysis using the model.

It should be noted that this work is exploratory, in that it examines a theoretical model developed from observations and findings from exploratory interviews and survey results. The model, therefore, should not be considered comprehensive.

5.3 System Dynamics overview

System Dynamics (SD) is a computer-aided approach based on system thinking and modelling methodology for designing and analysing policies and strategies in dynamic social, managerial and economic systems, in fact in any dynamic systems characterised by interdependence, mutual interactions, information feedback and circular causality.

Forrester (1961) first explained the concept of SD in his book *Industrial Dynamics*. Within a few years the systematic method and its applications grew from corporate and industrial management to economics, public policy, urban planning, defence and social sciences. Forrester (1997) explains that SD:

deals with how things change through time, which includes most of what most people find important. 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.

5.3.1 SD approach

SD aims to define phenomena in terms of continuous interconnected variables in loops of information feedback and circular causality. This strives for an endogenous, behavioural view of the system that focuses inward on the system characteristics which exacerbate the perceived problems.

The basic structure of an SD model consists of nonlinear, first-order differential equations:

$$\frac{d}{dt}x(t) = f(x,p)$$

where x is a state variable (stock), f is a non-linear function and p is a set of parameters.

This equation could easily be simulated by partitioning the simulated time into discrete intervals and stepping the system through successive intervals in turn. As a result each state variable is computed from its previous value. dt needs to be small enough to simulate the patterns of dynamic behaviour represented by the model.

5.3.2 Feedback loops

Feedback loops are the building blocks in an SD model. A feedback loop occurs when information resulting from some action travels through the systems and feeds back to its origin, influencing future actions. If the feedback information reinforces the initial action then the feedback loop is a positive or reinforcing loop. If the feedback information influences the initial action in the opposite direction then the feedback is negative or balancing. Balancing loops tend to produce a stable and equilibrating status while positive or reinforcing loops cause disequilibrating and destablising states, leading to potential growth or collapse.

5.3.3 Endogenous point of view

SD focuses more on endogenous system changes rather than exogenous ones, and so the causes and corrective responses are contained within the structure of the system itself. Although the impact of exogenous parameters is considered in the modelling process, the main focus is to understand the internal structure and self-corrective actions which are contained in the system and evidently under control. As a result, building theory and analysing policies based on SD models are heavily affected by this endogenous perspective, trying to comprehend the roots of system behaviour within the structure of the system itself.

5.3.4 System structure

Forrester's (1969) framework captures these concepts of a system's structure (Figure 5.2).

In this framework the term 'Closed Boundaries' refers to the focus of SD on an endogenous point of view in order to investigate system behaviour by studying causality within the boundaries of the system. In fact, the aim is to model a system which can simulate its essential characteristics without the need of exogenous explanations.

In this framework the feedback loops represent the aim to capture a system's dynamics within a closed causal boundary. Causal or feedback loops build system structure in a way to show that the cause of significant system behaviour is contained within closed causal loops within the system, rather than in variables outside it. Causal or feedback loops reinforce the endogenous point of view and give it structure.

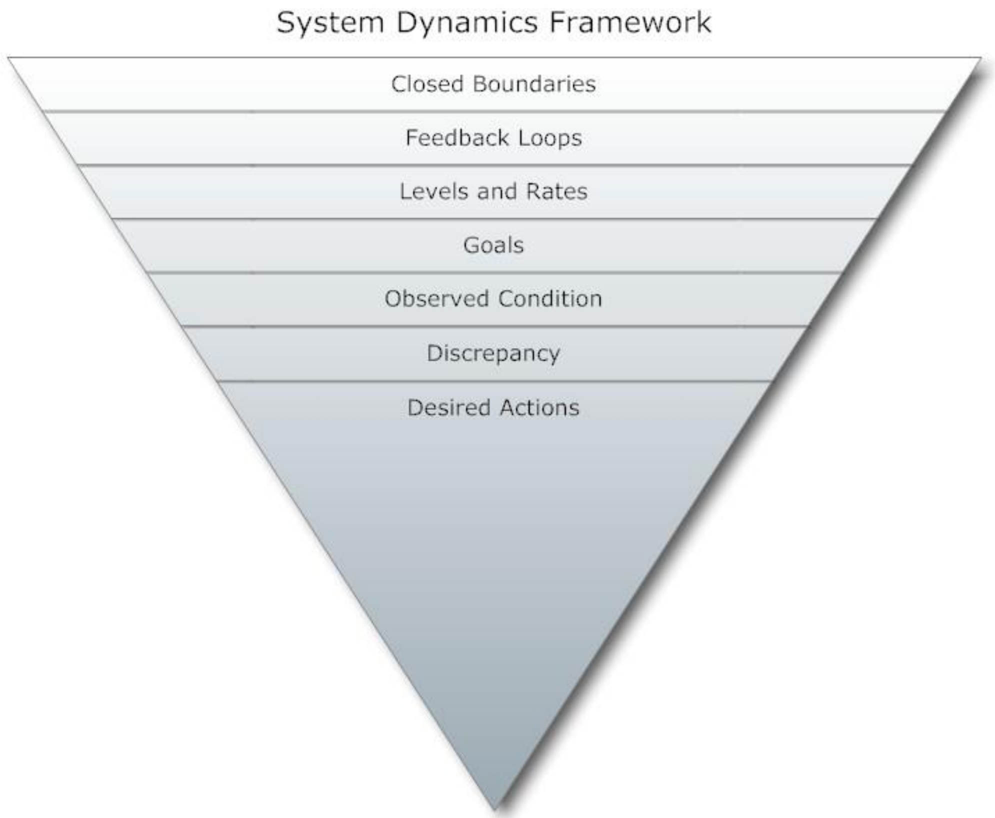

Figure 5.2 Forrester's (1969) framework for system structure

The building blocks of an SD model are stocks (levels) and flows (rates) variables. Stocks are accumulated state variables which represent the memory of a dynamic system and create the system's dynamic behaviour. Flows are to and from stocks. For instance, a constant flow leads to a linearly rising stock and a linearly rising inflow creates a stock rising in a parabolic path. SD uses rates to model a system's operating policies, with the classical assumption of system theory that a balancing feedback loop leads to corrective actions to close the gap between observed and desired conditions. In its typical form, rate variables could be described in the form of an equation:

$$flow = \frac{Goal - Stock}{Adj\_time}$$

where Adj_time is the time required for the stock (level) to reach the goal.

5.4 Causal loop modelling

Causal loop modelling is the second step of the system thinking and modelling methodology explained above in Section 5.2. A Causal Loop Diagram (CLD) is a tool for revealing the causal relationships among a set of variables operating in the system. The basic elements of CLDs are variables and arrows. A variable is a condition, situation, action or decision that can influence, and can be influenced by, other variables. Variables can be quantitative or qualitative. An arrow indicates a causal association between two variables, or a change in the state of these variables (Maani and Cavana, 2007).

The methodology to develop the causal model was based on examining relevant literature and findings from the exploratory interviews and survey results. The causal relationships presented in the model were mostly supported by literature and my findings. However, in some instances the logical structure of the model was the main reason for some of the connections and links. In the causal model, all types of links were colour-coded as blue: supported by literature, green: supported by this research and red: added due to logical structure. The causal model was validated by developing a parametric model using SD software called Vensim. The experimental validation process provided the opportunity to simulate a system's behaviour over time. My primary focus was on whether the system ran contrary to reasonable expectations and to identify situations that may lead to this (Forrester, 1971; Forrester and Senge, 1980). The testing with SD software provided support that the proposed causal structure was sound.

The causal loop model presented in Figure 5.3 was developed to reflect the relationship between system constructs, and was used to develop the Dynamic Model which was used to analyse system behaviour, as described in this chapter.

5.5 System structure and parametric model

This section describes the constructs and their relationships illustrated in Figure 5.3. Causal loops for each construct are analysed and CLDs are then used to construct Stock and Flow diagrams, which are the building blocks of the parametric model. In CLDs the emphasis is more on internal relationship between variables and less on exogenous variables. However, any relevant exogenous variables are displayed in the diagrams.

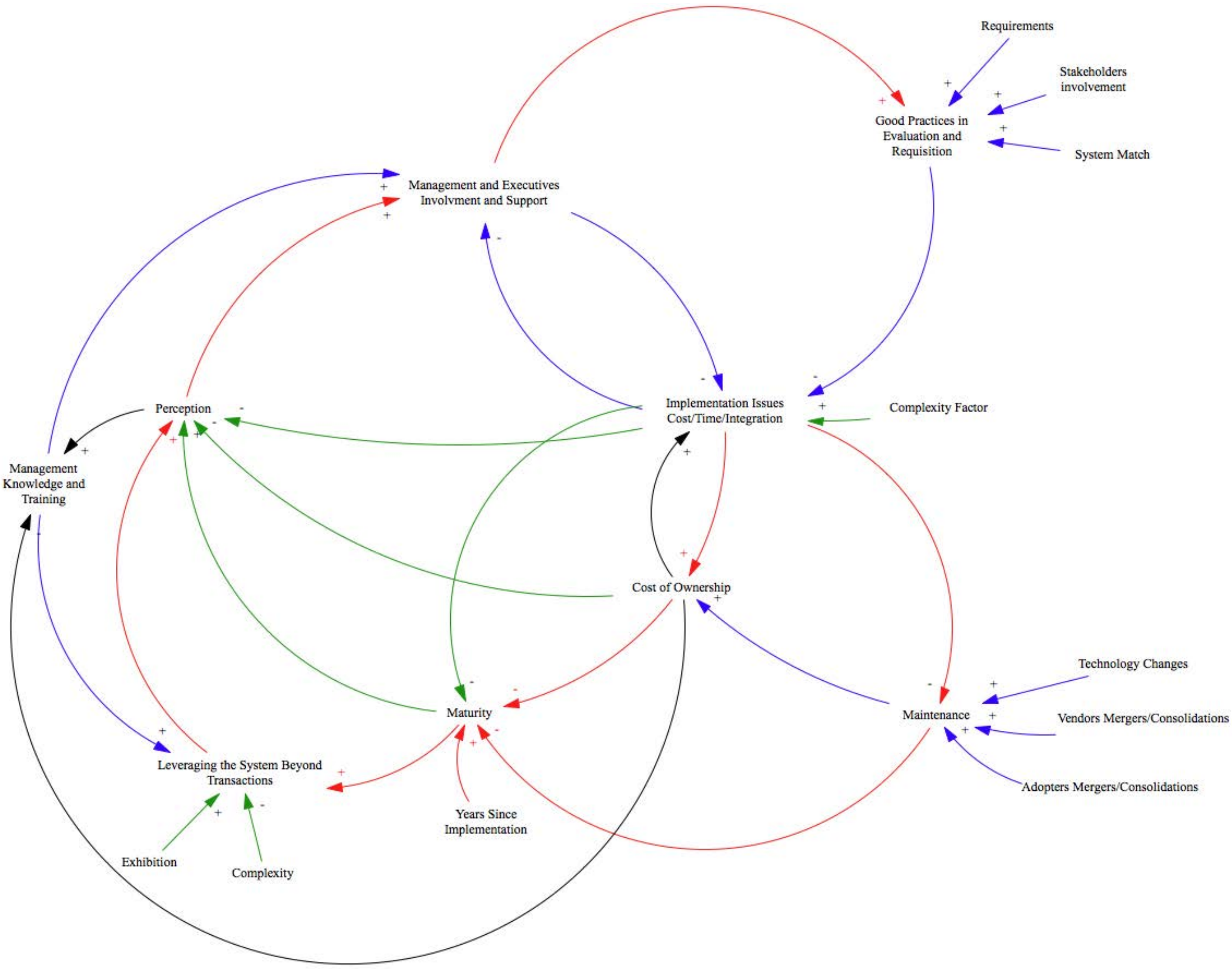

Figure 5.3 Causal Loop Diagram Including All Variables

5.5.1 Implementation issues

Implementation issues – including time and cost overrun and integration – were at the heart of this model. These issues, problems and obstacles have been the subject of numerous surveys, case studies and reports in both academia and industry (e.g., Bingi et al., 1999; Brynjolfsson and Hitt, 1996, 1998; Buckhout et al., 1999; Davenport, 1998b, 2000a). These studies focussed mainly on critical success factors impacting the successful implementation of ERP, and they often failed to investigate existing interactions between parameters across the whole system. In the conceptual model developed for this research, implementation issues were analysed as high-level parameters interacting with the rest of the system over time. Figure 5.4 shows the causal loop model for implementation issues based on the findings in previous phases of this research.

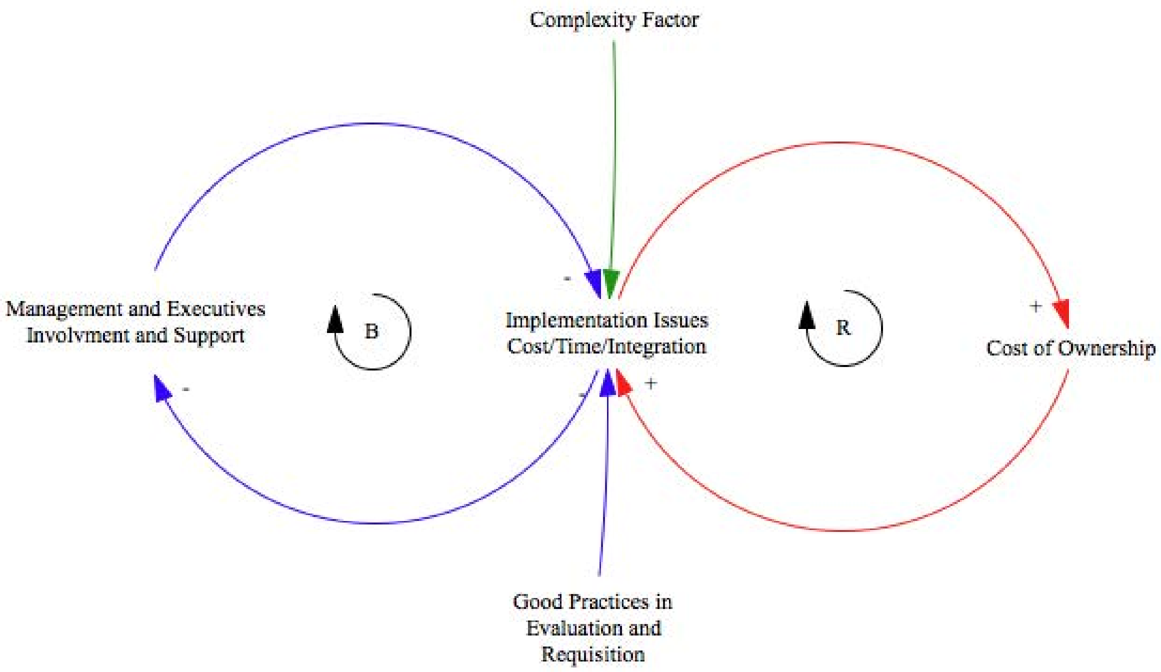

Figure 5.4 Causal loop: Implementation issues

Two reinforcing feedback loops in this model represent growing and declining actions.

The first reinforcing loop shows that management and executives' involvement and support results in fewer implementation issues, which could improve management support and commitment to the project. Management and executives' involvement and support could decrease implementation issues and successful implementation, and fewer operational issues is a contributing factor to improving management support and their active involvement. This loop has been identified as a major critical success factor for systems implementation success in general and to ERP implementation specifically (Houdeshel and Watson, 1987; Watson et al., 2001).

The second reinforcing loop shows that implementation issues such as cost and resources challenges and integration could have a direct impact on the cost of ownership, which in turn contributes to more issues arising in implementation. This loop is supported by both the findings of this research, discussed in Chapter 4, and the literature.

5.5.2 Cost of ownership

Cost of ownership of a system consists of implementation, running and upgrade/maintenance costs. This cost is significantly influenced by the success of the project's implementation. Any technical or non-technical implementation issues usually lead to greater cost, and greater cost and a tight budget can increase the difficulty of implementation. This creates a reinforcing loop, which is depicted in Figure 5.5. The findings from the statistical data analysis (Chapter 4) indicated significant correlation between these parameters.

Cost of ownership is influenced by a balancing loop, which includes maintenance and upgrade. Maintenance and upgrade activities cause increased cost, which increases the problems with implementation. However, organisations facing difficulties with implementation, such as technical, process and integration issues, tend to decrease their upgrade and maintenance activities, thereby causing a balancing loop.

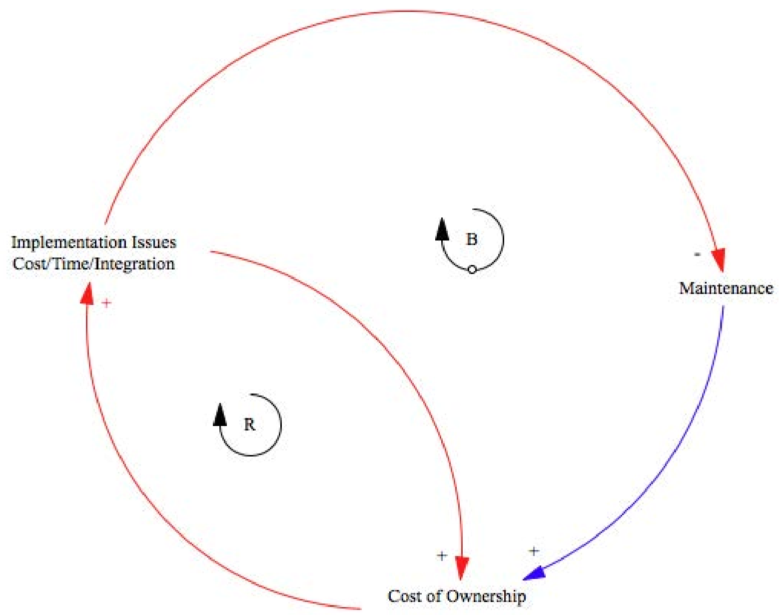

Figure 5.5 Causal loop: Cost of ownership

5.5.3 Maintenance

Maintenance, changes and upgrades activities cause the cost of ownership to increase, which in turn increases the project's implementation cost. At the same time, increased difficulties in implementation mean that maintenance, changes and upgrades become less frequent due to lack of resources. This is a balancing loop which works against the reinforcing loop between implementation issues and cost of ownership. These two causal loops are depicted in Figure 5.6.

Maintenance, changes and upgrades are also strongly influenced by exogenous variables such as ongoing technological advancement and changes, and ERP vendors' and adopter's mergers and consolidations. These variables have been explained in more detail in previous chapters.

This variable representing maintenance activities burdened to the organisations by external variables such as organisations mergers, consolidations and also technology. The use of new technology also could be considered as maintenance, however this has been considered in this variable and partially considered in other variables such as leveraging the system beyond it transactions capabilities.

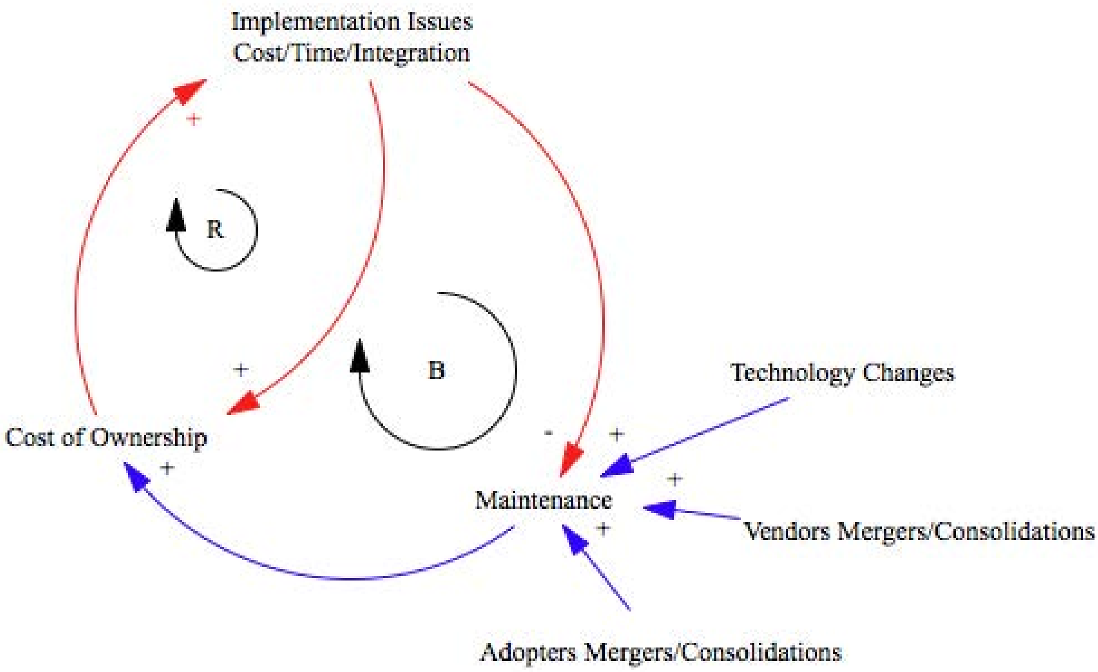

Figure 5.6 Causal loop: Maintenance and upgrade

5.5.4 Maturity

In previous chapters the concept of maturity in the process of ERP adaptation was analysed and the findings from the exploratory interviews and survey were discussed in detail. The findings showed the process of maturity in ERP implementation is always under the negative impact of increasing cost of ownership, constant maintenance, and upgrade and implementation issues. At the same time, maturity could lead to executives and managers acquiring a more positive perception of ERP systems, which eventually leads to their involvement and support in the ERP implementation and adaptation process. The increase in managerial involvement could decrease implementation problems. These causal links are depicted in Figure 5.7. In the causal diagram there is one reinforcing loop and one balancing loop, working against each other:

Balancing Loop: Maturity→ Perception→Management and Executives Involvement and Support→Implementation Issues Cost/Time/Integration→Maintenance

Reinforcing Loop: Maturity→Perception→Management and Executives Involvement and Support→Implementation Issues Cost/Time/Integration→Cost of Ownership

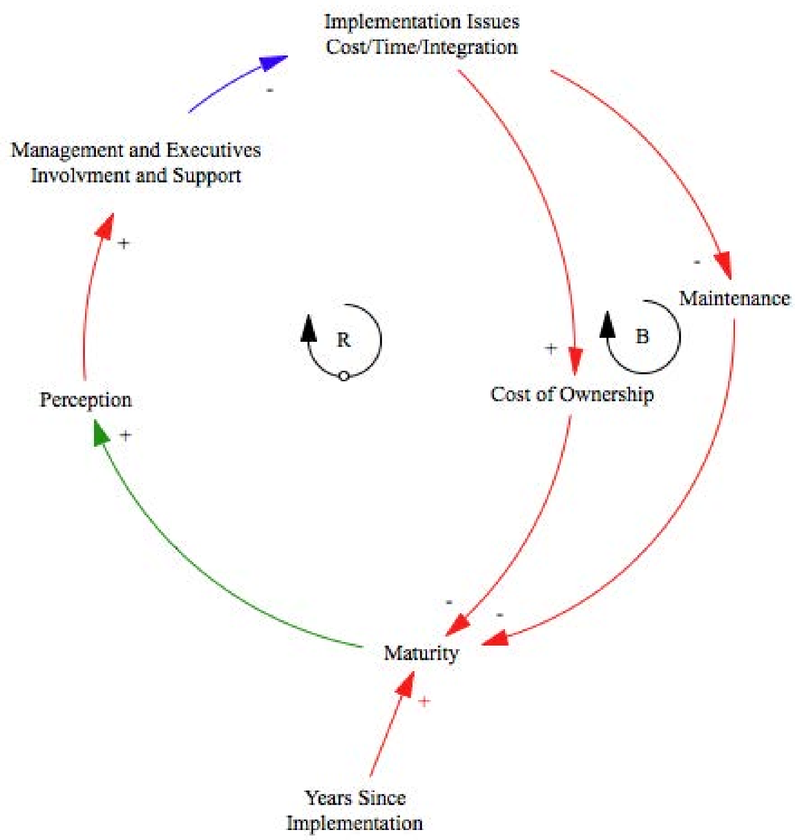

Figure 5.7 Causal loop: Maturity

5.5.5 Perception

Executives' and managers' perception of an ERP system is influenced by how the system is being implemented and used, particularly in terms of the system's more strategic benefits. The factors impacting managers' and executives' perceptions, based on both my findings and the literature, are captured in the causal loops presented in Figure 5.8.

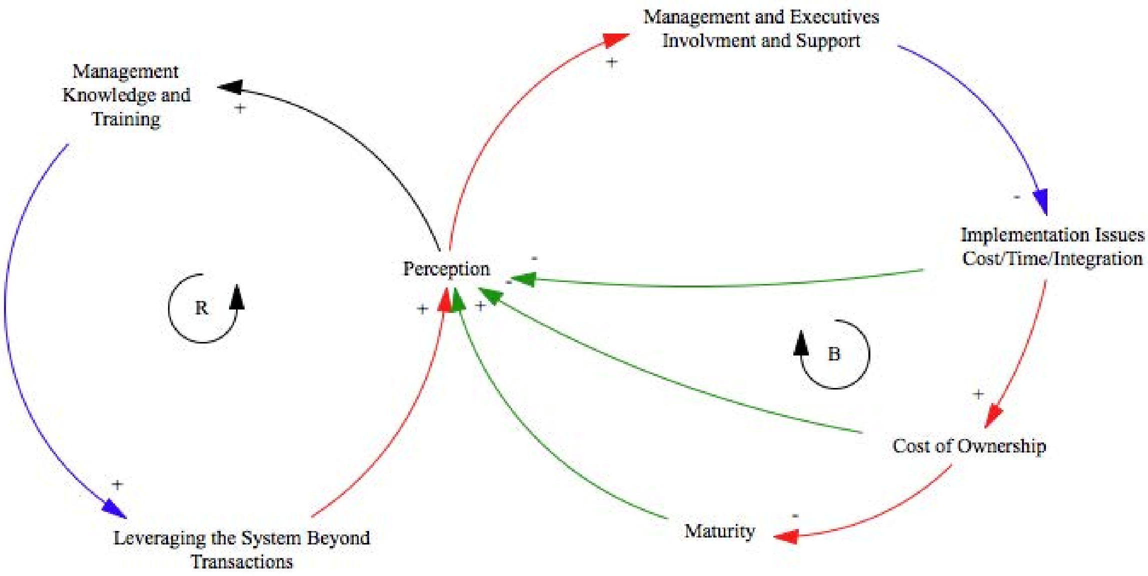

Figure 5.8 Causal loop: Perception

Perception is impacted by four loops. The first reinforcing loop shows that increasing positive perception encourages managers to gain more training and ultimately knowledge, which in turn leads to leveraging the system beyond its transactional capabilities and more towards strategic benefits.

Reinforcing Loop 1: Perception→Management Knowledge and Training→Leveraging the System Beyond Transactions

Another reinforcing loop involves positive perception increasing management involvement and support in the adaptation process. This has a direct impact on reducing implementation issues, which in turn reduces the cost and leads to gaining maturity, which helps increase the positive perception. Two other reinforcing loops within the big loop indicate the direct impacts of cost and implementation issues on perception.

Reinforcing Loop 2: Perception→Management and Executives' Involvement and Support→Implementation Issues Cost/Time/Integration→Cost of Ownership→Maturity

Reinforcing Loop 3: Perception→Management and Executives' Involvement and Support→Implementation Issues Cost/Time/Integration

Reinforcing loop 3 starts from positive perception which increases management involvement and support in the adaptation process which has a positive impact on implementation resulting reducing implementation issues as shown in Figure 5.8. This in turn results on improving perception.

Reinforcing Loop 4: Perception→Management and Executives' Involvement and Support→Implementation Issues Cost/Time/Integration→Cost of Ownership

Reinforcing loop 4 goes through the same variables as loop 3, however the impact of increased implementation issues has an impact on cost of ownership which in turn has a negative impact on perception.

5.5.6 Management knowledge and training

One of the important factors influencing the adaptation process of enterprise systems, and utilising them to their full potential, is the level of management knowledge and training about these systems. My findings and the literature suggest this factor is influenced by two reinforcing loops, as shown in Figure 5.9. On one side it helps to utilise the system beyond its transactional capabilities, thus providing strategic benefits that lead to change management perception in a positive way. This positive perception then leads to increased management knowledge and training by providing the required resources.

Reinforcing Loop 1: Management Knowledge and Training→Leveraging the System Beyond Transactions→Perception

On the other side, the cost of ownership influences the budget allocated to training, and so the cost of ownership has a negative causal relationship with this variable.

Reinforcing Loop Number: Management Knowledge and Training→Management and Executives' Involvement and Support→Implementation Issues Cost/Time/Integration→Cost of Ownership

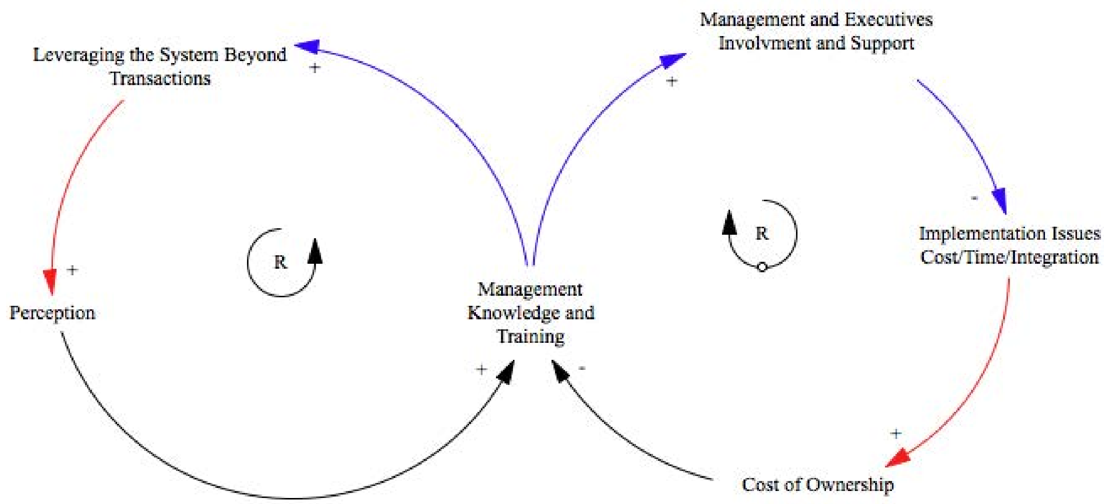

Figure 5.9 Causal loop: Management knowledge and training

5.5.7 Management and executives' involvement and support

The literature investigating ERP from different aspects highlights that a key success factor is management and executives' involvement and support at the time of implementation and during the life of the system. My findings also showed that greater management involvement and support reduce implementation difficulties and eventually create the reinforcing loop on the left-hand side of Figure 5.10.

Reinforcing Loop 1: Management and Executives' Involvement and Support→Implementation Issues Cost/Time/Integration→Cost of Ownership→Maturity→Perception

Another reinforcing loop on the right-hand side of Figure 5.10 shows the impact of this variable on good practices in evaluation and requisition. The positive impact leads to fewer implementation issues, which eventually increases management involvement and support.

Reinforcing Loop 2: Management and Executives' Involvement and Support→Good Practices in Evaluation and Requisition→Implementation Issues Cost/Time/Integration

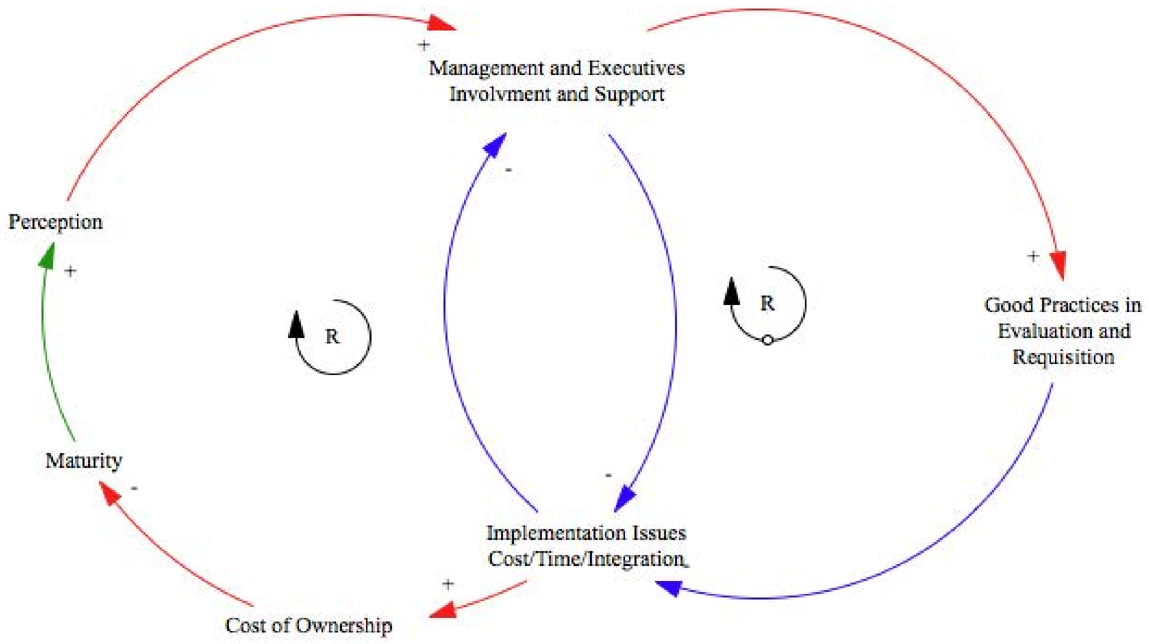

Figure 5.10 Causal loop: Management and executives' involvement and support

5.6 Dynamic modelling

This section explains the structure of the SD model, which was based on the causal loops model explained in the previous section. All variables in the SD model were the same as the variables presented in causal loops model, and so are not defined again here.

The main objective in building the model was to examine how the interaction between different system elements and their causal relationships creates a dynamic system. This is not possible in a linear model. I also used the model to perform sensitivity analysis in order to design strategy and policies to facilitate the greater use of ERP systems for their strategic benefits, beyond the usual transactional and operational benefits.

The ability to experiment with various policies and situations provided both theoretical and practical benefits, and enhanced our insight into the system's behaviour in terms of its structure, exogenous variables values and causal effects.

5.6.1 Limitations and assumptions

The dynamic model was a translation of the causal diagram in Figure 5.10 and its variables, explained in the previous section. The following assumptions and limitations applied to the SD model:

- The causal relationships presented in the model were mostly supported by literature and my findings. However, in some instances the logical structure of the model was the main reason for some of the connections and links. In the causal model, all types of links were colour-coded as ‘supported by literature’, ‘supported by this research’ or ‘added due to logical structure’. As the SD model was based on the causal model, all these links were relevant in the SD model.
- The majority of variables in this model were difficult to quantify, and so I took an indexed approach. I assumed each variable was allowed to move in a band between upper and lower limits of 130 and 70, respectively, with a normal value of 100. I nominated the unit of measurement for all these variables as ‘unit’.
- Exogenous variables in the model were assumed to have initial values or trends based on the literature or on my findings. These data were neither precise nor based on collected data; rather, they were an approximation to show the impact of changing variable on system variables. We also used these variables for performing sensitivity analysis.
- I assumed that each reservoir (level) variable had an initial value of 100 and the rates of flow into and out the accumulators were impacted by an accumulated value at any given time.
- I used month as the time unit for this model and ran it over a period of 100 units of time.
- The model had limitations. The model was built as a tool for understanding major factors and their impacts on each other, and the final outcomes of the system over time. Findings of modelling and sensitivity analysis were used mainly to provide insight into different aspects of such a complex system and to help practitioners and managers understand the impacts of their policies and decisions over time. The numbers displayed in outputs and graphs were purely for the purpose of finding upward and downward trends, and gauging the severity of such changes. None of these figures have any real meaning in real life.

5.6.2 Model structure

The basic structure of all reservoir variables was assumed to follow the rules and equations represented in Figure 5.11 and the equations presented in the subsequent paragraph.

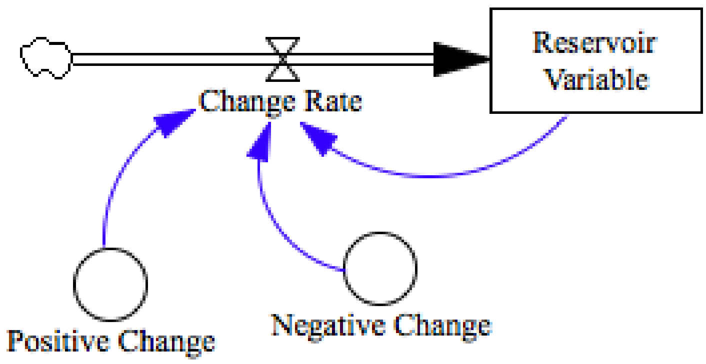

Figure 5.11 Basic reservoir structure

The value of Reservoir Variable at any given time (t) was equal to its value in a fraction of time earlier (t-dt) plus the change rate in dt. This was defined in the model with the following formulas:

*Reservoir Variable (t) = Reservoir Variable (t-dt) + (Change Rate)*dt*

*Where Change Rate = Reservoir Variable * (Positive Change + Negative Change)*

Reservoir Variable Initial Value = 100

Based on the above structure and the causal loop model, the elements of the SD model are shown in Figure 5.12. The equation follows the figure.

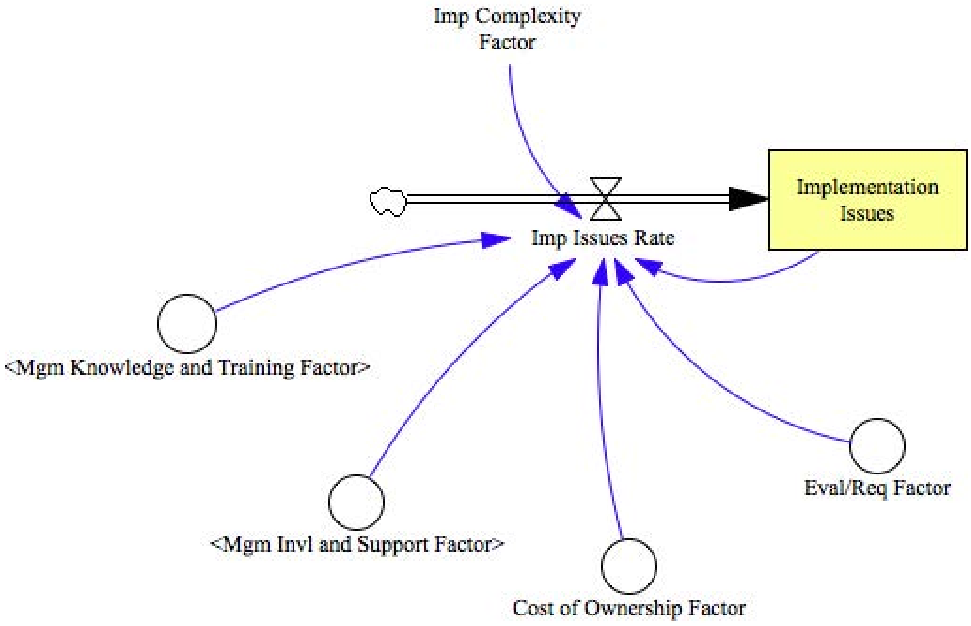

Figure 5.12 Implementation issues structure

Implementation Issues (dt)= Implementation Issues (t-td) + Implementation Issues(Cost of Ownership Factor-"Eval/Req Factor"+Imp Complexity Factor-Mgm Invl and Support Factor-Mgm Knowledge and Training Factor)*

Imp Complexity Factor was an exogenous variable used for testing the sensitivity of the system towards the complexity of the system. For the first simulation I used a constant value for this variable.

Other variables in this model translated reservoir variables values into factors that were used to calculate other variables in the model. Each of these was a function of the reservoir variable that they translated. I used that same logic to construct all the translation variables in this model. I assumed that all reservoir variables changed between the values 70 and 130, with 100 the equilibrium and initial value. Translating this range to factors that impacted on other variables in the model was based on a curve that was almost neutral around 95 to 105, and then slowly increased or decreased depending on the value of reservoir variable (Figure 5.13). In the model all factors were the same translation of reservoir variables.

The assigning of a range to variables could be against the normal practices in SD modelling, however this model is built as a tool to understand major factors, their interactions and behaviour over time. Findings of this model and sensitivity analysis are used mainly to provide insight into different aspects of such a complex system and to help practitioners and managers understand the impacts of their policies and decisions over time. The numbers displayed in outputs and graphs are purely for the purpose of finding upward and downward trends and gauging the severity of such changes.

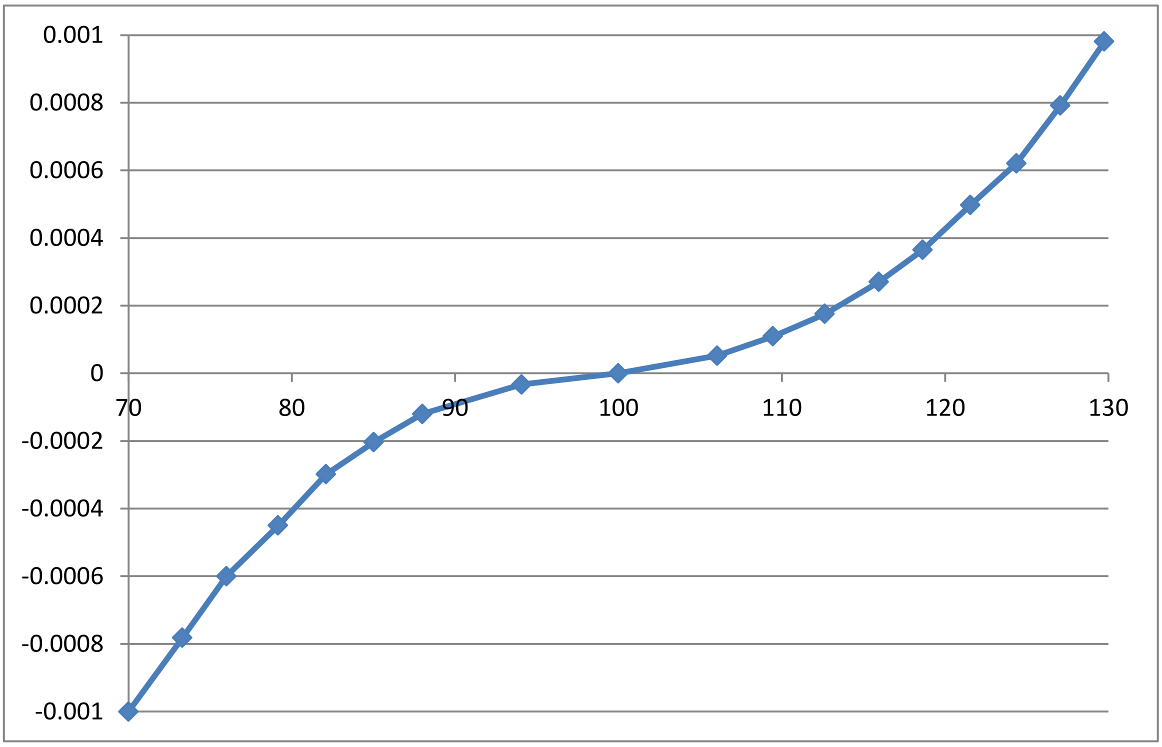

Figure 5.13 Cost of ownership factor

As indicated in the causal loop model, the cost of ownership was impacted by implementation cost, running cost, implementation issues and maintenance and upgrade. Figure 5.14 represents the reservoir variable cost of ownership.

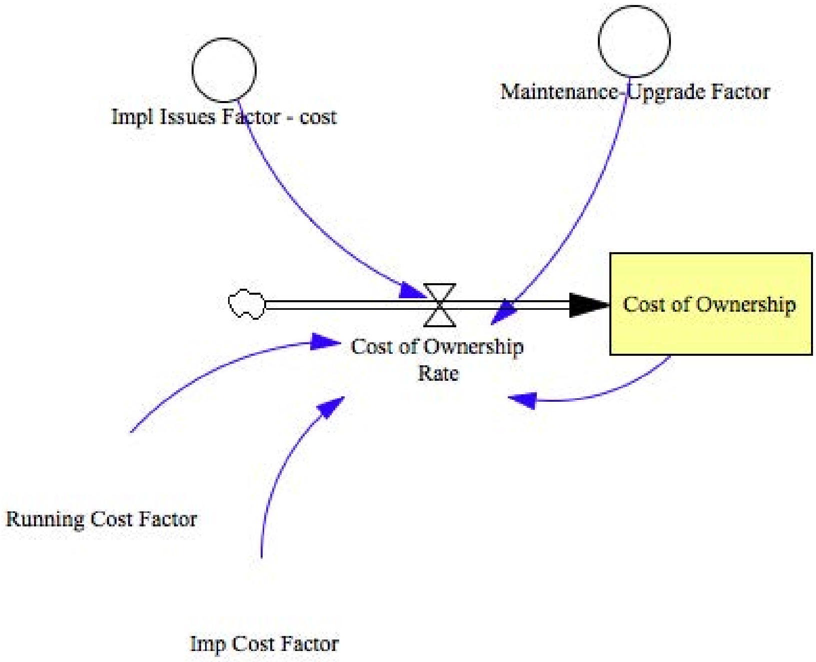

Figure 5.14 Cost of ownership level and rates diagram

Level of maturity as a reservoir variable was impacted by implementation issues, maintenance and upgrade, cost of ownership and years since implementation (Figure 5.15). All variables except "years since implementation" had a negative impact on level of maturity.

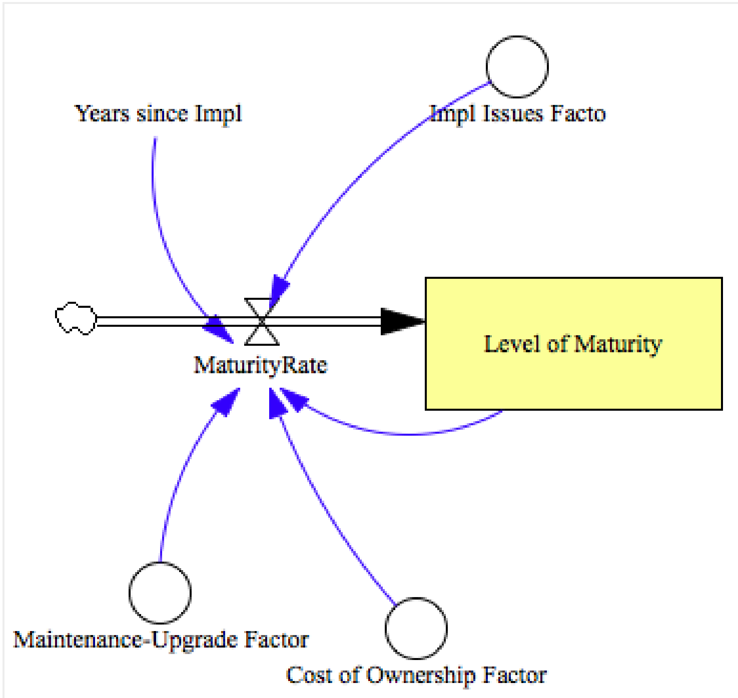

Figure 5.15 Level of maturity level and rates diagram

Good practices in evaluation and requisition was positively impacted by three exogenous variables: system match, stakeholders involvement and well-defined requirements (Figure 5.16). It was also positively impacted by the system variable “management involvement and support”.

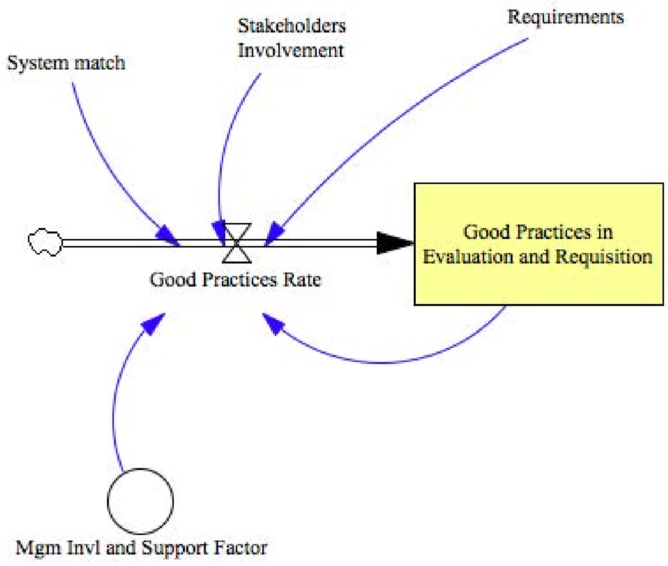

Figure 5.16 Good practices in evaluation and requisition level and rates diagram

Leveraging an ERP system beyond its transactional capabilities was impacted by two exogenous variables: complexity of the system, which has an important role in achieving, and exhibition of decision-making capabilities in the system (Figure 5.17).

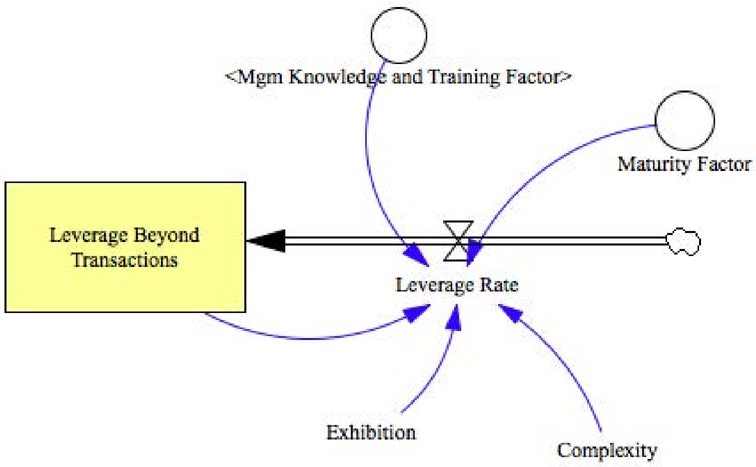

Figure 5.17 Leverage beyond transactions level and rates diagram

The variable "Maintenance, upgrade and changes" was highly impacted by environmental variables such as technological changes and advancements, and mergers and consolidations among vendor and adopter companies. These factors could force companies to change or upgrade their systems in order to stay with a technological trend or to change their enterprise systems to be in line with the rest of the company. Although these variables increased the reservoir variable, two internal variables in the model decreased its value (Figure 5.18).

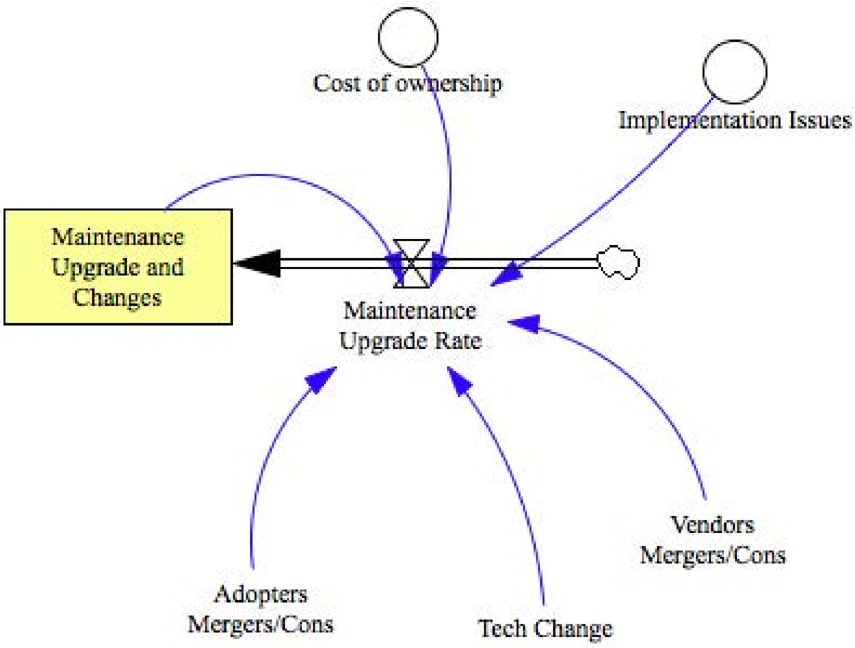

Figure 5.18 Maintenance, upgrade and changes level and rates diagram

Management and executives' involvement in ERP implementation and their support was another reservoir or level variable which was affected mainly by indigenous variables. Evidently management knowledge and their training have a positive impact, and any implementation problems could reduce the support that is vital for the success of adaptation process. At the same time, depending on the success or failure of the project, management perception could have either a negative or a positive impact on this variable (Figure 5.19).

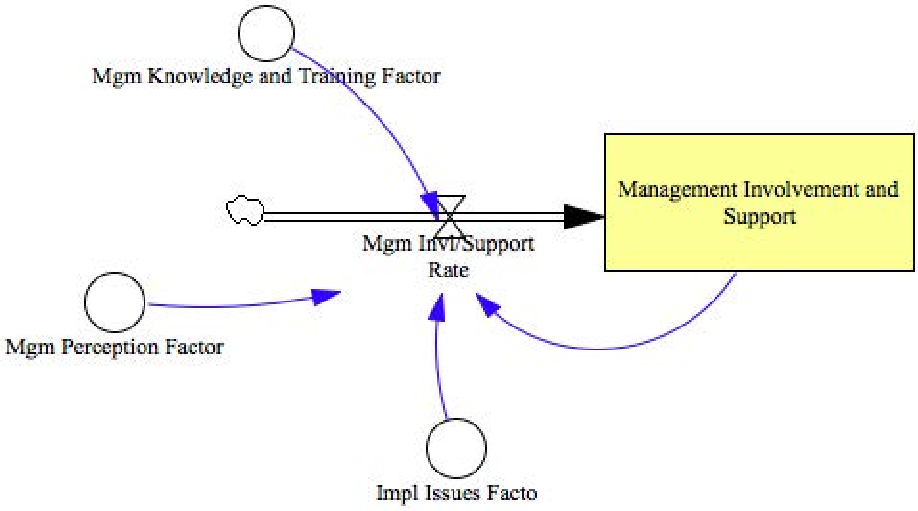

Figure 5.19 Management involvement and support level and rates diagram

Management knowledge and training was also impacted by variables indigenous to this model: cost and their perception could have a negative or positive impact on the level of training management and executive team receives (Figure 5.20).

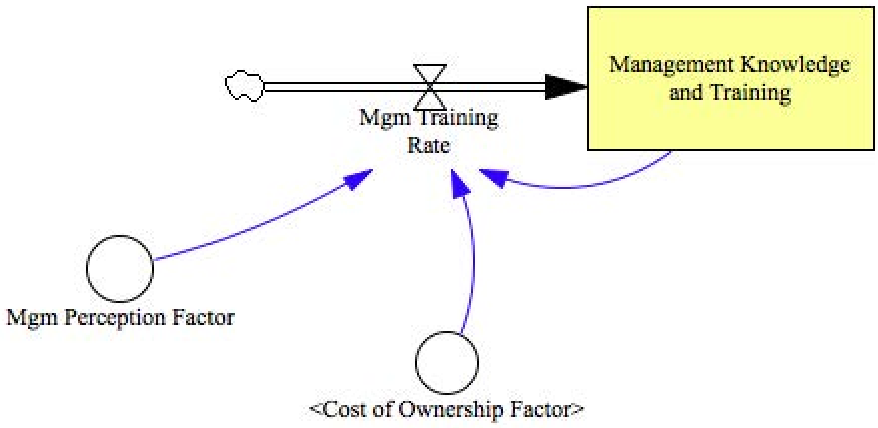

Figure 5.20 Management knowledge and training level and rates diagram

Management perception towards enterprise systems plays an important role in their involvement and support for the success and utilisation of such systems for more strategic benefits. This perception is usually based on the success of the project's implementation, the cost of ownership and the maturity level the organisation has achieved during the adaptation process (Figure 5.21).

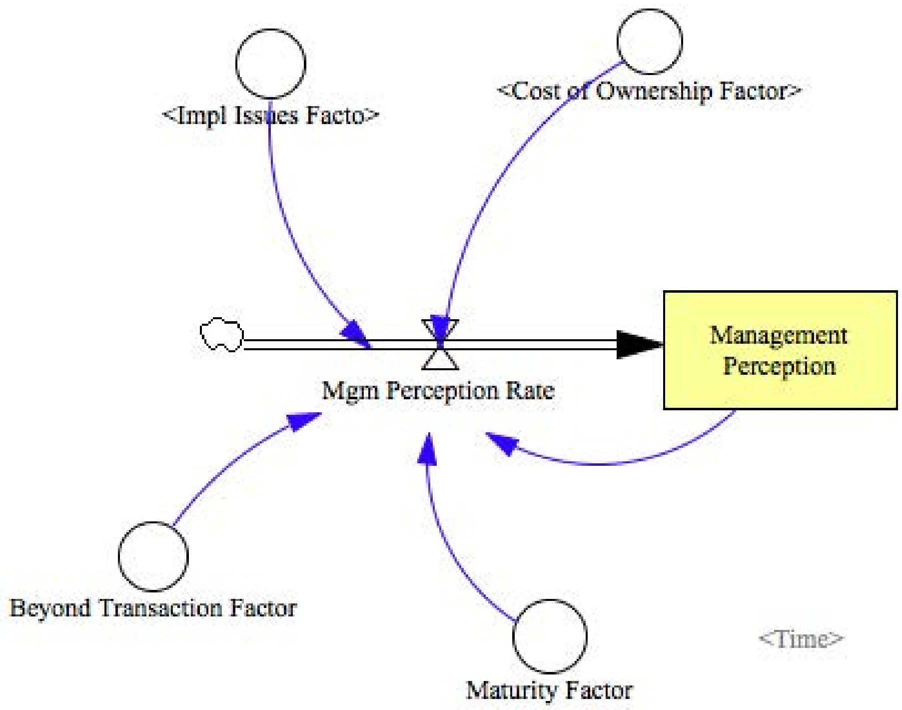

Figure 5.21 Management perception level and rates diagram

Putting all these variables together provides a picture of the model with all its variables and links. This model is presented in Figure 5.22. Exogenous variables are coloured orange and reservoir or level variables are yellow.

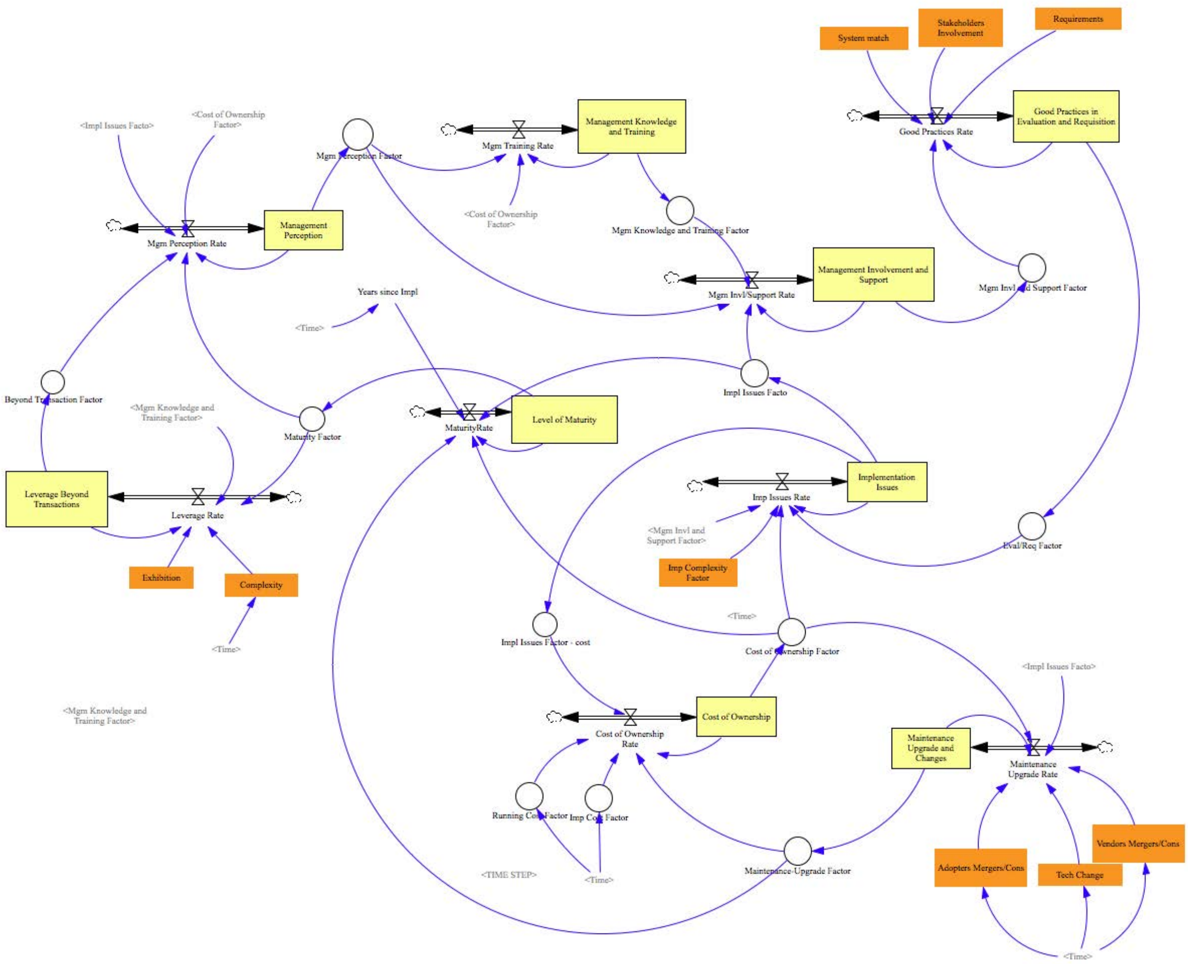

Figure 5.22 Integrated level and rates diagram

5.6.3 Reference mode

The first step of experimenting with the constructed model was to define the problem this model represents. This problem definition in SD terminology is called the reference mode. The reference mode may contain actual variables from collected data and abstract variables representing qualitative information. In the reference mode I assumed that exogenous variables “technology changes”, “vendors’ merger and consolidation” and “adopter merger and consolidation” followed an upward trend, represented in Figure 5.23. This trend was not based on any historical quantitative data and purely represented past experience and expected trends. In the reference mode I could not make similar assumptions for other exogenous variables because all could have different values based on system adopters and environmental circumstances. Therefore I left the other six exogenous variables as 0, and discuss their impacts in the sensitivity analysis section below.

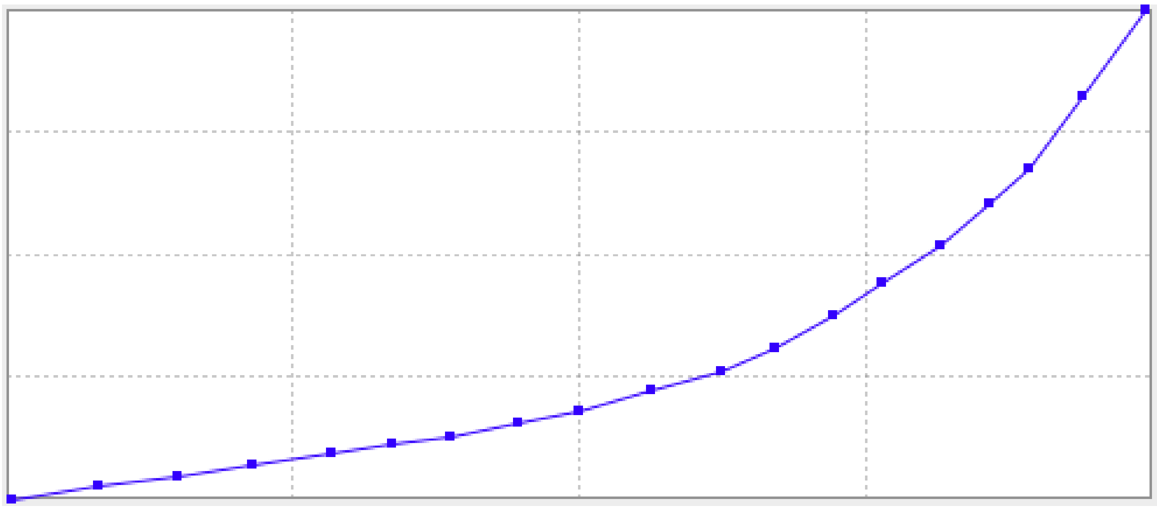

Figure 5.23 Exogenous variables (technology changes, merger and consolidation) over time

Another two exogenous variables with initial inputs for the reference mode were "implementation cost factor" and "running cost factor". Implementation cost factor represented the initial cost of adopting the system, which reached a maximum in the first few years and gradually reduced to 0. This is represented in Figure 5.24. This trend was not based on any historical quantitative data and purely represented past experience and expected trends.

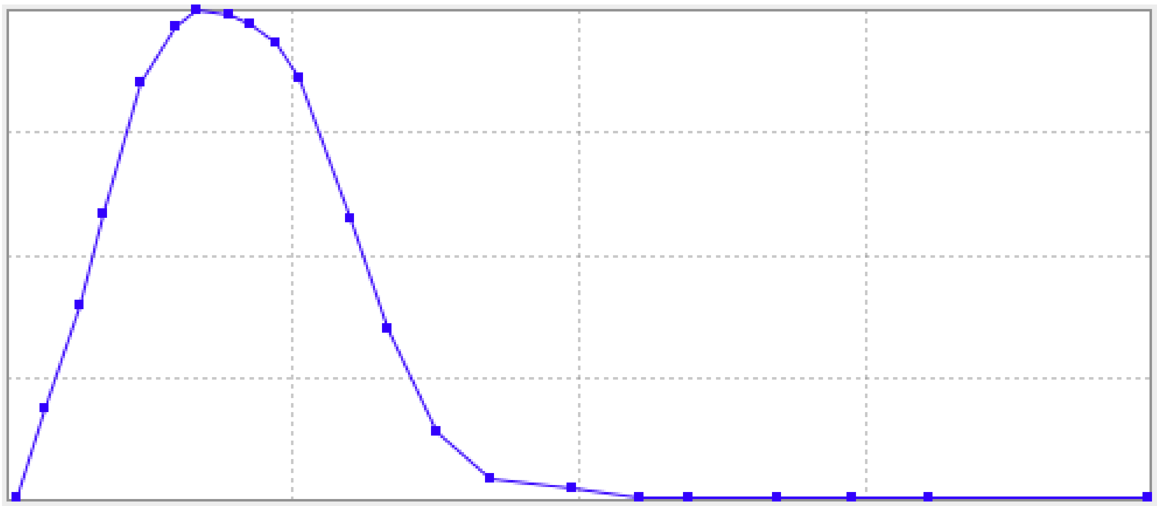

Figure 5.24 Exogenous variables (implementation cost) over time

Running cost factor represented the ongoing cost of adapting the system. This cost could go up the first few years and then stabilised for the rest of system's life (Figure 5.25). Once again this trend was not based on any historical quantitative data, but represented past experience and expected trends.

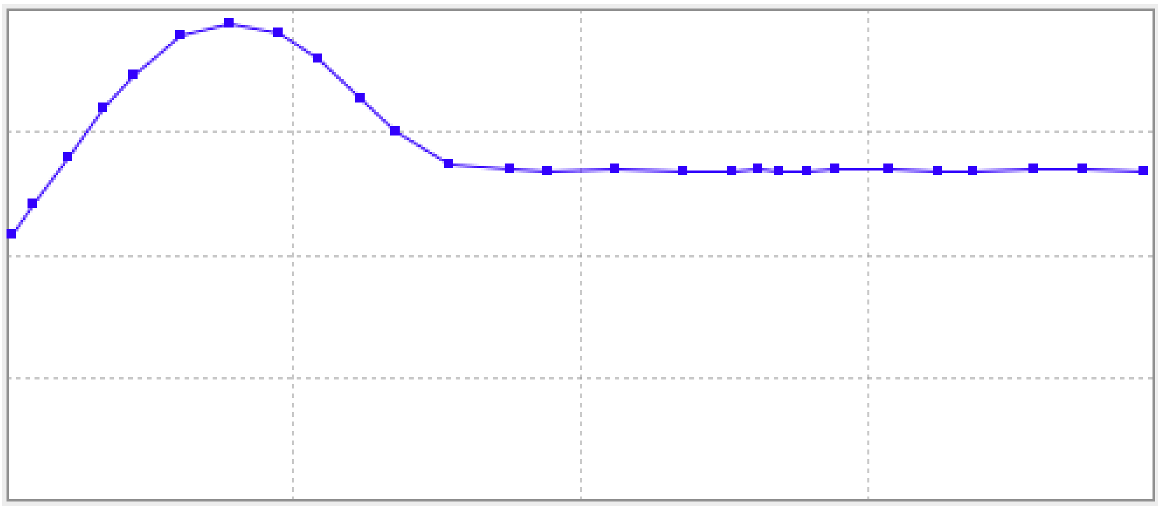

Figure 5.25 Exogenous variables (running cost) over time

As explained above, I left the value of the remaining exogenous variables (Table 5.1) as 0 (meaning no real impact) because these variables were highly circumstantial and the best way to simulate their impacts on the model was through sensitivity analysis.

Variable	***Description***
Imp complexity factor	Implementation complexity factor
System match	Degree of compatibility between acquired system and organisation operations and structure
Stakeholders' involvement	Stakeholders' involvement in evaluation and requisition
Requirements	Well-defined requirements in evaluation and requisition
Exhibition	Exhibition of decision support features and capabilities
Complexity	Complexity factor in leveraging the system beyond its transactional capabilities

Table 5.1 List of exogenous variables with no impacts in the reference mode simulation

(i) Simulating reference mode

I ran the model for 100 months in the reference mode, with exogenous variables values as described in this section. Most variables behaved as per expectations, verifying that the model structure had no major defect and could be used to analyse the impact of other variables as they were added individually into the simulations. Figures 5.26–5.41 show the system outputs for the reference mode.

Cost of evaluation, acquisition and implementation initially increased rapidly in the first few years and then dropped to a level of ongoing cost. This started to increase from period 50 again as more system change, maintenance and upgrade was required due to the age of the system. Figure 5.26 shows the cost of ownership rate and Figure 5.27 shows the accumulated cost of ownership as a level variable.

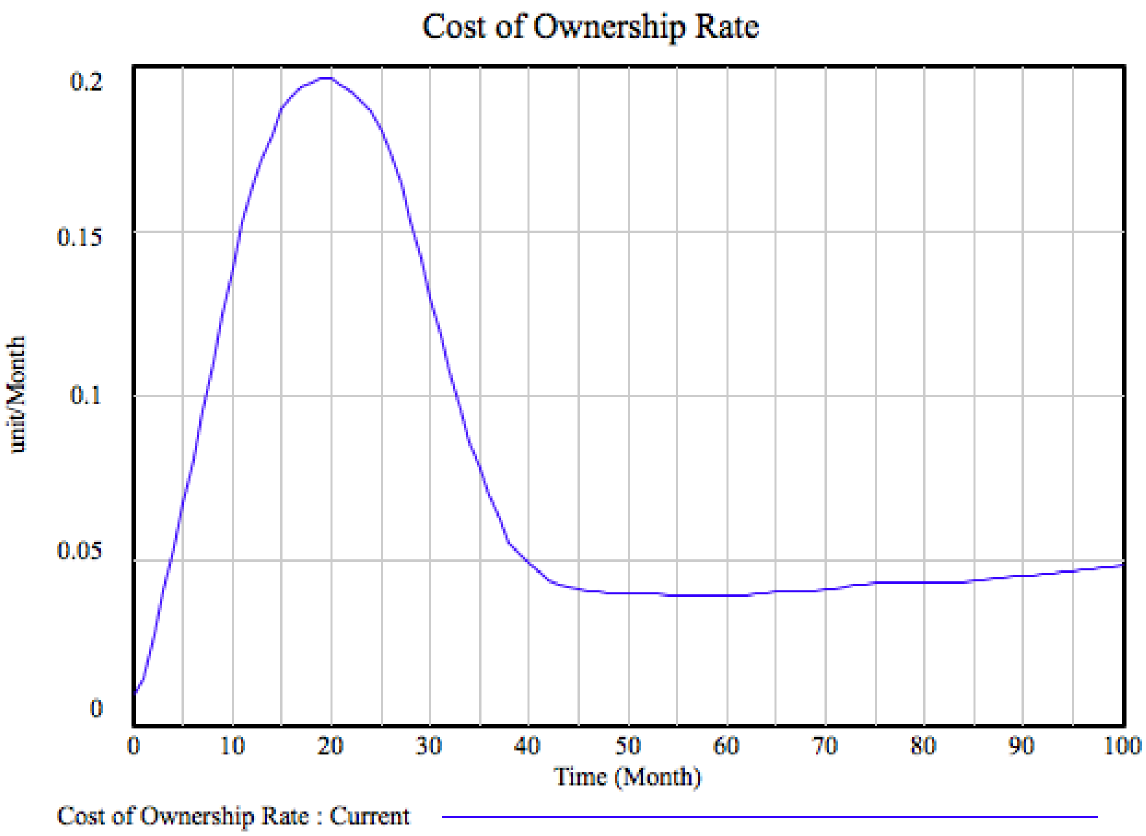

Figure 5.26 Cost of ownership rate

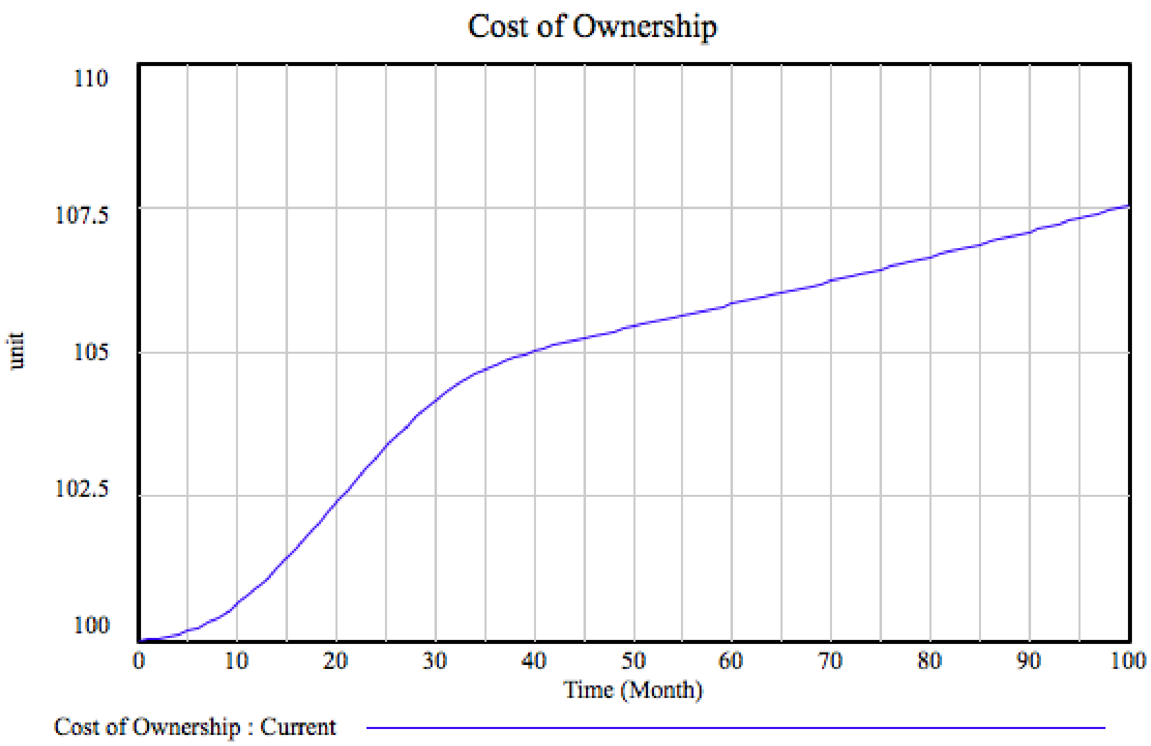

Figure 5.27 Cost of ownership level variable

Increasing cost of maintenance and upgrade level variable was a result of an increase in three exogenous variables: “technology changes”, “vendors’ merger and consolidation” and “adopter merger and consolidation” (figures 5.28–5.29). The impact of increasing cost of maintenance, upgrade and change, along with the cost of ownership initially caused implementation issues to increase exponentially (figures 5.30–5.31), which in turn had a negative impacts on maturity (figures 5.32–5.33). This in turn caused a decline in management perception, management support, management knowledge and training, and eventually led to less chance of leveraging the system beyond its transactional capabilities (figures 5.34–5.41).

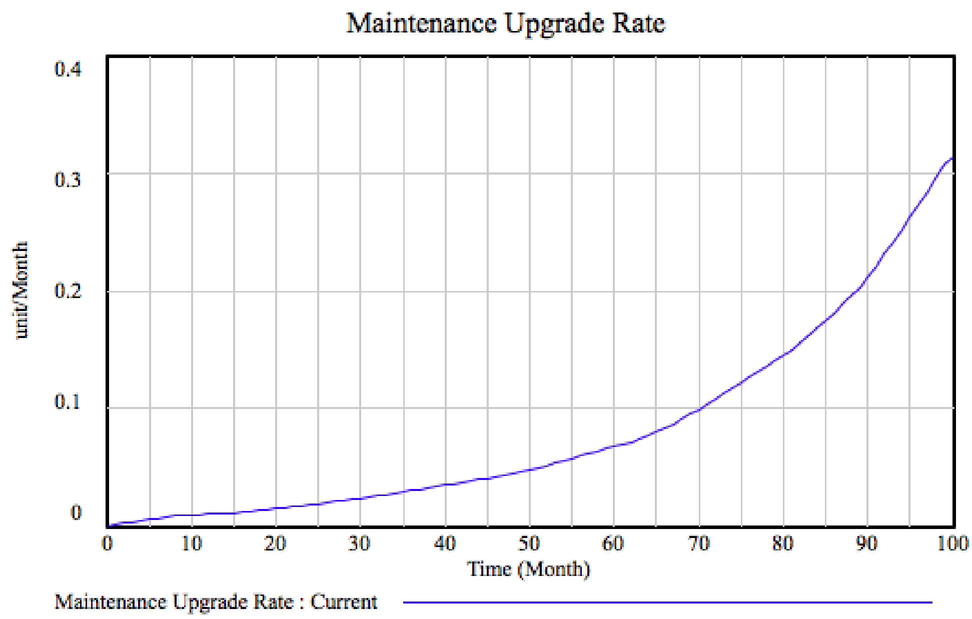

Figure 5.28 Maintenance upgrade rate

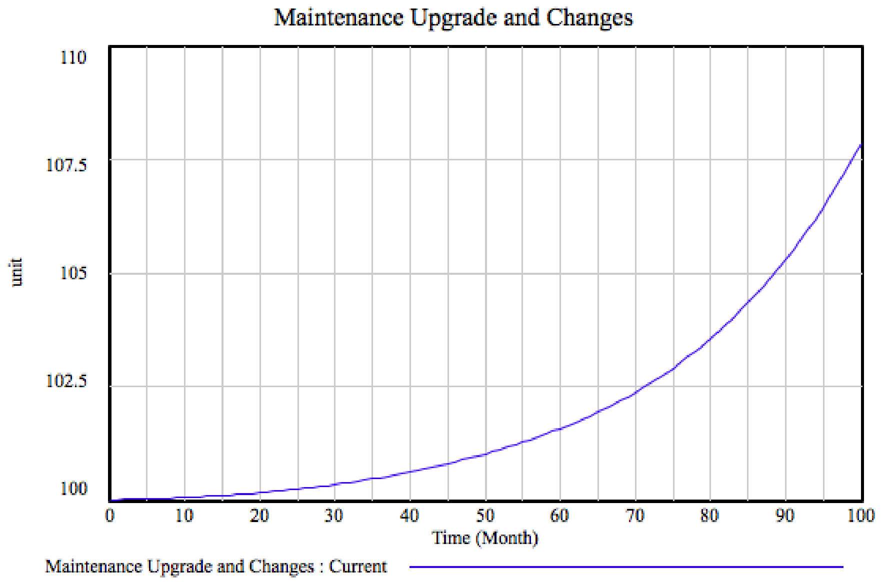

Figure 5.29 Maintenance upgrade and changes level variable

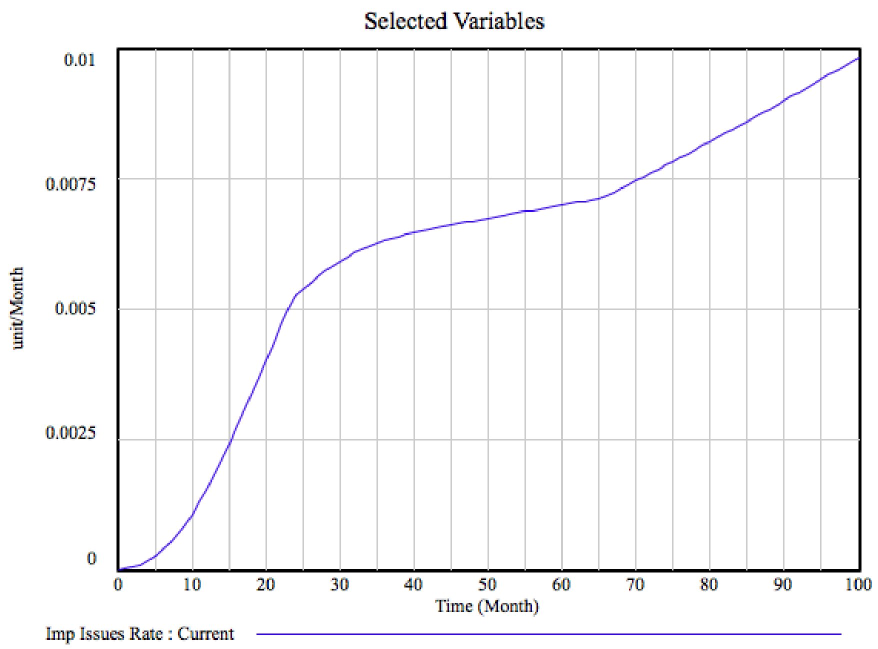

Figure 5.30 Implementation issues rate

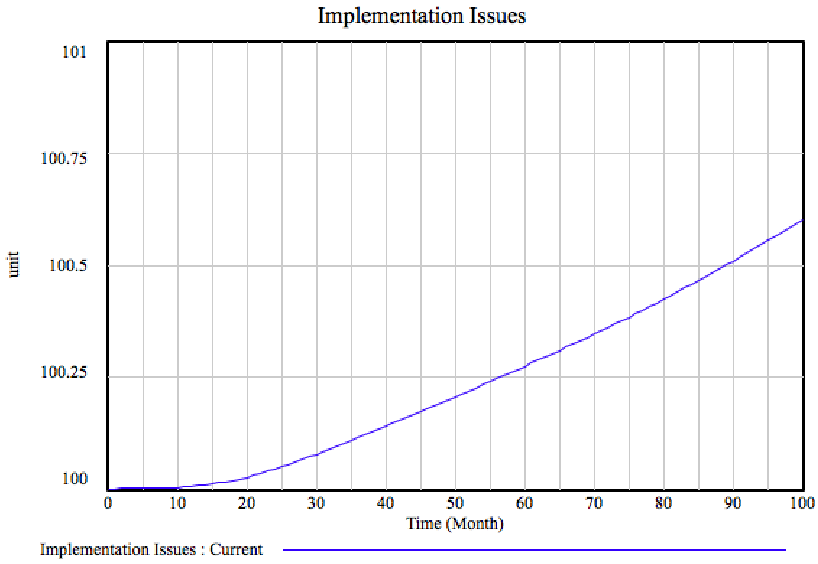

Figure 5.31 Implementation issues level variable

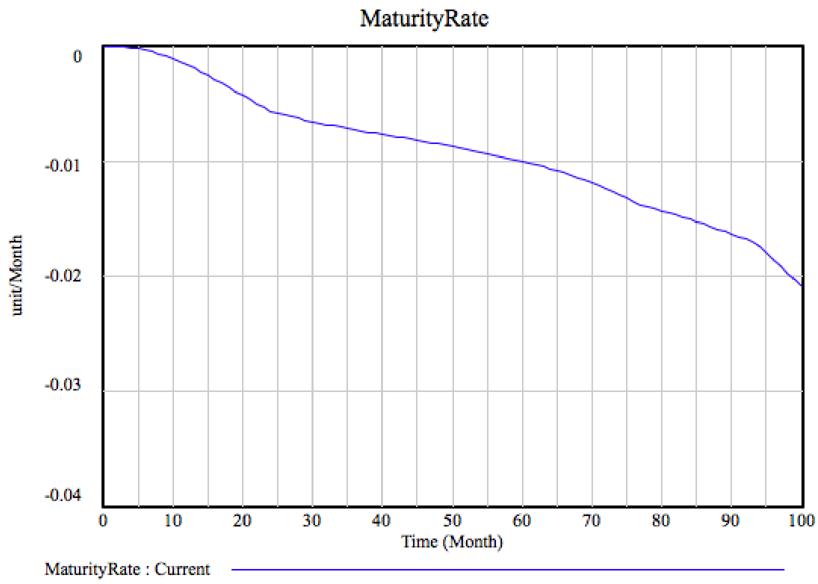

Figure 5.32 Maturity rate

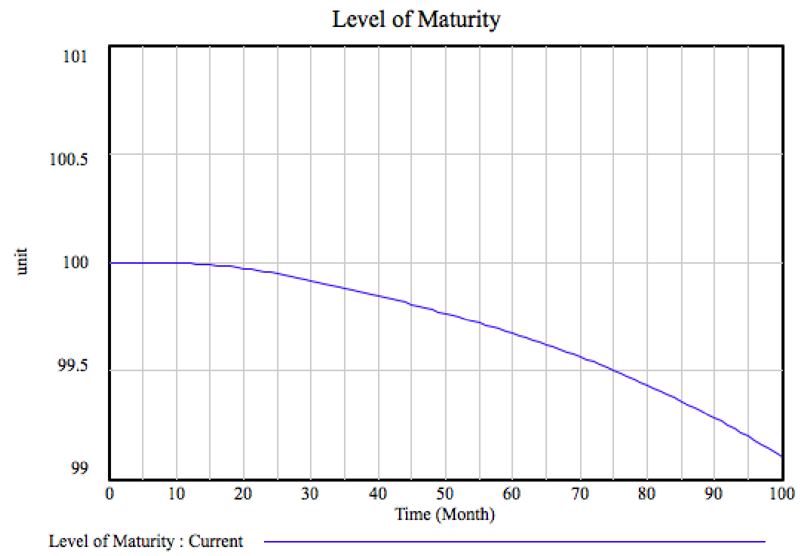

Figure 5.33 Maturity level variable

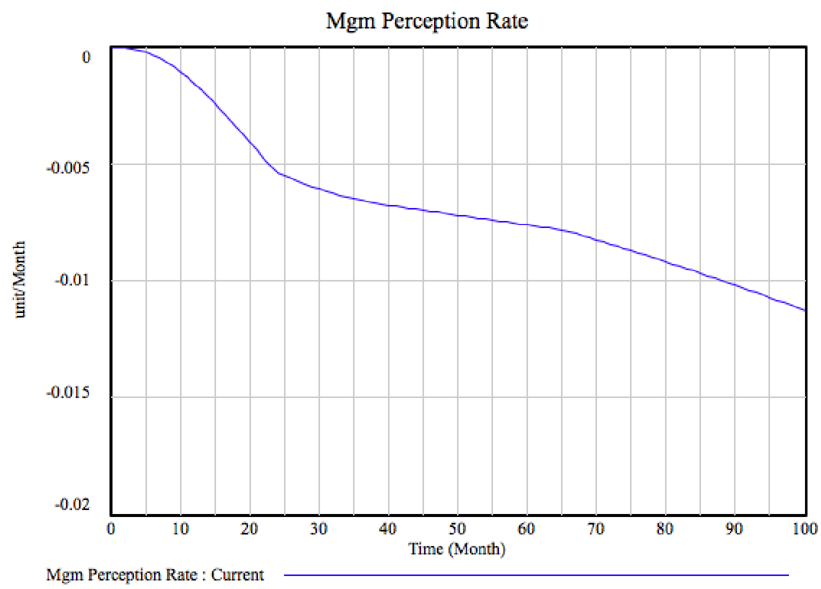

Figure 5.34 Management perception rate

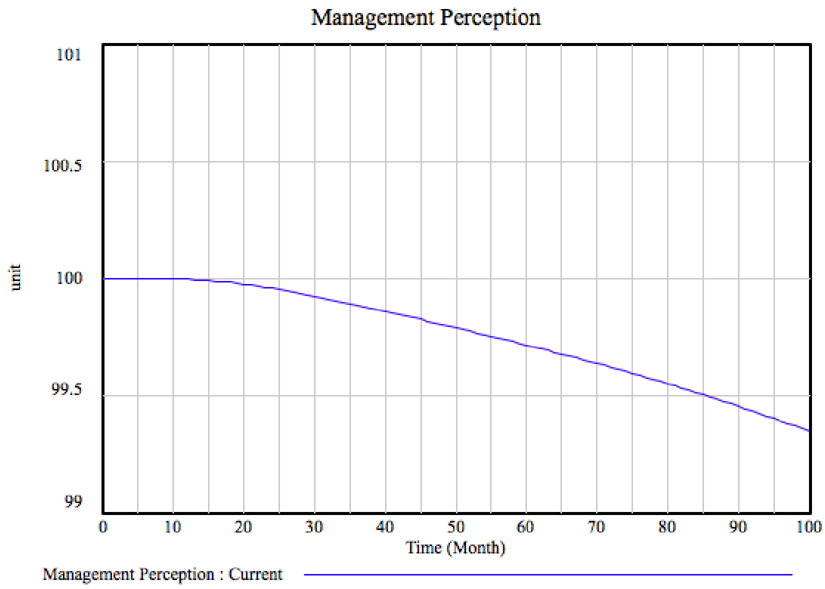

Figure 5.35 Management perception level variable

Figure 5.36 Management training rate

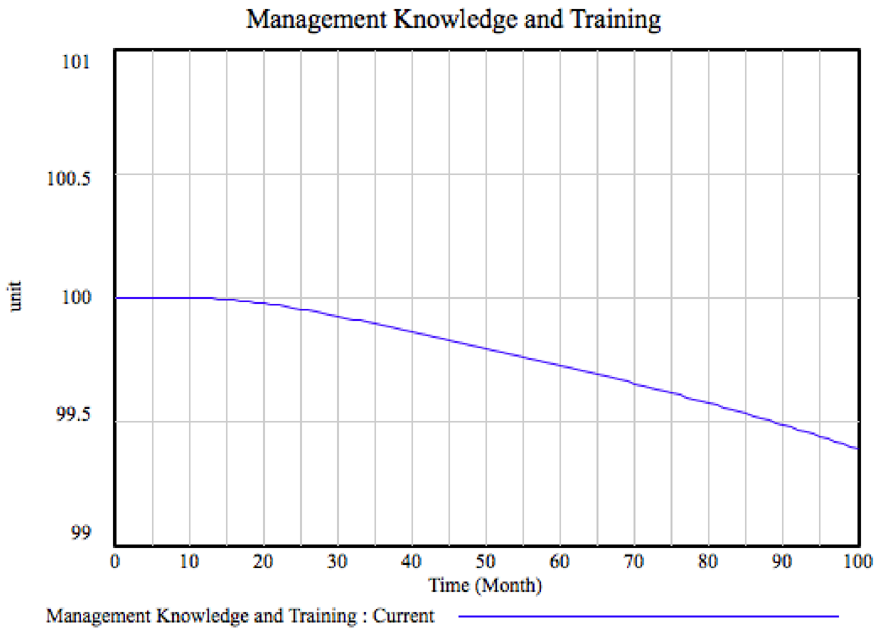

Figure 5.37 Management knowledge level variable

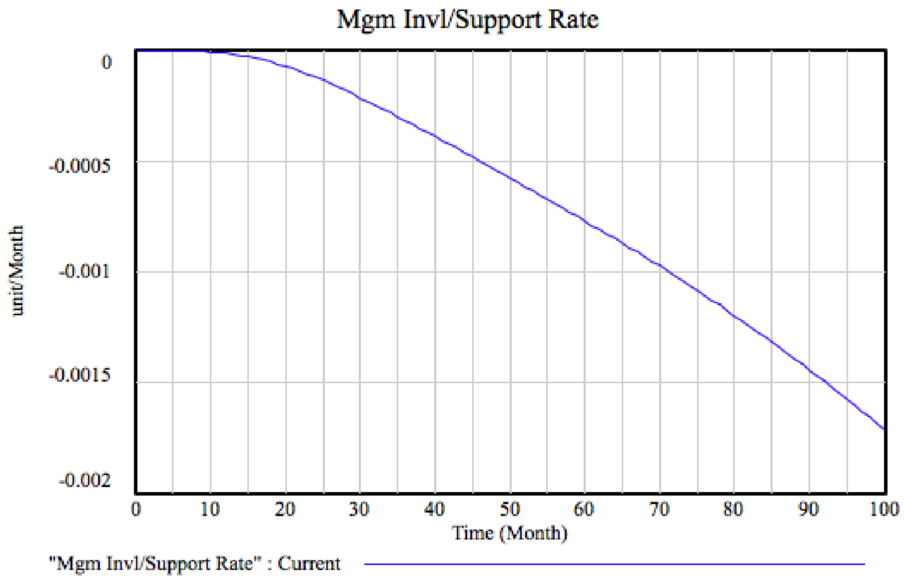

Figure 5.38 Management involvement and support rate

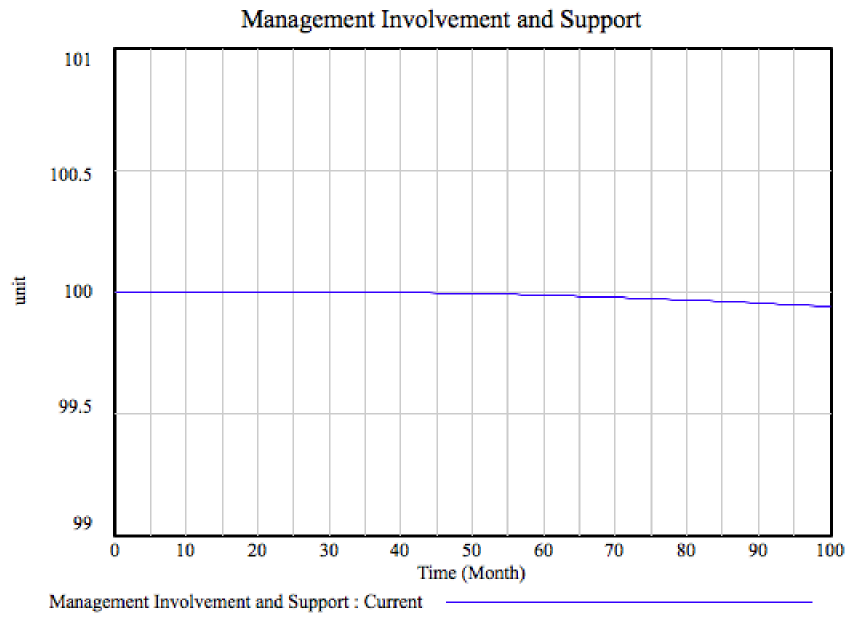

Figure 5.39 Management involvement and support level variable

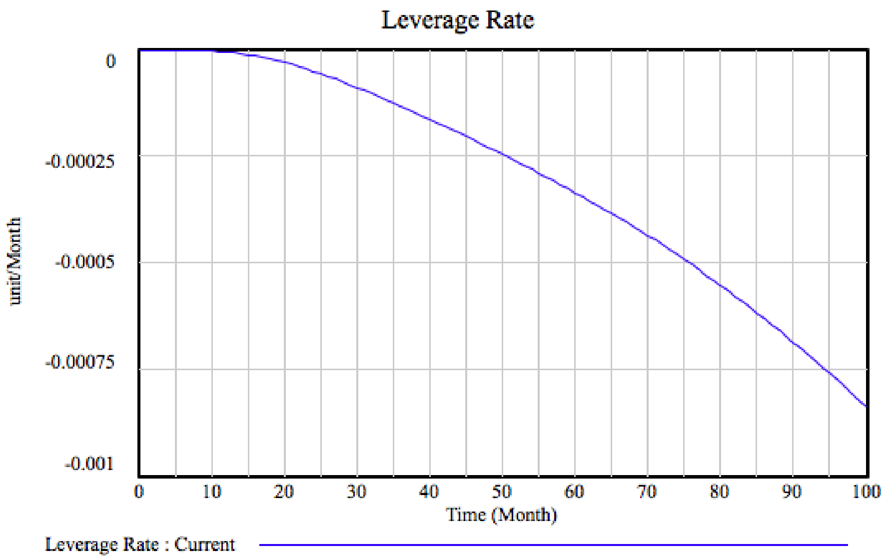

Figure 5.40 Leverage beyond transactional capabilities rate

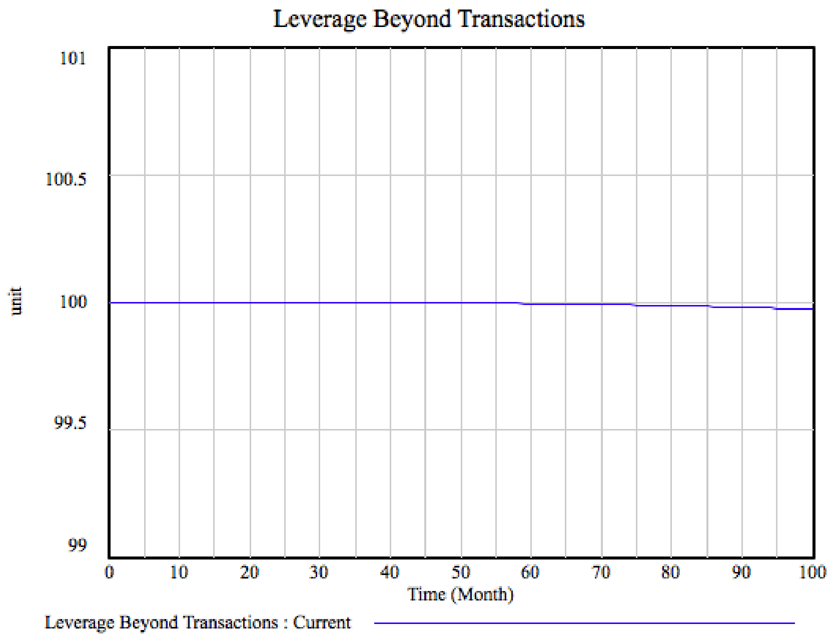

Figure 5.41 Leverage beyond transactional capabilities level variable

5.6.4 Scenarios

The reference mode presented in the previous section provided a realistic result based on the findings in the early part of the research. Using the SD model I tried to run different scenarios in which I changed this situation based on different values/trends given to variables. I considered the reference mode as a non-ideal situation, although it more or less represented what I had found in the qualitative and quantitative data analysis.

This section describes two simulated scenarios, which I called "ideal" and "promising". The ideal scenario presented a situation where all variables were moving in the right direction, system implementation was done with reasonable cost and effort, and it had matured by the time its strategic benefits, such as helping management to make better decisions, were realised. In the promising scenario I tried to improve the reference mode so that it more closely represented the current situation, with realistic and reasonable strategies. This scenario should be the one to be used for practical improvements in real-life implementation.

(i) Ideal scenario

In the ideal scenario it was assumed that all exogenous variables were in a favourable condition. This means the organisation had good evaluation and requisition processes, with well-defined requirements and adequate involvement from all stakeholders. In this situation, there was a good degree of match between the organisation's operations and selected tools. These good practices in evaluation and requisition, along with less complex implementation and use of the system beyond its transactional capabilities, and adequate decision support capabilities and features, meant that most of the variables in the model moved in the right direction.

Exogenous variables values for the ideal scenario are displayed in Table 5.2. I left three exogenous variables defining maintenance and upgrade the same as reference mode (see Figure 5.22).

Exogenous Variable	Value
System match	0.05
Stakeholder involvement	0.05
Requirements	0.05
Imp complexity factor	-0.025
Leverage beyond transaction - complexity factor	0
Exhibition	0.025

Table 5.2 Exogenous variables in ideal scenario

Implementation and never-ending problems during the system's life were one of the major obstacles for a successful implementation. Complexity had a major influence on this variable's behaviour. By reducing the complexity factor in the ideal model, implementation issues gradually decreased, indicating a healthy implementation. Figure

5.42 shows the changed behaviour of this variable (ideal: red) compared with the reference mode (current: blue).

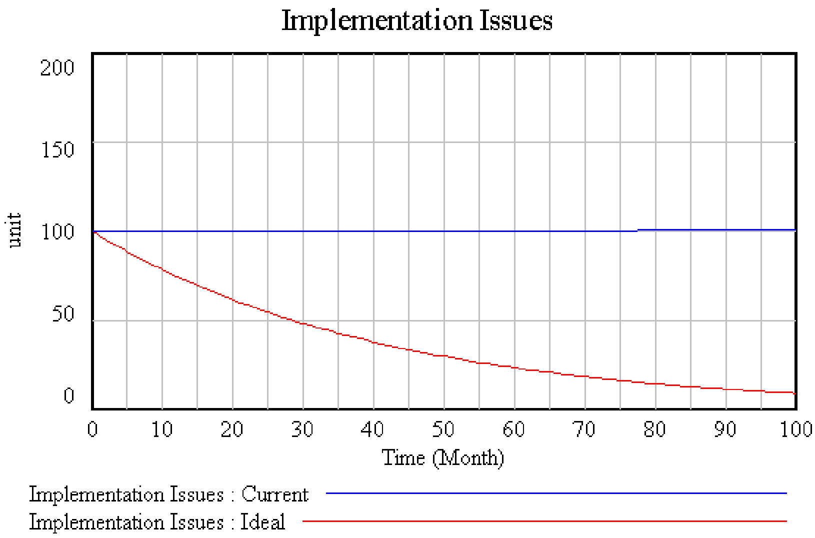

Figure 5.42 Implementation issues in current and ideal scenarios

Cost of ownership: Decreasing implementation issues over time had a positive impact on the cost of ownership, in both implementation and support. As shown in figures 5.43 and 5.44, implementation project cost increased with a more reasonable slope in the first three years of implementation and, after reaching a peak, started to decline at a constant rate, which indicated less cost during the upgrade and maintenance phases.

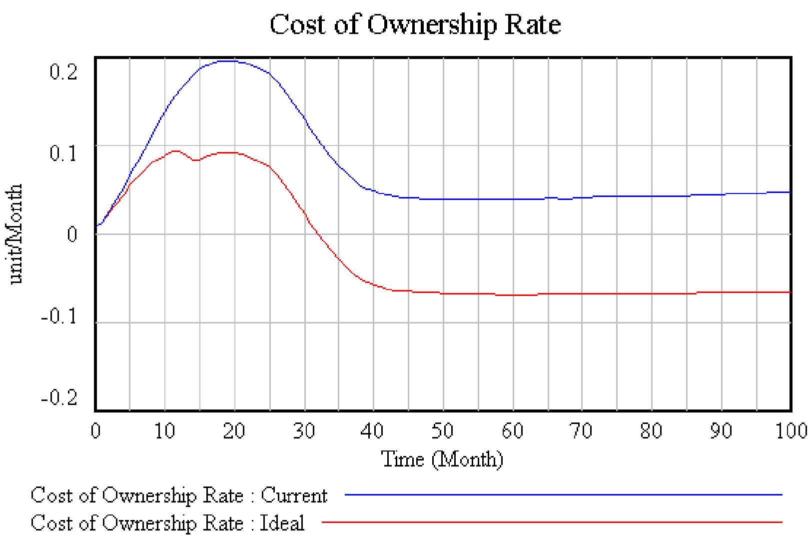

Figure 5.43 Cost of ownership rate in current and ideal scenarios

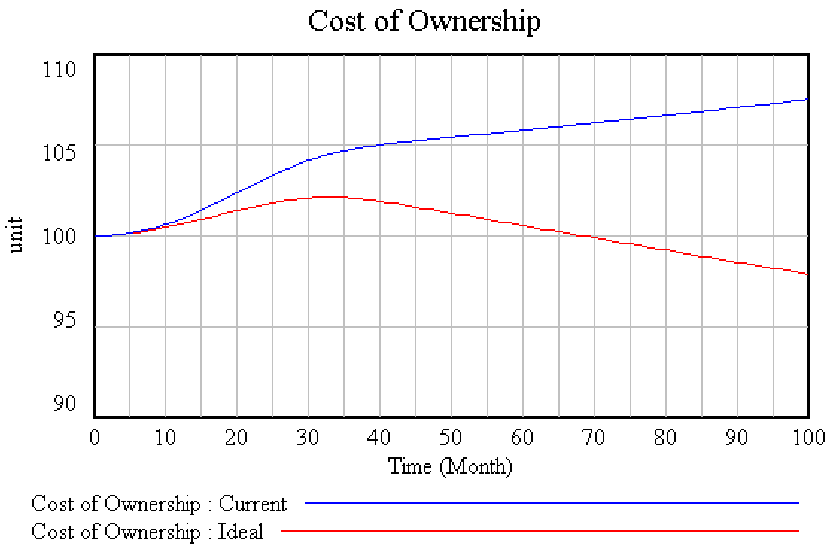

Figure 5.44 Cost of ownership in current and ideal scenarios

Maintenance, upgrade and changes: Three exogenous variables impacting the behaviour of this variable were not changed compared with the reference mode. However, because of the decreased complexity factor impacting the implementation and cost of ownership, this variable also behaved differently. As shown in Figure 5.45, the impact of decreasing implementation issues and also less increase in the cost of ownership rate caused this variable to decrease during the first three years (red), compared with the reference mode (blue), which had a constant increase from the first day. This means that less problematic implementation and hence a more successful project did not require much change and upgrade during the implementation phase, and maintenance and upgrade started to increase at a much lower rate only after implementation. This rate change is reflected in the behaviour of the variable in Figures 5.45 and 5.46.

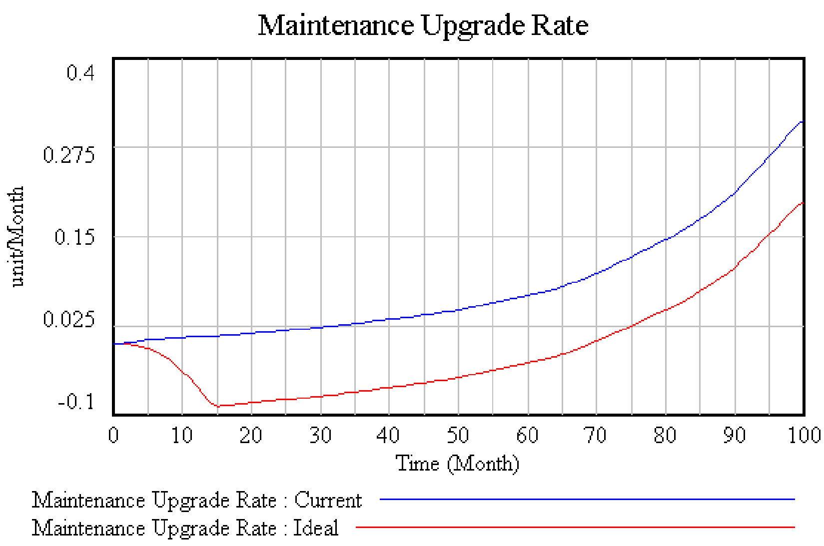

Figure 5.45 Maintenance upgrade rate in current and ideal scenarios

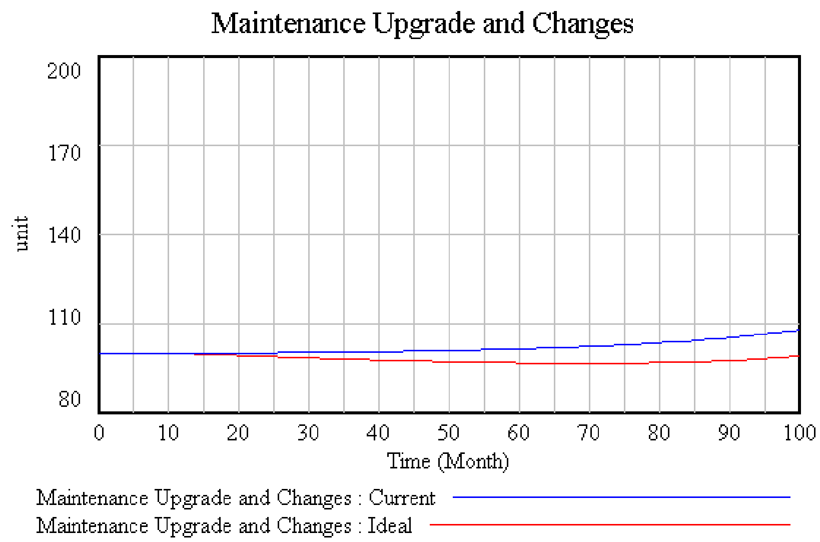

Figure 5.46 Maintenance upgrade in current and ideal scenarios

Maturity: Implementation costs of ownership and maintenance/upgrade were the main three variables impacting the behaviour of the maturity variable. Changes in these three variables caused the maturity rate to behave in a totally different direction compared with the reference mode (Figure 5.47). The maturity rate increased exponentially during the first three years of the implementation phase and then its steady increase afterwards caused the maturity level to increase during the life of the system at a steady rate (Figure 5.48). This was a significant difference between the behaviour of the model in reference mode (blue) and this scenario (red).

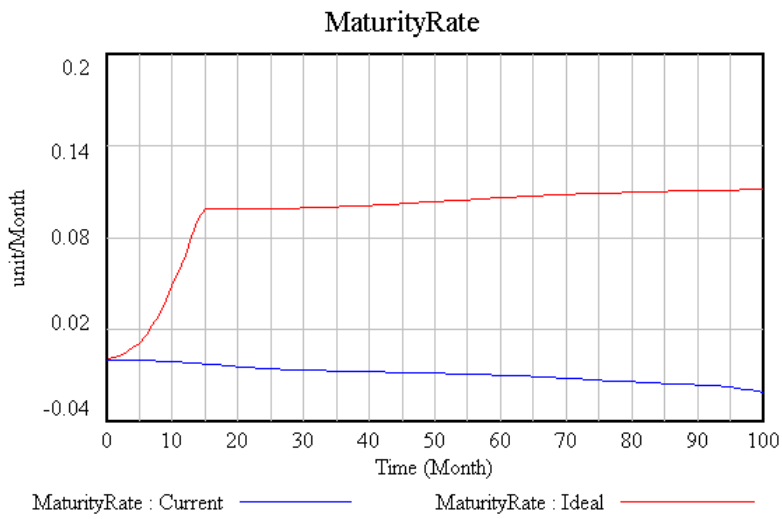

Figure 5.47 Maturity rate in current and ideal scenarios

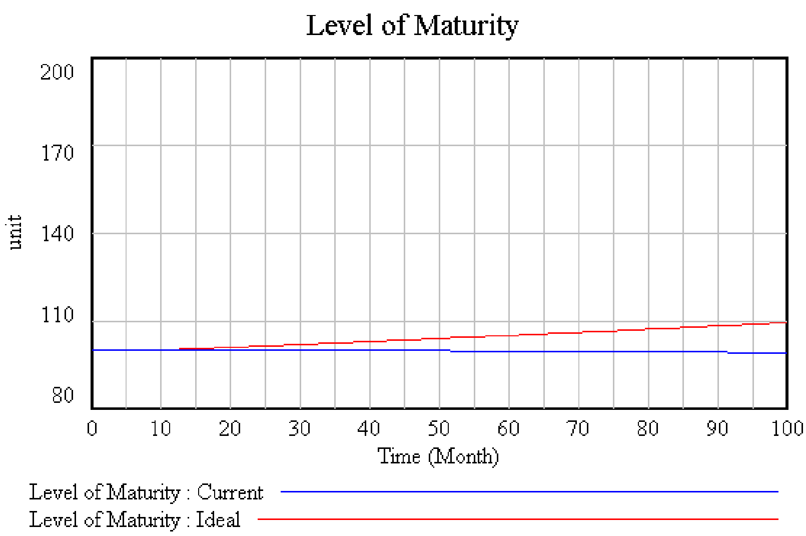

Figure 5.48 Maturity in current and ideal scenarios

Leverage beyond transactions: A steady increase in organisational maturity following adaptation with an ERP system could positively influence the use of these systems for decision making and more strategic benefits beyond their transactional capabilities. However, in the ideal mode this positive impact turned into an exponential increase because of the changes to the exogenous variables; in the ideal run I increased the value of exhibition and decreased the complexity. As a result both leverage rate and level variables had a significant exponential increase. This means that in the ideal mode the organisation is gaining valuable experience from its system adaptation and has ever fewer implementation problems. This is in line with a system that exhibits features and capabilities for decision making which, together with a healthy cost of ownership, facilitate the exponential growth visible in figures 5.49 and 5.50.

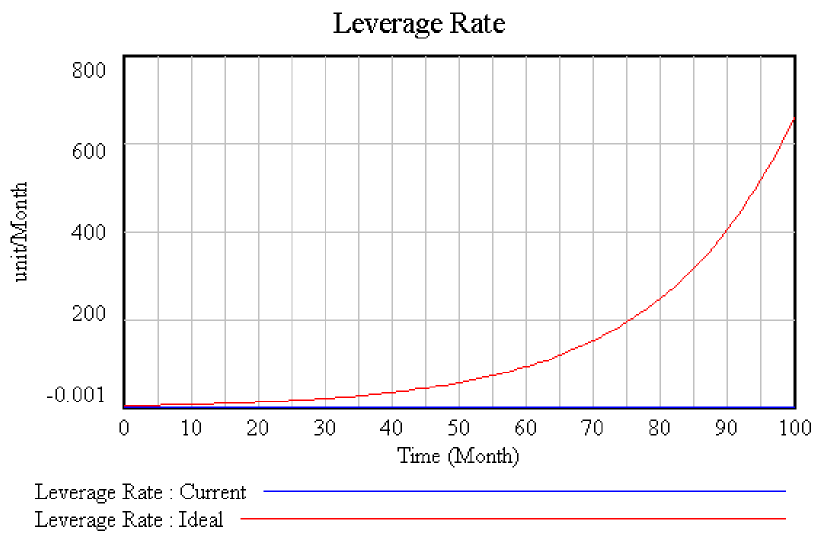

Figure 5.49 Leverage beyond transaction rate in current and ideal scenarios

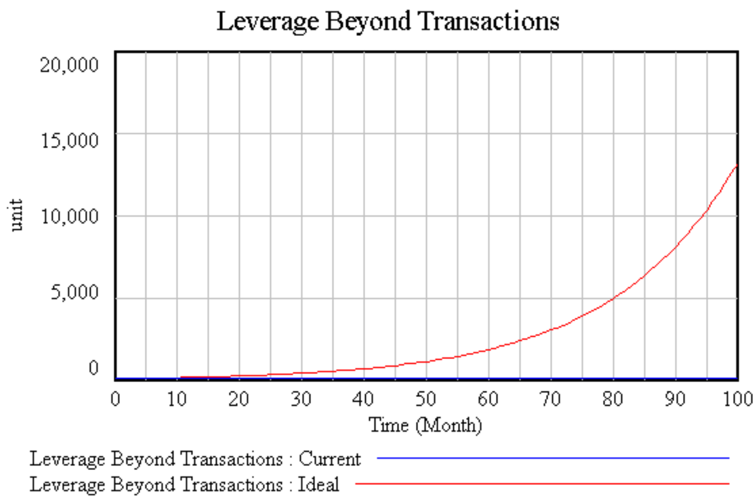

Figure 5.50 Leverage beyond transaction in current and ideal scenarios

Management behaviour: As a result of the ideal situation in the implementation project, the cost of ownership, maturity and system utilisation, and positive management perception towards ERP system increased sharply, which led to the management increasing their involvement and support for the ERP implementation project. These positive movements, combined with less budgetary pressure, caused a sharp increase in management training and knowledge (Figure 5.51). All of these positive movements eventually feed back to the system, causing further positive behaviour.

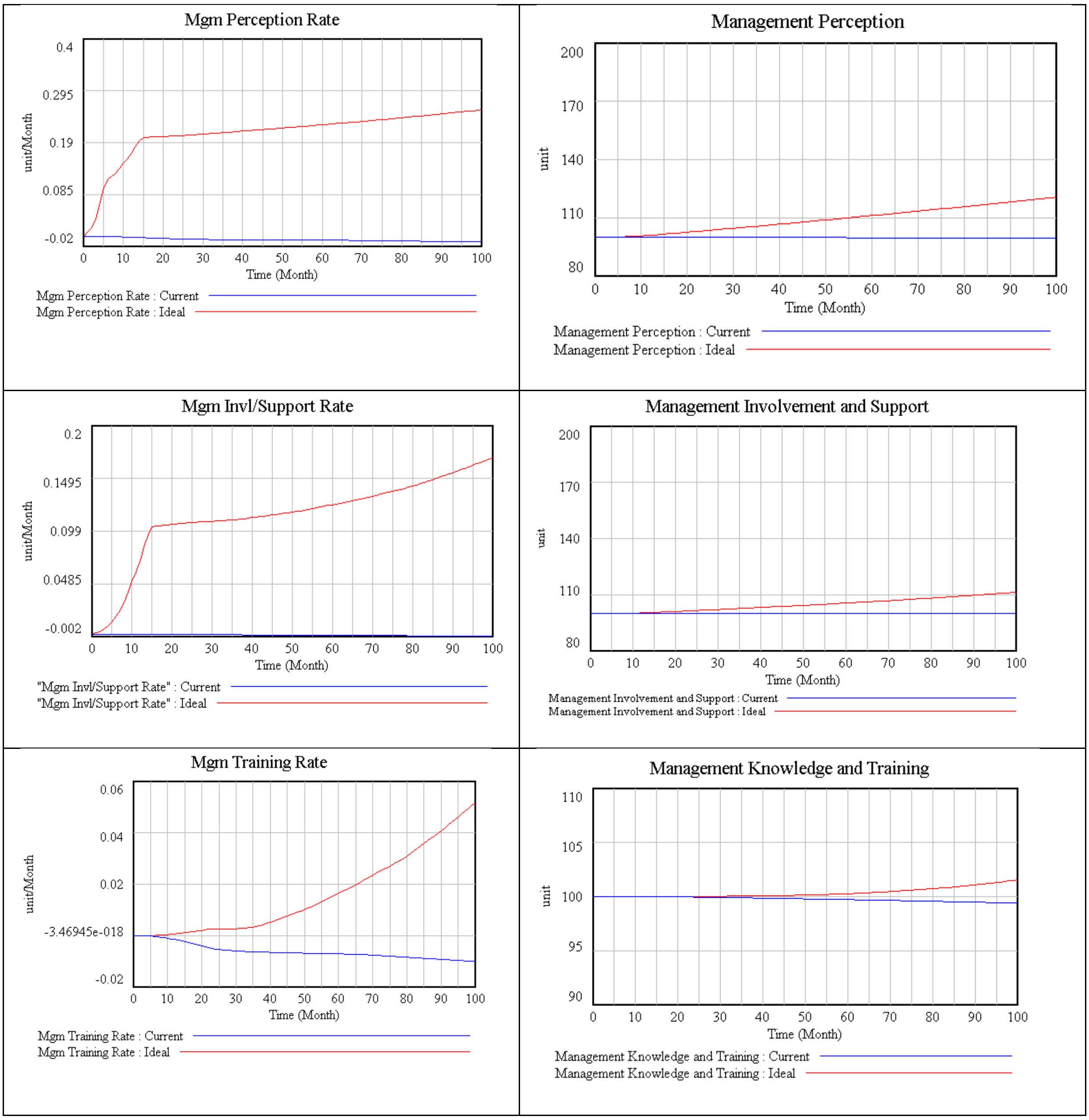

Figure 5.51 Management variables in current and ideal scenarios

(ii) Realistic scenario

In the ideal scenario it was assumed that most of the exogenous variables were favourable. However, in real situations it is almost impossible to have all variables in a favourable condition. To define a more realistic scenario and in order to find a combination of values that produces acceptable results, I used the SyntheSim tool, part of the Vensim simulation software, which is a way to simulate models with considerable interactivity. This interactive tool indicated model sensitivity towards different variables, and showed the impacts of variables on each other and on system outputs.

In this analysis I tried to limit the impacts of adopters and vendors merger/consolidation and technology advancements by formulating a policy preventing continuous escalation of maintenance and upgrade. In this way I could achieve a reasonable level of success with a realistic approach towards exogenous variables values (Table 5.3). In other words, I assumed there was no high level of system match, stakeholders' involvement and proper processes in defining and analysing the requirements. At the same time, both implementation and leveraging beyond transactions were moderately complex, and the system exhibited little in the way of tools and capabilities to facilitate the decision-making process. This situation is similar to the current situation in many organisation investigated in this research. The model's output for this set of variables was less attractive than previous runs.

Exogenous Variable	Value
System match	0.01
Stakeholder involvement	0.01
Requirements	0.01
Imp complexity factor	0.01
Leverage beyond transaction - complexity factor	0.01
Exhibition	0.01

Table 5.3 Exogenous variables in Realistic scenario

The system dynamic output for major level variables is displayed in Figure 5.52.

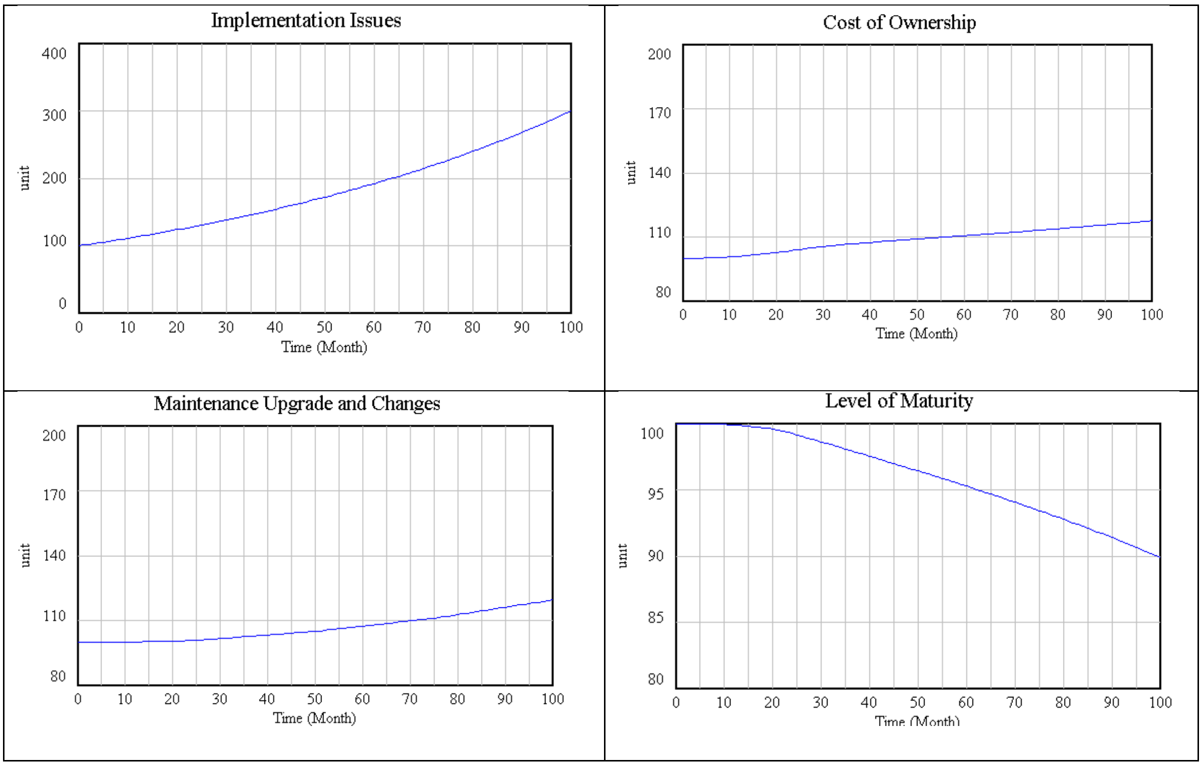

Figure 5.52 Major variables in realistic scenario

I used SyntheSim to test system sensitivity. In this mode all variables displayed their current graph, and I could change exogenous variables values using a handle bar. The screen shot in Figure 5.53 displays a portion of the model in this mode. By examining all variables, it was evident that implementation complexity factors and exhibition of decision support functionality and features were having major impact in changing the system output towards positive territory.

This result indicated once again the importance of successful implementation on all other variables in the process of adaptation between organisation and enterprise systems. It was also clear that the tool and its functions and features played a significant role in achieving higher degrees of utilisation of ERP systems towards decision making. At the same time, maintenance and upgrade policy and changes made to the model didn't seem to significantly impact on trends.

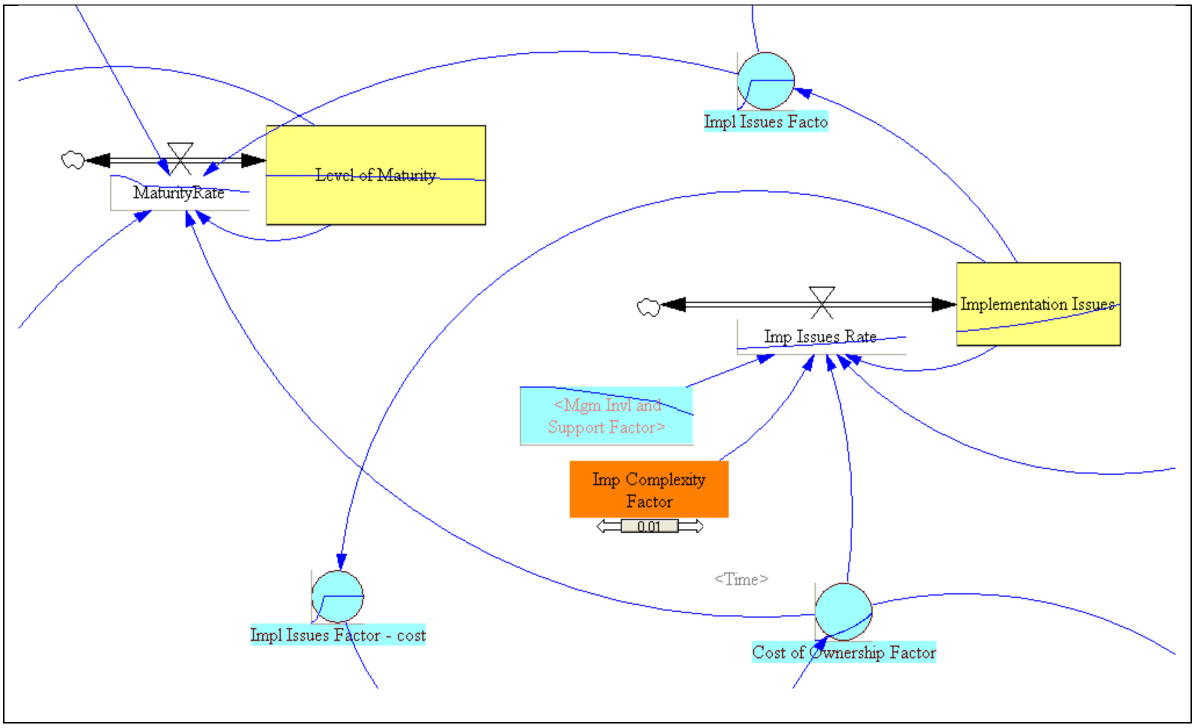

Figure 5.53 Sensitivity analysis

5.6.5 Conclusion

The main objective of making the SD model described in this chapter was to provide key insights into the interactive behaviour of system elements and their trends and changes over a period of time. These behaviours are not obvious through non-systematic approaches. The SD model was based on the findings from this research, the literature and on personal experiences. This model is by no means complete or comprehensive; rather, it serves as a medium to help researchers understand the phenomenon in its entirety using a systemic approach. As such this model could provide a basis for more comprehensive models which are supported by more comprehensive data and theoretical frameworks.

By simulating the reference mode model, which represents the current situation, I found that all exogenous variables were in a favourable condition and so concluded that implementation issues play a key role in changing system behaviour. In another words, although all other variables had an impact on how the whole system operates, the model's sensitivity towards implementation was very dominant. This means any reduction in implementation complexity and ongoing adaption process will successfully reduce the cost of ownership in the long term, eventually leading to an increased rate of maturity and a positive impact on the level of utilising the system for decision making. This positive loop continues through other variables until the feedback causes a positive exponential growth. This outcome means that, in the ideal situation, organisations are gaining valuable experience from their system adaptations, which leads to fewer implementation issues. This is indeed a system that exhibits features and capabilities for decision making and, with a healthy cost of ownership, provides fertile ground for the exponential growth in utilising systems towards their strategic benefits.

CHAPTER 6

CONCLUSION

6.1 Introduction

Organisations in all sectors seek to gain a competitive advantage by investing in information systems. Packaged end-to-end solutions which claim to provide full integration of process and data across organisational structure – the holy grail of enterprise information systems – have received overwhelming acceptance from managers and practitioners. However, excited adopters of such systems are faced with continuous operational and technological issues which potentially prevent them gaining access to the strategic benefits of those systems, such as providing information and processes which could enhance the decision-making process.

Despite the enormity of investment in enterprise systems and its important role in providing a holistic view of operations in order to make informed decisions, few studies have investigated the extent to which decision-support benefits accrue to adopters of these systems (Holsapple, 2005). This type of research in the context of Australian organisations is particularly rare.

In this research I have sought insight into the current utilisation of ERP systems towards decision-making processes among Australian organisations within the first-tier ERP market, investigating organisations with more than six years of experience with ERP and which had completed their implementation at least five years prior to the study. In addition, I have tried to understand the major factors and their interactions through using statistical analysis and system dynamics modelling.

Earlier chapters presented the literature review, research methods, and empirical results from the qualitative and quantitative parts of the research. Chapter 5 outlined an exploratory approach, using a system dynamics model to conduct experiments with the findings from the qualitative and quantitative data analysis. This system dynamics model can help researchers and practitioners gain a holistic understanding of their system, and the underlying contributing factors and their interactions. This chapter summarises and highlights the contributions of this research study, emphasises their practical uses, and explores possible future studies that could benefit from and extend these research results.

6.2 Contributions

This research was designed to investigate the topic from three different perspectives: expectations, exhibition and realisation (see Chapter 2). Based on the findings presented in Chapter 4, stakeholders and users of enterprise systems perceive substantial importance in the potential of ERP to improve the decision-making process, at both strategic and operational levels, by providing necessary information and the tools and capabilities necessary to enhance the decision-making process (expectations). However, in practice, this positive perception doesn't materialise to an acceptable degree among first-tier ERP adopters in Australian organisations (realisation). Also, from participants' perspectives, ERP systems provide few capabilities and features for decision support (exhibition). Further investigations into these three main categories revealed some of the factors that prevent the realisation of these benefits. These factors and their potential impacts and interactions were discussed in detail in chapters 4 and 5 and are briefly summarised here.

Users and stakeholders expressed their high expectation of enterprise systems and the potential impact on the decision-making process and decision quality. However, this expectation has not generally led to the inclusion of ERP decision-support features and capabilities among the main objectives for investment in ERP. In another words, decision-support features of ERP do not play an important role in the evaluation and requisition process.

In addition, participants do not perceive that ERP systems provide capabilities that help improve their decision-making process or that provide information to help managers and users make more informed decisions. In the context of this research, adopters' high expectations do not match the exhibition of capabilities and features in ERP systems. This is despite the fact that an increasing number of enterprise systems have been introducing business intelligence modules and decision-support capabilities in recent years. Future research could investigate the barriers and obstacles preventing organisations from using these tools in practice.

Although a lack of exhibition of decision-support features and capabilities was among the reasons found for not realising such benefits in practice, further investigation into the problem suggested that the numerous obstacles and difficulties of the ERP adaptation process are among the main factors preventing utilisation of ERP towards more strategic benefits. One of the greatest obstacles is probably achieving a reasonable level of integration across enterprise processes and data. In many cases this has led to decoupled or semi-integrated ERP implementation, a major compromise on one of the main objectives of investing in ERP. Decoupled modules, along with a department-centric mentality, contribute to the downgrade of valuable ERP data; rather than being utilised in organisation-level strategic decision making, these data are being used for departmental day-to-day operations.

One of the exogenous factors having impacts on the research topic is the increasing numbers of ERP vendors and customers being merged, bought or consolidated. As a result, continuous changes in ERP systems, the need for integration between different ERP systems and the consolidation of data from different sources consume a good portion of allocated budgets to ERP programs, preventing organisations reaching the maturity stage in their adaptation process.

Other major factors affect management training and systems' user-friendliness. Although most participants recognised the impact of ERP systems for making better decisions, the majority of managers and decision makers had no official training in using EPR, interpreting data or recognising the potential benefits to be gained by using BI modules. In addition, although many ERP vendors have invested in making their systems user friendly and have equipped them with intuitive report writers and BI modules, most legacy systems and older versions of enterprise systems used by first-tier ERP adapters lack any such features. Even for those systems with effective user-interface and BI modules already in place, these features are not easily accessible due to users' lack of training or awareness.

Building the SD model based on the findings from this research, the literature and on personal experiences served to provide better understanding of the phenomenon in its entirety, using a systematic approach. In addition, the sensitivity analysis highlighted the strength of the model's sensitivity towards implementation. This means efforts in reducing complexities in both implementation and the ongoing adaption process will successfully reduce the cost of ownership in the long term, eventually leading to an increased rate of maturity and greater utilisation of the system for decision making. Such a situation happens only with favourable conditions in exogenous variables, such as the exhibition of decision-making capabilities and features. A system that exhibits features and capabilities for decision making with manageable implementation issues could lead to the exponential growth of utilising such systems towards their strategic benefits.

6.3 Managerial implications

6.3.1 Best of Breed (BoB) vs. integrated systems

The exploratory interviews and survey showed that many organisations fail to reach maturity or eventually realise the strategic benefits of enterprise systems because of difficulties and obstacles in the adaptation process. I labelled all these factors "implementation issues". One of these obstacles seems particularly unattainable: data and process integration at the enterprise level. The severe impact of these obstacles was verified in the sensitivity analysis exercise using the SD model (see Chapter 5). Overcoming these obstacles has been the focus of many previous studies. However, it seems that advances in integration techniques and distributed computing might provide another approach to solving this problem through investigating the possibilities of the "Best of Breed" (BoB) approach rather than using fully integrated enterprise systems.

With the BoB approach, organisations utilise specific software programs or packages for each application or requirement. In simple terms this usually means having function-oriented systems such as accounting, human resources and so on dedicated as an information system for each functional area. This approach was superseded when the idea of integrated enterprise systems, with all its benefits and promises, was introduced. It could be argued that the main reason for the triumph of integrated systems over BoB was the complexities surrounding the integration of different function-oriented systems. However, achieving the promised integration has proved in hindsight to be not as straightforward as was first perceived by the public and advertised by vendors.

Recent technological advancements in standardisation, information exchange, web services, distributed computing and integration have once again made the BoB a viable option. This means that organisations could also consider BoB as a more manageable implementation scenario while making their preliminary investigations.

In conclusion, despite the perception that integration is achievable only through native integration through ERP modules, I argue that BoB solutions could be a viable option for many organisations, and they should certainly consider BoB in their evaluation process as a potential way of minimising their implementation risks and costs. They could also distribute implementation costs and effort over a period of time suitable for their business. By taking advantage of BoB, organisations could integrate their current system into the new system, rather than scrapping it altogether. The end result could be a cheaper system with a higher degree of integration than the decoupled ERP currently experienced by many organisations.

6.3.2 Decision support features and capabilities in enterprise systems

The data analysis showed a significant gap between managers' and stakeholders' expectations of the ability of enterprise systems to support the decision-making process, and what these systems exhibit as their capabilities and features. This could be an opportunity for ERP vendors to consider their customers' high expectations and incorporate the desired features, tools and capabilities into their systems. It must be emphasised that the finding related to exhibition of decision-making capabilities and features is purely our participants' perception; this research did not investigate these tools for these features. Even if this perception doesn't represent reality, ERP vendors should nevertheless accept that they have not been able to inform their customer base of existing features and capabilities through their training, seminars, involvement in user groups and direct communication. This could be another opportunity for vendors to provide a realistic image of their products by initiating the necessary policies and campaigns, as well as investing in integration techniques and building intuitive business intelligence modules.

6.3.3 Baby steps towards Business Intelligence (BI)

Building the ultimate business intelligence (BI) module on top of an ERP system could be an idealistic scenario for most of the organisations studied. However, management's and stakeholders' high expectations of enterprise systems to support decision-making could be partially satisfied by focusing on a phased BI approach.

Using a big-bang approach to build a foundation which supports and improves the decision-making process seems overly idealistic for organisations who are struggling to overcome their operational issues. However, available data in enterprise systems could be utilised without requiring a complex BI implementation. Practical steps towards utilising ERP data for decision-making could include building data marts, web-based reporting layers, and KPI reporting using web techniques. These disparate activities, together with enterprise systems, could eventually lead to BI.

6.3.4 Training and awareness

Management commitment and support is one of the main success factors for any enterprise system implementation. This is also true in terms of achieving a working BI solution. However, this support and commitment occurs only if the management team is well aware of potential benefits and risks associated with these systems. This study found that a lack of training and awareness prevents the utilisation of vast amounts of data in the decision-making process. Providing training on using EPR, interpreting data and recognising the potential benefits of BI could increase organisations' chances of utilising valuable ERP data to gain a competitive advantage. Increased management knowledge could increase the expectations of ERP decision-support features and have a positive impact on using existing features and capabilities within the organisation.

6.4 Future research

Participants in this study perceived that enterprise systems do not provide the capabilities necessary to help improve the decision-making process, and do not provide information in a way that helps managers and users make more informed decisions. This is in contrast with the current trend where increasing numbers of enterprise systems are introducing business intelligence modules and decision-support capabilities. Investigating the reasons behind this phenomenon could reveal interesting and useful findings for both vendors and users, by identifying barriers and obstacles preventing organisations from effectively using these tools.

Investigating factors and parameters impacting organisations' decision towards Best of Breed (B.o.B) or integrated enterprise systems in their evaluation and requisition process could be beneficial to organisations and managers to select the right path in their enterprise systems implementation.

The exploratory system dynamics model built as part of this research study was structured mainly from investigated variables and the findings from the exploratory interviews and survey. Although this model neither is comprehensive not complete, and was built purely to verify the findings from this study, it could be a foundation for further research on barriers and obstacles faced by enterprise systems adopters utilising a system dynamics approach.

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Appendices

Appendix 1: CSFs for ERP implementation identified in literature

		Management/ Organisation					People					Process and Planning										Technology							
CSF		F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28
Total		**20**	**1**	**0**	**1**	**1**	**12**	**11**	**1**	**1**	**3**	**17**	**8**	**0**	**6**	**1**	**3**	**3**	**1**	**8**	**7**	**6**	**3**	**4**	**4**	**1**	**3**	**3**	**4**
Al-Mashari et al.	2003	1						1			1	1	1				1					1							
Ang et al. (94,95,02)	2002	1					1	1		1			1				1					1			1				1
Berchet and Habchi	2005						1	1	1			1			1	1													
Bingi et al.	1999	1					1	1				1													1				
Botta-Genoulaz et al.	2005	1					1						1																
Bradford and Florin	2003	1						1									1												
Brown	1994	1																			1								
Buckhout et al.	1999	1					1													1									
Burns and Turnipseed	1991	1					1					1										1			1				
Calisir	2004																									1			
Cheung et al.	2001				1																								
Cox and Clark	1984	1					1	1					1																1
Duchessi	1998	1											1							1	1								
Esteves et al.	2002		1									1																	

		Management/ Organisation					People					Process and Planning										Technology							
CSF		F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28
Falkowski et al.	1998	1					1					1	1		1					1	1								
Fitsgerald and O'Kane	1999	1						1				1						1						1				1	
Herb	2000					1	1																						
Holland and Light	1999	1					1					1	1		1					1	1		1				1		
Hong and Kim	2002										1	1																	1
Ike et al.	2005	1					1					1							1	1		1		1					
Kwon and Smud	1987	1						1				1						1						1				1	
Lyytinen et al.	1998	1						1				1						1						1				1	
Mabert et al. a and b	2003							1				1								1		1							1
Mainthou et al.	1996	1													1						1								
Mandal and Gunasekaran	2002							1				1										1							
Markus et al. a	2000																												
Motwania et al.	2002										1	1													1				
Roberts and Barrar	1992	1										1			1					1	1						1		
Rosario	2000	1					1					1	1		1					1	1		1				1		
Sarker and Lee	2003	1																											

		Management/ Organisation					People					Process and Planning										Technology							
CSF		F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20	F21	F22	F23	F24	F25	F26	F27	F28
Scheer and Habermann	2000																						1						
Somers and Nelson	2004	1		1				1				1	1	1			1							1	1				
Stefanou	1999	1					1																						
Sum et al.	1997	1						1		1												1			1				1
Sumner	1999	1						1				1						1						1				1	
Sun and Yazdania	2004	1					1					1											1						1
Thite	2000				1																								
Umble et al.	2003	1						1				1					1												1
Wang et al.	2005				1																								
Wee	2000	1					1						1							1	1		1				1		
Welti	1999												1				1												
White et al.	1982																												
Wilson et al.	1994						1			1																			
Yusuf et al.	2004	1					1	1		1	1	1	1				1					1			1				

CSFs codes

	Code	Critical Success Factor(s)
Management/ organisation	F1	Top management support/strong and committed leadership/Project management principles
	F2	Sustained management support
	F3	Steering committee
	F4	Charismatic leadership
	F5	Leaders effectiveness
People	F6	Empowered project team/Cohesiveness/HR development/User characteristics and participation
	F7	End users' training
	F8	Confidence and knowledge
	F9	Company wide support
	F10	Cultural fit
Process and Planning	F11	Process/BPR
	F12	Open and honest communication/Visibility of implementation
	F13	Inter-departmental cooperation and communications
	F14	Performance indicators/Continues monitoring and performance evaluation
	F15	Detailed documentation
	F16	Clear goals and objectives
	F17	Careful software and vendor selection
	F18	Feasibility and critical evaluation
	F19	Upfront planning/Business plan and vision
	F20	Change management
Technology	F21	IT infrastructure
	F22	Technology
	F23	Consulting services/Use of people with technical and business experience
	F24	Vendor support
	F25	Perceived usefulness and learnability /UI
	F26	Lack of customisation
	F27	Integration with other systems
	F28	Data accuracy and integrity

Appendix 2: Semi-structured interview instrument

Interviews are informal and semi-structured. Interviewee will be invited to express his/her understanding and experience with minimum interruptions. As the initial step the subject topic will be introduced by the interviewer and then his role will be adequate probing and providing necessary control to stay on the subject.

Introductory Script (guide only)
In this research we are looking at ERP from the perspective of decision support characteristics. ERP is regarded as a tool, which can solve operational and transactional problems; however, its capabilities as a tool that could provide potential benefits in decision-making are not clear.

Our main data collection method is survey, however, because of the lack of underlying knowledge and theories and comprehensive studies on this subject, we thought interviews in companies which have adopted ERP systems and are in their maturity stage can let us gain required insight for designing survey instrument and constructs.

I need to emphasise that this is completely anonymous. Your name will not be quoted in any document or published material as a result of this research.

Also, I have an Interview Consent form which requires my signature and yours. (In case of phone interviews will be faxed to participants).

With your permission and if you have no objection I will record this interview and then will send you the transcript for any correction or modifications. You don't have any problems with that?

Semi-structure interview questions for ERP users

Topic	***Suggested Questions***
Participant's point of view towards ERP and their experience from ERP implementation in general	*1. From your point of view, what have been the main objectives for implementing ERP in your organisation? Have those objectives been fulfilled?*
ERP and decision making capabilities	*3. Some claim that the focus of ERP is on operational and tactical level and ERP systems lack comprehensive reporting and analysis functionalities at the strategic level. In another word, although ERP is a powerful tool with regard to transaction processing and reporting, analytical tools and decision support features are not well supported in the system. Do you agree or disagree with these claims?* *4. There are increasing interests on analytic applications such as Strategic Enterprise Management (SEM) systems and Business Intelligence (BI) solutions. There are claims that these using these improves the decision making process. What is your company position towards such tools and what is your perception in regards to the role of such tools in improving the decision making process.* *5. Have you added any plug-ins or in-house developed application to your ERP for supporting other functionalities*

	rather than ERP core functionalities? *6. If your company has a current SEM or BI program in place, which management tasks could benefit more: planning, monitoring and control or decision making?* *7. If ERP is contributing to effectiveness of decision making process, which factors are more important in such contribution (e.g. improved quality of reports, increased flexibility in information generation, facilitating decision making process and so on)*
Intra-organisational Integration	*8. If ERP is considered to be the core component for operational data and processes, how do other existing enterprise systems such as SCM, CRM, and so on interact with it? Is there any integration level? Is there any plan for such integration to take place?* *9. EAI provides a platform for integration with other systems inside or outside the corporation. Do you have any initiatives for such implementation?* *10. Some people claim that integration between disparate enterprise systems (ERP, CRM, SCM and so on) is an important prerequisite for effectiveness of BI and SEM tools. Do you agree or disagree with this statement?*
Inter-organisational Integration	*11. Extended Enterprise (EE) may be defined as a virtual enterprise of all the relevant functions of a company, its suppliers and its customers which have introduced the idea of loosely coupled supply chain (or as sometimes referred to as adaptive supply network). Are there any initiatives in your organisation to go beyond intra-organisational integration and extend integration to customers and suppliers using B2C, B2B and so on?* *12. Some companies support single vendor strategy for their enterprise systems acquisitions with the hope of potential easier integration between enterprise systems. However, best of breed (BoB) is also getting some momentum as EAI middleware is increasingly being used as a tool to integrate supply chain. What is your point of view on taking BoB or single vendor strategy?*
Data warehouse	*13. Data warehouse shrinks the time between occurrence of a business event and executive alerts. Information is integrated from all internal and possibly external sources and across time. If you have a DW implementation in your company, how you describe it in terms of level of integration with your enterprise systems?* *14. If you have a DW, how you explain its impacts on decision making process for different levels of management?*
	15. Would you like to address any other issues which we have not discussed?

Appendix 3: Survey instrument

The survey questionnaire and its constructs were based on the outcomes of the first phase of this research utilising exploratory interviews with managers and ERP practitioners.

Survey Instrument

Please select the industry sector which best categorises your organisation:

Automotive
High Technology
Defence
Logistic
Services (finance/insurance)
Other/Not Specified

Please select the functional area in which you conduct your usual duties:

Finance
Executives/Board
Human Resources
Information Systems
Other/Not Specified

How many years since the ERP system went live in your organisation?

How many years of experience you have in using ERP system in your current organisation?

On a 5-point scale from 1 = "not at all" to 5 = "to a great extent", please answer the following questions:

Management knowledge and training	**1**	**2**	**3**	**4**	**5**
How would you rank your knowledge about using enterprise systems towards decision making?					
Have you had any training towards utilizing ERP in decision making?					
Have you had any training towards decision making process and potential tools which could utilised this process					

From your point of view how important are the following characteristics in an ERP system in order to provide better information for decision making and to facilitate the decision-making process:

ERP Characteristics	**1**	**2**	**3**	**4**	**5**
Decision support features of an ERP has to be one of the objectives for ERP implementation					
Decision support features of an ERP system					

need to be considered in the evaluation and requisition process?					
ERP should provide tools to enhance decision makers' ability to process information (OLAP analysis, knowledge repository)					
ERP should provide tools for better facilitation of decision making process (e.g. collaboration, communication)					
ERP should provide facilities to encourage exploration and new approaches to the problem (e.g. sensitivity analysis, simulation tools)					
ERP should provide a user friendly interface					

Based on your experience with your organisation's ERP system, to what degree does your enterprise system exhibit the following characteristics?

ERP Characteristics	**1**	**2**	**3**	**4**	**5**
Our ERP provides tools to enhance decision makers' ability to process information (OLAP analysis, knowledge repository)					
Our ERP provides tools for better facilitation of decision making process (e.g. collaboration, communication)					
Our ERP provides facilities to encourage exploration and new approaches to the problem (e.g. sensitivity analysis, simulation tools)					
Our ERP provides a good user interface (e.g. simple and convenient format, customised queries, customised results, scheduling queries, customised user interface)					
Has decision support features of ERP been one of the objectives for your ERP implementation?					
Has decision support features of ERP been considered in the evaluation and requisition process of your ERP?					

Based on your experience with using your organisation's ERP system, to what degree do you think the following have happened?
To what degree does your organisation realise the following benefits from ERP implementation:

Organisation ERP Characteristics	**1**	**2**	**3**	**4**	**5**
ERP has improved the quality of decisions					
ERP has helped to reduce the cost of decision making					
ERP has shortened decision making time					

ERP has improved the reliability of decision making process					
ERP has improved decision makers abilities to tackle complex problems					
ERP has increased satisfaction with decision making process					

Implementation issues

Evaluation and Selection	**1**	**2**	**3**	**4**	**5**
In our ERP evaluation/selection process, did you all requirements were defined and documented					
In our ERP evaluation/selection process all potential stakeholders were involvement					
In our ERP evaluation/selection process all the possible options were considered (including use of BoB and so on)					
Our ERP system is matched to our business					
Our evaluation/selection process could have been improved					

Implementation	**1**	**2**	**3**	**4**	**5**
All stakeholders and users were engaged in ERP implementation					
Our executive team was informed and supportive of the ERP program					
Our ERP implementation was over budget					
Our ERP implementation was over time					
Process and data integration proved to be one of the most challenging task					
Our ERP system is well integrated and most modules are working harmoniously					

Maintenance and upgrade	**1**	**2**	**3**	**4**	**5**
Our ERP have been fairly stable an there have been no need to patch/upgrade					
Our ERP been upgraded (or migrated) multiple times due to change in technology					
Our ERP been upgraded (or migrated) multiple times due to ERP vendors mergers and consolidation					
Our ERP been upgraded (or migrated) multiple times due to our company merger and consolidation with other companies					
Our ERP system seems to be mature now					

Appendix 4: Paired samples t-test

Comparing expectations and Exhibitions Variables

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Perceived Objective	3.51	82	.997	.110
	Exhibit Objective	1.78	82	.721	.080
Pair 2	Perceived Evaluation	3.66	82	.878	.097
	Exhibit Evaluation	1.51	82	.633	.070
Pair 3	Perceived DM Tools	3.85	82	.788	.087
	Exhibit DM Tools	1.66	82	.724	.080
Pair 4	Perceived DM Process	3.45	80	.926	.104
	Exhibit DM Process	1.35	80	.530	.059
Pair 5	Perceived DM Exploration	2.37	82	.854	.094
	Exhibit DM Expl	1.27	82	.446	.049
Pair 6	Perceived User Friendliness	4.27	82	.668	.074
	Exhibit UI	3.07	82	.979	.108

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	Perceived Objective & Exhibit Objective	82	.262	.018
Pair 2	Perceived Evaluation & Exhibit Evaluation	82	.096	.389
Pair 3	Perceived DM Tools & Exhibit DM Tools	82	-.089	.428
Pair 4	Perceived DM Process & Exhibit DM Process	80	.242	.030
Pair 5	Perceived DM Exploration & Exhibit DM Expl	82	.063	.572
Pair 6	Perceived User Friendliness & Exhibit UI	82	.083	.459

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	98% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Perceived Objective - Exhibit Objective	1.732	1.066	.118	1.452	2.011	14.706	81	.000
Pair 2	Perceived Evaluation - Exhibit Evaluation	2.146	1.032	.114	1.876	2.417	18.836	81	.000
Pair 3	Perceived DM Tools - Exhibit DM Tools	2.195	1.116	.123	1.903	2.488	17.812	81	.000
Pair 4	Perceived DM Process - Exhibit DM Process	2.100	.949	.106	1.848	2.352	19.785	79	.000
Pair 5	Perceived DM Exploration - Exhibit DM Expl	1.098	.938	.104	.852	1.343	10.599	81	.000
Pair 6	Perceived User Friendliness - Exhibit UI	1.195	1.138	.126	.897	1.493	9.511	81	.000

Appendix 5: Factor analysis

Factor Analysis Implementation

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.532
Bartlett's Test of Sphericity	Approx. Chi-Square	75.101
	df	28
	Sig.	.000

Component Matrixa

a. 4 components extracted.

Pattern Matrix[a]

	Component			
	1	2	3	4
Imp Involvement	.835			.275
Imp Executive Support	.858			
Imp Integration		-.810		
Imp Maturity			.779	.406
ImpOverBudget_Reversed	-.509	.235	-.242	.368
ImpOverTime_Reversed				.914
ImpIntegrationChallenge_Reversed			.793	-.222
ImpDecoupled_Reversed		.820		

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalisation.
a. Rotation converged in 6 iterations.

Total Variance Explained

Component		Rotation Sums of Squared Loadingsa
		Total
dimension0	1	1.754
	2	1.457
	3	1.361
	4	1.262

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Structure Matrix

	Component			
	1	2	3	4
Imp Involvement	.763			
Imp Executive Support	.859	.203		
Imp Integration		-.809	-.228	
Imp Maturity			.728	.351
ImpOverBudget_Reversed	-.604	.259	-.312	.551
ImpOverTime_Reversed				.838
ImpIntegrationChallenge_Reversed			.820	-.311
ImpDecoupled_Reversed		.805		

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalisation.

Component Correlation Matrix

Component		1	2	3	4
dimension0	1	1.000	.040	.083	-.231
	2	.040	1.000	.065	.162
	3	.083	.065	1.000	-.117
	4	-.231	.162	-.117	1.000

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalisation.

Factor Analysis Maintenance

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.723
Bartlett's Test of Sphericity	Approx. Chi-Square	211.496
	df	6
	Sig.	.000

Component Matrix[a]

	Component
	1
Maintenance Technology	.914
Maintenance VendorMerger	.939
Maintenance CompanyMerger	.913
MaintenanceStable_Reversed	-.502

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Communalities

	Extraction
Maintenance Technology	.835
Maintenance VendorMerger	.882
Maintenance CompanyMerger	.833
MaintenanceStable_Reversed	.252

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component	Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %
dimension0 1	2.802	70.038	70.038

Extraction Method: Principal Component Analysis.

Factor Analysis - Management

Communalities

	Initial	Extraction
Management knowledge	1.000	.123
Management Training ERP	1.000	.852
Management Training DM	1.000	.782

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component		Initial Eigenvalues			Extraction Sums of Squared Loadings		
		Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
dimension0	1	1.758	58.590	58.590	1.758	58.590	58.590
	2	.963	32.086	90.675			
	3	.280	9.325	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
Management knowledge	-.351
Management Training ERP	.923
Management Training DM	.884

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Factor Analysis - Realisation

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.395
Bartlett's Test of Sphericity	Approx. Chi-Square	45.620
	df	15
	Sig.	.000

Component Matrix[a]

a. 3 components extracted.

Rotated Component Matrix[a]

	Component		
	1	2	3
Realised DM Quality	.720		-.413
Realised DM Cost		.837	.219
Realised DM Time	.668		.496
Realised DM Reliability			.855
Realised DM Complex		.854	
Realised DM Process	-.680		

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
a. Rotation converged in 4 iterations.

Total Variance Explained

Component		Rotation Sums of Squared Loadings		
		Total	% of Variance	Cumulative %
dimension0	1	1.433	23.886	23.886
	2	1.431	23.852	47.738
	3	1.229	20.479	68.216

Extraction Method: Principal Component Analysis.

Component Transformation Matrix

Component		1	2	3
dimension0	1	.607	.788	.103
	2	-.779	.564	.274
	3	.158	-.246	.956

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.

Factor Analysis - Evaluation

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.573
Bartlett's Test of Sphericity	Approx. Chi-Square	39.183
	df	10
	Sig.	.000

Component Matrix[a]

	Component	
	1	2
Evaluation Requirments	.702	
Evaluation Involvement	.403	-.417
Evaluation Options		.838
Evaluation Match	.702	.452
EvaluationImprove-Reversed	.809	

Extraction Method: Principal Component Analysis.
a. 2 components extracted.

Communalities

	Extraction
Evaluation Requirments	.502
Evaluation Involvement	.336
Evaluation Options	.703
Evaluation Match	.697
EvaluationImprove-Reversed	.661

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component		Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
		Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
dimension0	1	1.803	36.059	36.059	1.796	35.928	35.928
	2	1.096	21.913	57.973	1.102	22.044	57.973

Extraction Method: Principal Component Analysis.

Rotated Component Matrix[a]

	Component	
	1	2
Evaluation Requirments	.690	
Evaluation Involvement	.361	-.454
Evaluation Options		.836
Evaluation Match	.742	.382
EvaluationImprove-Reversed	.797	

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
a. Rotation converged in 3 iterations.

Component Transformation Matrix

Component	1	2

dimension0	1	.995	-.096
	2	.096	.995

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.

Factor Analysis - Exhibition

Communalities

	Initial	Extraction
Exhibit Objective	1.000	.610
Exhibit Evaluation	1.000	.452
Exhibit DM Tools	1.000	.727
Exhibit DM Process	1.000	.742
Exhibit DM Expl	1.000	.750
Exhibit UI	1.000	.363

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component		Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
		Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
dimension0	1	2.354	39.230	39.230	2.354	39.230	39.230	2.297	38.282	38.282
	2	1.291	21.517	60.747	1.291	21.517	60.747	1.348	22.465	60.747
	3	.902	15.036	75.782						
	4	.752	12.536	88.319						
	5	.377	6.282	94.601						
	6	.324	5.399	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
Exhibit Objective	.228	.747
Exhibit Evaluation	.524	.422
Exhibit DM Tools	.847	.103
Exhibit DM Process	.824	-.253
Exhibit DM Expl	.795	-.343
Exhibit UI		-.603

Extraction Method: Principal Component Analysis.
a. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
Exhibit Objective		.779
Exhibit Evaluation	.412	.532
Exhibit DM Tools	.800	.296
Exhibit DM Process	.860	
Exhibit DM Expl	.853	-.149
Exhibit UI	.136	-.587

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
a. Rotation converged in 3 iterations.

Component Transformation Matrix

Component		1	2
dimension0	1	.973	.231
	2	-.231	.973

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.

Factor Analysis - Perception

Communalities

	Initial	Extraction
Perceived Objective	1.000	.717
Perceived Evaluation	1.000	.562
Perceived DM Tools	1.000	.637
Perceived DM Process	1.000	.742
Perceived DM Exploration	1.000	.327
Perceived User Friendliness	1.000	.586

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component		Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
		Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
dimension0	1	2.085	34.755	34.755	2.085	34.755	34.755	1.864	31.065	31.065
	2	1.484	24.741	59.496	1.484	24.741	59.496	1.706	28.431	59.496
	3	.894	14.895	74.391						
	4	.744	12.405	86.796						
	5	.442	7.369	94.165						
	6	.350	5.835	100.000						

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component	
	1	2
Perceived Objective	.681	.504
Perceived Evaluation	.660	.355
Perceived DM Tools	.723	-.338
Perceived DM Process	.578	-.638
Perceived DM Exploration	.551	-.153
Perceived User Friendliness	.161	.748

Extraction Method: Principal Component Analysis.
a. 2 components extracted.

Rotated Component Matrix[a]

	Component	
	1	2
Perceived Objective	.235	.814
Perceived Evaluation	.309	.683
Perceived DM Tools	.780	.170
Perceived DM Process	.847	-.156
Perceived DM Exploration	.531	.213
Perceived User Friendliness	-.326	.692

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.
a. Rotation converged in 3 iterations.

Component Transformation Matrix

Component		1	2
dimension0	1	.795	.607
	2	-.607	.795

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalisation.

Factor Analysis – Management Knowledge and Training

Communalities

	Initial	Extraction
Management knowledge	1.000	.123
Management Training ERP	1.000	.852
Management Training DM	1.000	.782

Extraction Method: Principal Component Analysis.

Total Variance Explained

Component		Initial Eigenvalues			Extraction Sums of Squared Loadings		
		Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
dimension0	1	1.758	58.590	58.590	1.758	58.590	58.590
	2	.963	32.086	90.675			
	3	.280	9.325	100.000			

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component
	1
Management knowledge	-.351
Management Training ERP	.923
Management Training DM	.884

Extraction Method: Principal Component Analysis.
a. 1 components extracted.

Appendix 6: Comparison of perception, exhibition and realisation

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	F_Perception_General	3.8130	82	.64171	.07086
	F_Exhibition_General	2.1220	82	.43670	.04823
Pair 2	F_Perception_DM	3.2195	82	.64410	.07113
	F_Exhibition_DM	1.4228	82	.48019	.05303

Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	F_Perception_General - F_Exhibition_General	1.69106	.71584	.07905	1.53377	1.84834	21.392	81	.000
Pair 2	F_Perception_DM - F_Exhibition_DM	1.79675	.79393	.08768	1.62230	1.97119	20.493	81	.000

Comparison of exhibition and realisation

Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	F_Exhibition_DM	1.4228	82	.48019	.05303
	F_Realisation_Quality_Time_Process	1.9187	82	.41096	.04538
Pair 2	F_Exhibition_DM	1.4228	82	.48019	.05303
	F_Realisation_Cost_Complex	1.4390	82	.54654	.06036

Paired Samples Correlations

		N	Correlation	Sig.
Pair 1	F_Exhibition_DM & F_Realisation_Quality_Time_Process	82	-.116	.301
Pair 2	F_Exhibition_DM & F_Realisation_Cost_Complex	82	.460	.000

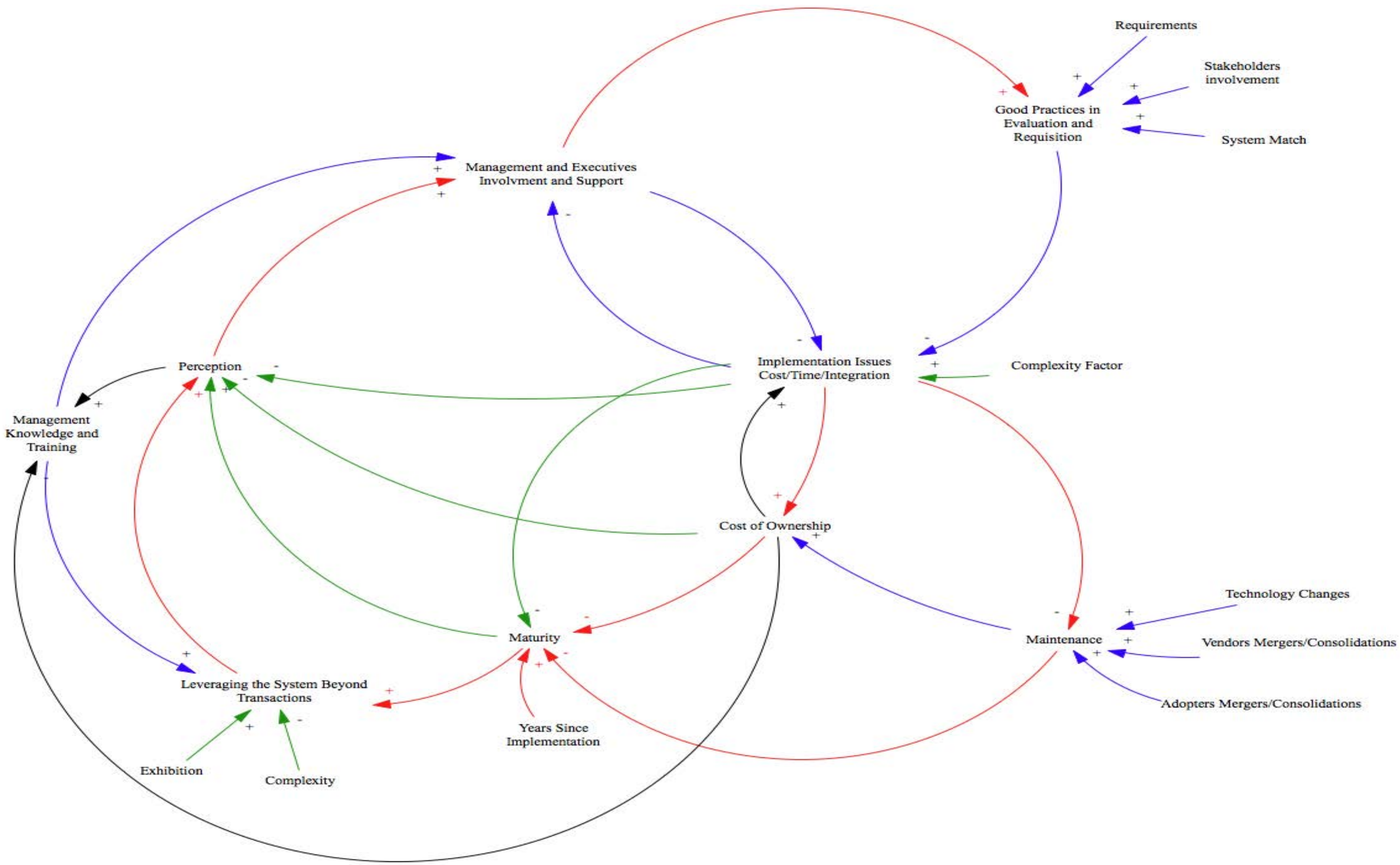
Paired Samples Test

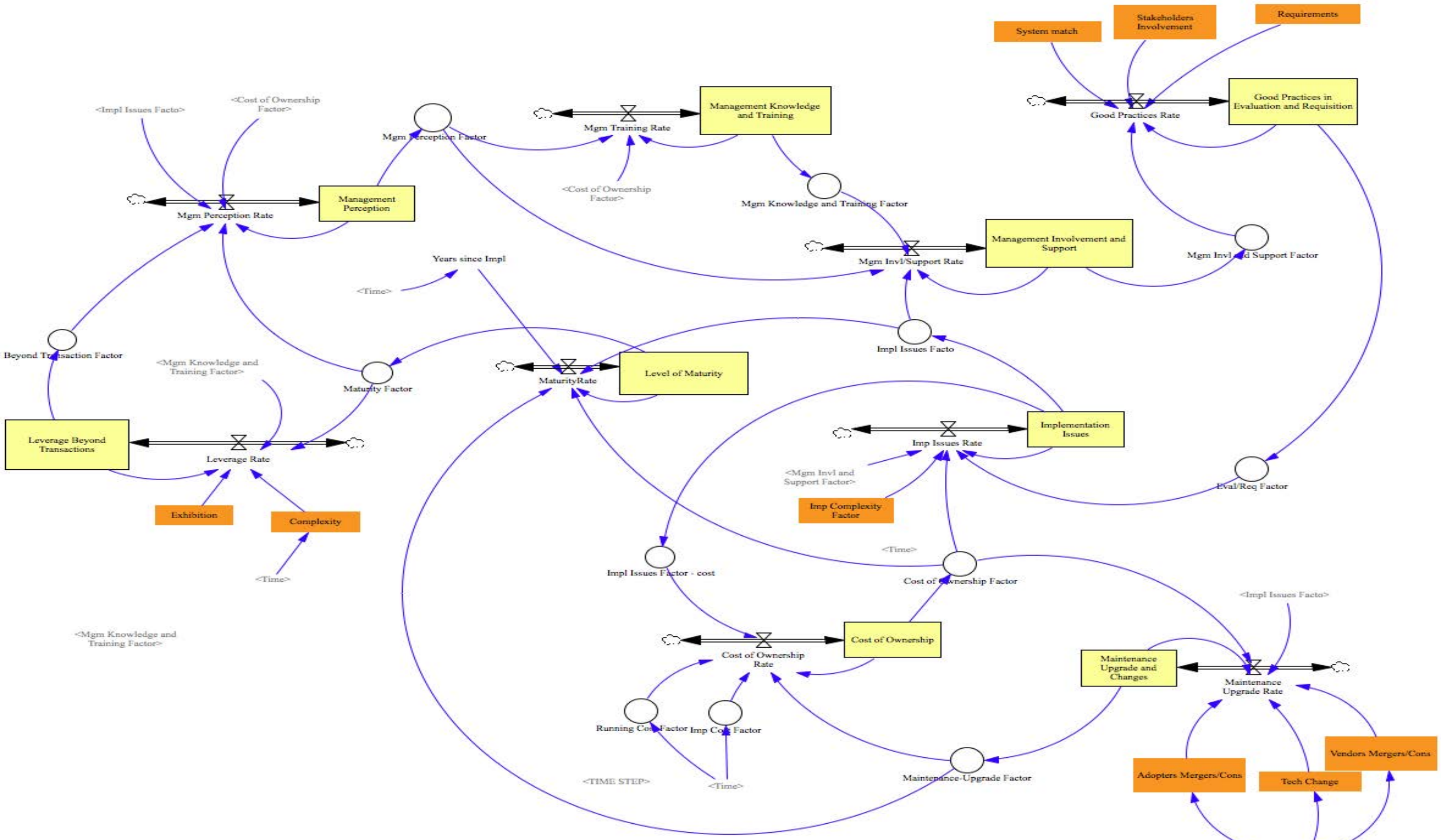
	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
				Lower	Upper			

Pair 1	F_Exhibition_DM - F_Realisation_Quality_Time_Process	-.49593	.66717	.07368	-.64253	-.34934	-6.731	81	.000
Pair 2	F_Exhibition_DM - F_Realisation_Cost_Complex	-.01626	.53647	.05924	-.13414	.10161	-.274	81	.784

Appendix 7: System Dynamics Models

In this Appendix two main system Dynamics models are presented for readability purposes.


Requirements
Stakeholders involvement
Good Practices in Evaluation and Requisition
System Match
Management and Executives Involvment and Support
Implementation Issues Cost/Time/Integration
Complexity Factor
Perception
Management Knowledge and Training
Cost of Ownership
Technology Changes
Maturity
Maintenance
Vendors Mergers/Consolidations
Leveraging the System Beyond Transactions
Adopters Mergers/Consolidations
Years Since Implementation
Exhibition
Complexity


System match
Stakeholders Involvement
Requirements
Good Practices Rate
Good Practices in Evaluation and Requisition
<Impl Issues Facto>
<Cost of Ownership Factor>
Mgm Perception Factor
Mgm Training Rate
Management Knowledge and Training
<Cost of Ownership Factor>
Mgm Knowledge and Training Factor
Mgm Perception Rate
Management Perception
Mgm Invl/Support Rate
Management Involvement and Support
Mgm Invl and Support Factor
Years since Impl
<Time>
Beyond Transaction Factor
<Mgm Knowledge and Training Factor>
Maturity Factor
MaturityRate
Level of Maturity
Impl Issues Facto
Leverage Beyond Transactions
Leverage Rate
Imp Issues Rate
Implementation Issues
<Mgm Invl and Support Factor>
Eval/Req Factor
Exhibition
Complexity
Imp Complexity Factor
<Time>
<Time>
Impl Issues Factor - cost
Cost of Ownership Factor
<Impl Issues Facto>
<Mgm Knowledge and Training Factor>
Cost of Ownership Rate
Cost of Ownership
Maintenance Upgrade and Changes
Maintenance Upgrade Rate
Running Cost Factor
Imp Cost Factor
Vendors Mergers/Cons
Adopters Mergers/Cons
Tech Change
<TIME STEP>
<Time>
Maintenance-Upgrade Factor
<Time>

Appendix 8: Published papers presenting research findings

In this appendix two papers presenting research finding are included. The first paper titled "Utilizing Enterprise Resource Planning in Decision-Making Process" was accepted in the ERP 2012 conference organised by university of Innsbruck in Austria. Second paper titled "Impacts of Enterprise Resource Planning implementation on decision making processes in Australian organisation" was published by Pacific Asia conference on information Systems 2009 (http://www.pacis-net.org/index.jsp?t=proceeding&y=2009) . Both papers are presented in this appedix for reference

Utilizing Enterprise Resource Planning in Decision-Making Processes

Bahram Bahrami and Professor Ernest Jordan

Abstract. This paper reports on findings from a research project investigating Enterprise Resource Planning (ERP) and its utilization on decision-making processes in Australian organizations. The focus of the study is to reveal if and how the vast amount of data, which is generated by ERP systems, could improve decision-making processes on strategic and tactical levels. The findings are based on data consists of information collected in two phases by semi-structured interviews and survey. Findings from two phases of data collection is used to build a System Dynamics model as an exploratory vehicle to verify findings and formulate practical scenarios to help managers utilizing enterprise systems for their more strategic benefits such as decision-making.

Keywords: ERP, Decision Making, Decision Support Systems, System Dynamics

Introduction

ERP Definition and evolution

In recent decades, the term ERP has been used by both practitioners and academics in divergent applications and as a result it has acquired number of different meanings and also allowed for confusion regarding the meaning of the term. In fact, the term ERP itself could have contributed to the confusion, as 'Resource Planning' is not the main purpose of acquiring ERP systems.

ERP is a set of integrated, configurable information systems applications software that can be bought 'off-the-shelf' and tailored by an organization in order to integrate and share its information and related business processes within and across functional areas [1]. Such off-the-shelf packages (as opposed to applications built in-house) help organizations manage important aspects of their business, such as accounting, finance, manufacturing, distribution, human resources and sales [2, 3]. ERP eventually enables organizations to achieve inter-organizational supply chains [4,5] by evolving into Extended ERP systems that can exploit technological advances in the areas of internet and electronic commerce, and support inter-organizational processes on an extended network of supplier and distributors [6].

The fundamental capabilities of ERP systems come from transaction processing and structured record keeping of those transactions, and not 'planning' as the name Enterprise Resource Planning suggests. Although planning and decision support applications can be optional add-ons, they are not the core capabilities of the system [7]. However such features and capabilities are the most valuable benefits that ERP adopters expect from their investment on ERP to gain competitive advantages. This research is an investigation to see if and how these benefits are materialized in practice among Australian organizations in the first tier of ERP market.

Research Methodology

This research is a preliminary step to examine the extent to which adapters of ERP systems benefit from potential decision support characteristics of such systems. The aim is to investigate the problem from different perspectives such as user expectations, exhibition of decision support features in ERP systems and actual realization of such benefits in practice within Australian organizations.

Decision support characteristics of ERP systems and its utilization in practice has not been the focus of notable number of research both in industry and academia spheres. The lack of knowledge and theory on the underlying research question is the main reason to design this research as a two-stage study based on qualitative and quantitative methods. In the first stage of this research qualitative methods are utilised to investigate the current status of Australian organisations and industry practitioners in regards to utilizing ERP systems towards decision making process. In this stage, semi-structured exploratory interviews with purposefully selected participants were conducted in order to cater for the lack of underlying knowledge and theories and comprehensive studies on the main subject of the research in the Australian context.

In the second stage, gained insight from the qualitative stage is utilized to provide necessary foundation to make effective use of qualitative methods to investigate the subject in more depth and details.

Finally, based on findings from the qualitative and quantitative data analysis a theoretical System Dynamics (SD) model was built. The use of SD approach provides key insights into the interactive behavior of system elements over times that are normally not obvious through non- systematic approaches. The theoretical model in addition to establishing a wholistic view of studied incorporating factors and parameters, provides a vehicle to conduct sensitivity analysis, policy experimentation and simulation in order to offer insight and to formulize practical guidance into better utilization of ERP data towards decision-making.

This paper briefly presents findings from the first and second stages of the research, however it primarily focuses on explaining the underlying login behind the SD model and on findings from the modeling exercise.

Participants

Research participants were purposefully selected from Australian organizations in technology, defense, finance, logistics and telecommunications sectors. All of these organizations are in the first tier ERP market and have been using an ERP for the last five years. Participants were senior managers and middle managers and professionals who can potentially benefit from ERP decision making capabilities or have been involved with implementation and day to day use of ERP systems in those organizations.

Data collection

For the first stage of this study data consists of material collected from semi-structured interviews with open-ended questions, reflection notes which were taken during interviews and researchers' personal experience with ERP systems. Insight gained from the qualitative first stage provided a foundation for the qualitative methods used in the second stage to investigate the subject in more depth and detail. In this phase a survey instrument was designed to identify the major factors and their potential relationships.

Data Analysis Findings

Analyzing collected data in the first and second stages of this research indicates that ERP adopters perceive substantial importance and potential for utilizing ERP data to improve the decision-making process at both strategic and tactical levels. It was also revealed that decision-support features of ERP systems do not play an important role in the evaluation process, and this could contribute to decreased materialization of such benefits in practice. In this regard the findings support those of some previous studies. As supporting the decision-making process is not an objective, it is then not part of evaluation process.

Although ERP is perceived to have an important potential role in supporting the decision-making process, these benefits do not materialize among first-tier Australian ERP adopters. Participants' high expectations and their efforts to achieve some of the benefits do not match ERP vendors' effort to provide the necessary tools and features in their systems. It seems that among expectation, exhibition and realization, the weakest link is the exhibition of decision-making capabilities and features in ERP systems.

Based on data analysis, ERP adaptation process, with its numerous obstacles and difficulties, is among the main factors preventing utilization of ERP towards more strategic benefits. Probably the greatest obstacle is achieving a reasonable level of integration across enterprise processes and data, which in many cases can lead to decoupled or semi-integrated ERP implementation. Such implementation is a major compromise on one of the main objectives of investing in ERP. Decoupled modules, along with a department-centric mentality, contribute to the downgrade of valuable ERP data from being utilized in organization-level strategic decision making to being treated as departmental data used for day-to-day operations.

ERP vendors and customers' mergers and acquisitions and rapid changes in technology consume most of the resources allocated to the ERP program by getting caught up in a never ending spiral of systems upgrades and changes preventing top management and operational teams to consider utilization of ERP for decision making.

Other contributing factors identified were management training and systems' user-friendliness. Although majority of participants recognized the potential importance of ERP data for decision making, the majority of managers and decision makers had had no official training on using EPR, interpreting data or the potential benefits gained by using BI modules. In addition, although many ERP vendors have already invested in making their systems user-friendly and equipped with intuitive report writers and BI modules, most legacy systems and older versions of enterprise systems in use in first-tier ERP adapters suffer from a lack of user-friendliness, intuitive report and query generators or any BI modules.

Modeling

System thinking and modeling methodology

The systems thinking and modeling methodology used in this study was based on the SD methodology initially developed by Jay Forrester and others at the Massachusetts Institute of Technology in the late 1950s. Such an approach aims to understand the behavior of complex systems over time and deals with internal feedback loops and time delays that affect the behavior of the entire system [8].

A systems thinking and modeling methodology involves five distinct but interrelated stages: problem structuring, causal loop modelling, dynamic modelling, scenario planning and modeling, implementation and organizational learning (Figure 1).

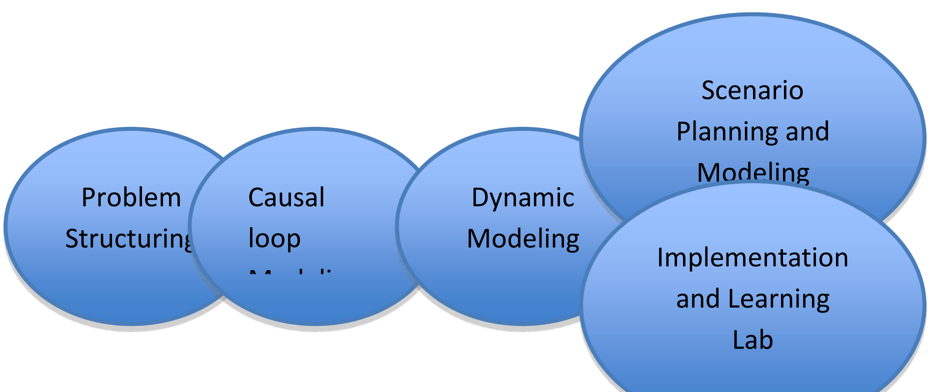


Fig. 5. Stages of the systems thinking and modelling methodology

The findings from the first and second phases of this study indicated a complex system with major factors interacting and changing their behavior over time. One could argue that major parameters do not follow a linear flow and are part of a dynamic system with complex feedback loops that change with time. Consequently, examining the dynamic behavior of the system over time can provide a deeper and richer understanding of impacting factors and their inter-relationships. Using the findings from the exploratory interviews and survey results together with information from the literature, a conceptual model was built and used to experiment with various proposed scenarios and behaviors. The purpose of this experimentation was to enhance our understanding of a system's behavior over time and of the roles and interactions of major parameters, in order to define strategies and policies towards better utilization of ERP systems in decision making.

It should be noted that this model is exploratory, in that it examines a theoretical model developed from observations and findings from exploratory interviews and survey results. The model, therefore, should not be considered comprehensive and final.

System structure and parametric model

This section describes the constructs and their relationships illustrated in Figure 2. Causal loops for each construct are analyzed and Causal Loop Diagrams (CLDs) are then used to construct Stock and Flow diagrams, which are the building blocks of the parametric model. In CLDs the emphasis is more on internal relationship between variables and less on exogenous variables. However, any relevant exogenous variables are displayed in the diagrams.

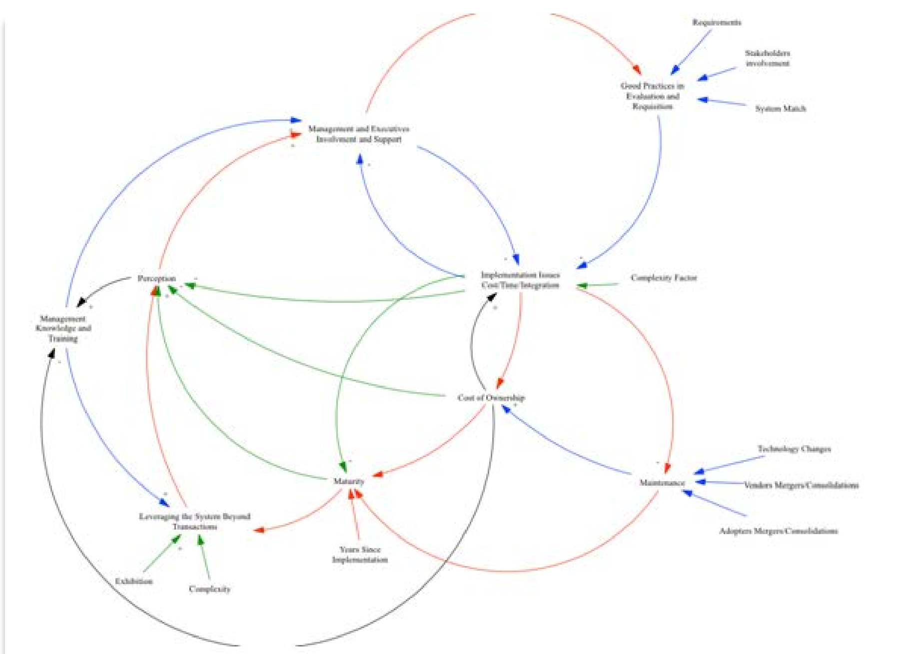


Fig. 6. Causal Loop Diagram

Implementation issues

Implementation issues – including time and cost overrun and integration – are at the heart of this model. These issues, problems and obstacles have been the subject of numerous surveys, case studies and reports in both academia and industry [9,10,11,12,13,14]. These studies focused mainly on critical success factors impacting the successful implementation of ERP, and they often failed to investigate existing interactions between parameters across the whole system. In the conceptual model developed for this research, implementation issues were analyzed as high-level parameters interacting with the rest of the system over time. Figure 3 shows the causal loop model for implementation issues based on the findings in previous phases of this research.

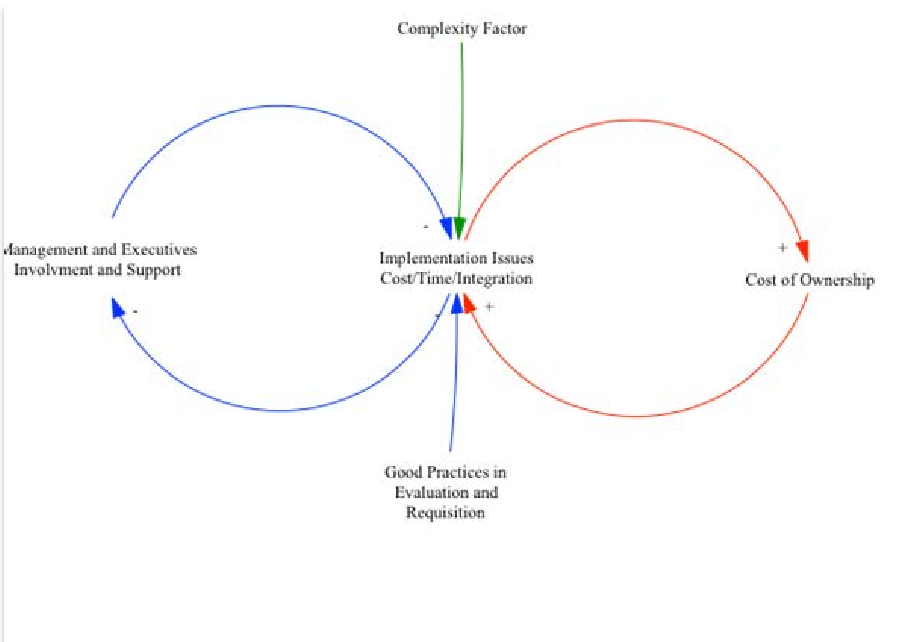


Fig. 7. Causal Loop: Implementation issues

Two reinforcing feedback loops in this model represent growing and declining actions. The first reinforcing loop shows that management and executives' involvement and support results in fewer implementation issues, which could improve management support and commitment to the project. Management and executives' involvement and support could decrease implementation issues and successful implementation, and fewer operational issues is a contributing factor to improving management support and their active involvement. This loop has been identified as a major critical success factor for systems implementation success in general and to ERP implementation specifically [15, 16]

The second reinforcing loop shows that implementation issues such as cost and resources and integration could have a direct impact on the cost of ownership, which in turn contributes to more issues arising in implementation. This loop is supported by both the findings of this research and the literature.

Cost of ownership

Cost of ownership of a system consists of implementation, running and upgrade/maintenance costs. This cost is significantly influenced by the success of the project's implementation. Any technical or non-technical implementation issues usually lead to greater cost, and greater cost and a tight budget can increase the difficulty of implementation. This creates a reinforcing loop, which is depicted in Figure 4. The findings from survey data analysis indicated significant correlation between these parameters.

Cost of ownership is influenced by a balancing loop, which includes maintenance and upgrade. Maintenance and upgrade activities cause increased cost, which increases the problems with implementation. However, organizations facing difficulties with implementation, such as technical, process and integration issues, tend to decrease their upgrade and maintenance activities, thereby causing a balancing loop.

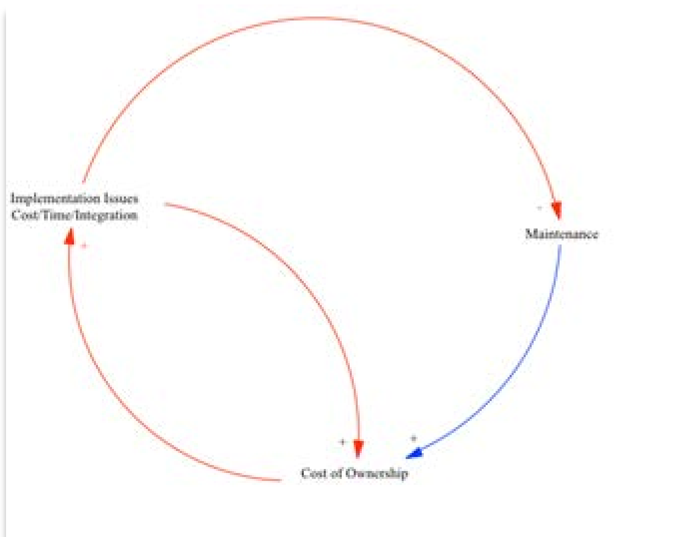


Fig. 8. Causal Loop: Cost of ownership

Maintenance

Maintenance, changes and upgrades activities cause the cost of ownership to increase, which in turn increases the project's implementation cost. At the same time, increased difficulties in implementation mean that maintenance, changes and upgrades become less frequent due to lack of resources. This is a balancing loop which works against the reinforcing loop between implementation issues and cost of ownership. These two causal loops are depicted in Figure 5.

Maintenance, changes and upgrades are also strongly influenced by exogenous variables such as ongoing technological advancement and changes, and ERP vendors' and adopter's mergers and consolidations. These variables have been explained in more detail in previous chapters.

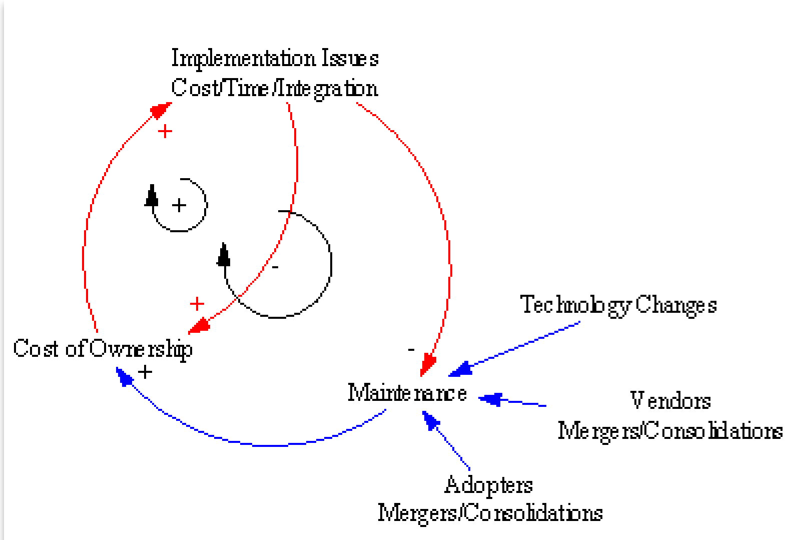


Fig. 9. Causal Loop: Maintenance and upgrade

Maturity

The process of adaptation between organizations and ERP system is referred to as maturity. This process is often long and sometimes never ending. Findings of this research showed that the process of maturity in ERP implementation is always under the negative impact of increasing cost of ownership, constant maintenance, and upgrade and implementation issues. At the same time, maturity could lead to executives and managers acquiring a more positive perception of ERP systems, which eventually leads to their involvement and support in the ERP implementation and adaptation process. The increase in managerial involvement could decrease implementation problems. These causal links are depicted in Figure 6. In the causal diagram there is one reinforcing loop and one balancing loop, working against each other

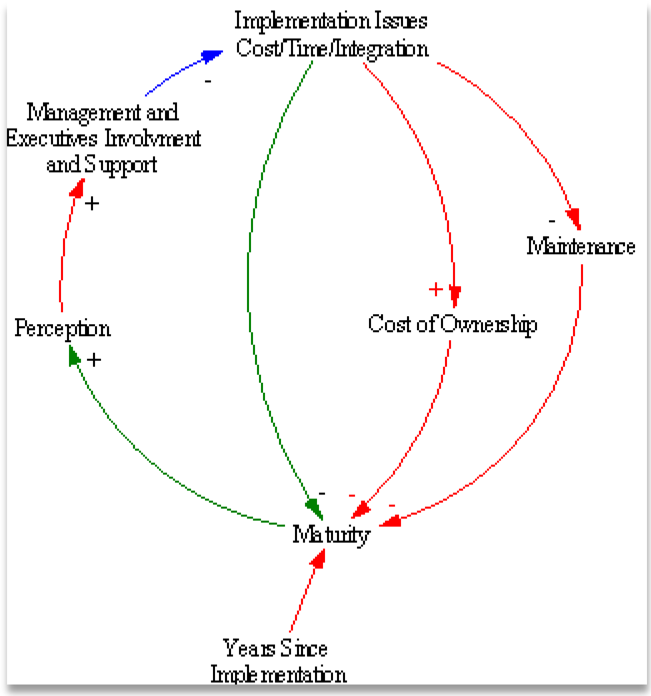


Fig. 10. Causal Loop: Maturity

Perception

Executives’ and managers’ perception of an ERP system is influenced by how the system is being implemented and used, particularly in terms of the system’s more strategic benefits. The factors impacting managers’ and executives’ perceptions, based on both my findings and the literature, are captured in the causal loops presented in Figure 7.

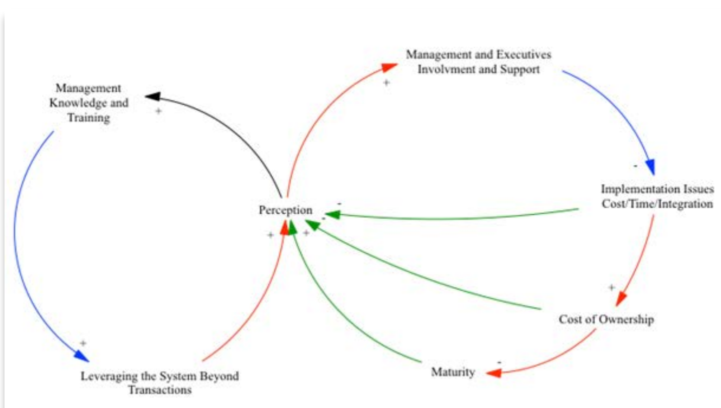


Fig. 11. Causal Loop: Perception

Perception is impacted by four loops. The first reinforcing loop shows that increasing positive perception encourages managers to gain more training and ultimately knowledge, which in turn leads to leveraging the system beyond its transactional capabilities and more towards strategic benefits.

Another reinforcing loop involves positive perception increasing management involvement and support in the adaptation process. This has a direct impact on reducing implementation issues, which in turn reduces the cost and leads to gaining maturity, which helps increase the positive perception. Two other reinforcing loops within the big loop indicate the direct impacts of cost and implementation issues on perception.

Management knowledge and training

One of the important factors influencing the adaptation process of enterprise systems, and utilizing them to their full potential, is the level of management knowledge and training about these systems. Our findings and the literature suggest this factor is influenced by two reinforcing loops, as shown in Figure 8. On one side it helps to utilize the system beyond its transactional capabilities, thus providing strategic benefits that lead to change management perception in a positive way. This positive perception then leads to increased management knowledge and training by providing the required resources.

On the other side, the cost of ownership influences the budget allocated to training, and so the cost of ownership has a negative causal relationship with this variable.

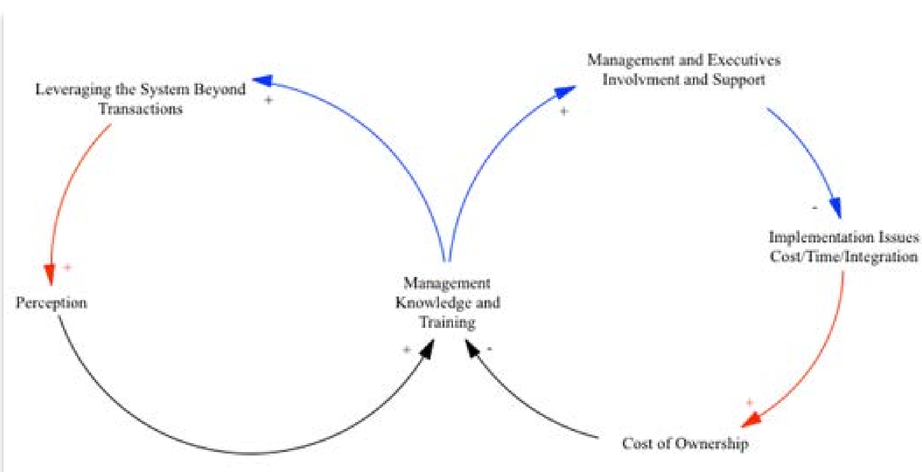


Fig. 12. Causal Loop: Management knowledge and training

Management and executives' involvement and support

The literature investigating ERP from different aspects highlights that a key success factor is management and executives' involvement and support at the time of implementation and during the life of the system.

Our findings also showed that greater management involvement and support reduce implementation difficulties and eventually create the reinforcing loop on the left-hand side of Figure 9.

Another reinforcing loop on the right-hand side of Figure 9 shows the impact of this variable on good practices in evaluation and requisition. The positive impact leads to fewer implementation issues, which eventually increases management involvement and support.

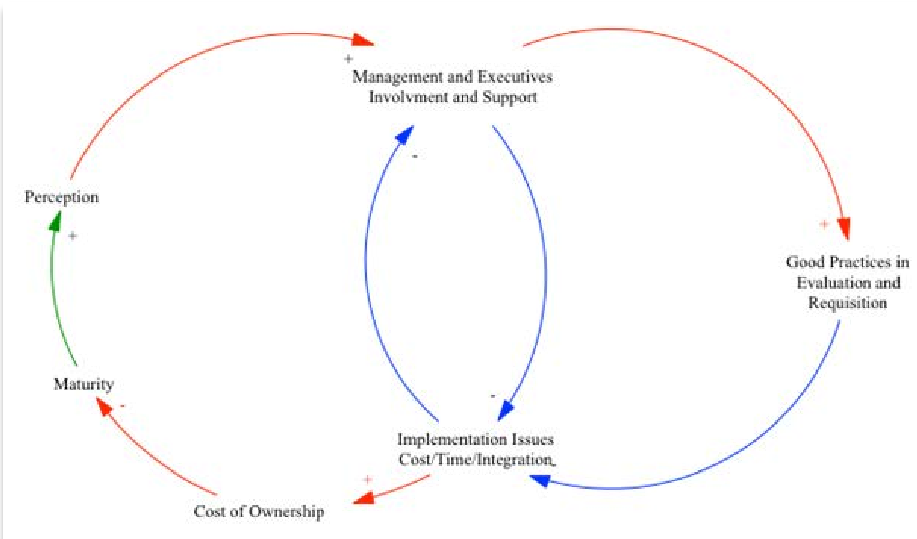


Fig. 13. Causal Loop: Management and executives' involvement and support

Dynamic modeling

SD model was built based on building blocks explained in causal loop diagrams earlier. The main objective in building the model was to examine how the interaction between different system elements and their causal relationships creates a dynamic system. The model was also used to perform sensitivity analysis in order to design strategy and policies to facilitate the greater use of ERP systems for their strategic benefits, beyond the usual transactional and operational benefits.

The ability to experiment with various policies and situations provided both theoretical and practical benefits, and enhanced our insight into the system's behavior in terms of its structure, exogenous variables values and causal effects.

Limitations and assumptions

The dynamic model was a translation of the causal diagram in Figure 2 and its variables, explained in the previous section. The following assumptions and limitations applied to the SD model:

The causal relationships presented in the model were mostly supported by literature and our findings. However, in some instances the logical structure of the model was the main reason for some of the connections and links. In the causal model, all types of links were colour-coded as ‘supported by literature’, ‘supported by this research’ or ‘added due to logical structure’. As the SD model was based on the causal model, all these links were relevant in the SD model.

The majority of variables in this model were difficult to quantify, and so we took an indexed approach. We assumed each variable was allowed to move in a band between upper and lower limits of 130 and 70, respectively, with a normal value of 100. We nominated the unit of measurement for all these variables as ‘unit’.

Exogenous variables in the model were assumed to have initial values or trends based on the literature or on my findings. These data were neither precise nor based on collected data; rather, they were an approximation to show the impact of changing variable on system variables. We also used these variables for performing sensitivity analysis.

We assumed that each reservoir (level) variable had an initial value of 100 and the rates of flow into and out the accumulators were impacted by an accumulated value at any given time.

We used month as the time unit for this model and ran it over a period of 100 units of time.

Model structure

The basic structure of all reservoir variables was assumed to follow the rules and equations represented in Figure 5.11 and the equations presented in the subsequent paragraph.

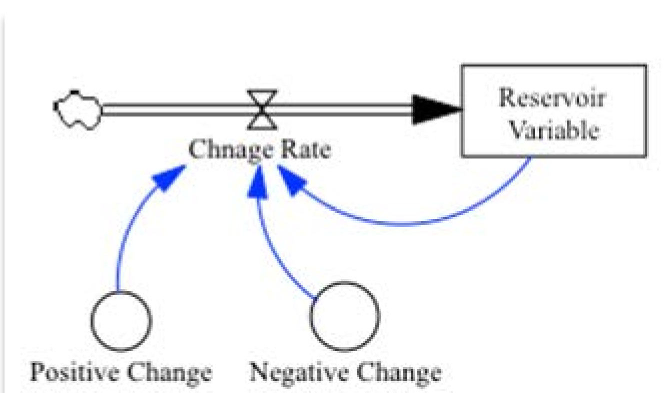


Fig. 14. Basic reservoir structure

The value of Reservoir Variable at any given time (t) is equal to its value in a fraction of time earlier (t-dt) plus the change rate in dt. This was defined in the model with the following formulas:

$$\text{Reservoir Variable (t)} = \text{Reservoir Variable (t-dt)} + \text{(Change Rate)*dt} \qquad (1)$$

$$\text{Where Change Rate} = \text{Reservoir Variable * (Positive Change + Negative Change)}$$

$$\text{Reservoir Variable Initial Value} = 100$$

Based on the above structure and the causal loop model, the elements of the SD model are shown in Figure 11. The equation follows the figure.

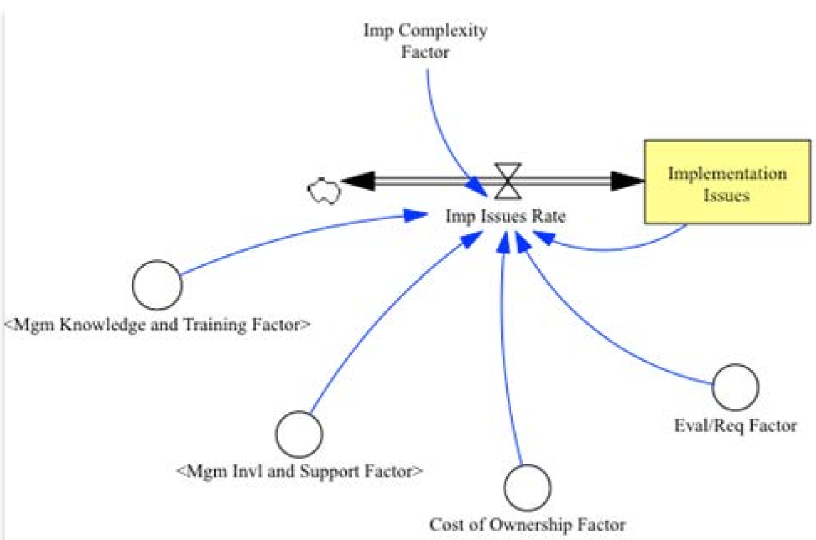


Fig. 15. Implementation issues structure

Implementation Issues (dt)= Implementation Issues (t-td) + Implementation Issues*(Cost of Ownership Factor-"Eval/Req Factor"+Imp Complexity Factor-Mgm Invl and Support Factor) (2)

Imp Complexity Factor is an exogenous variable used for testing the sensitivity of the system towards the complexity of the system. For the first simulation we used a constant value for this variable.

Other variables in this model translated reservoir variables values into factors that were used to calculate other variables in the model. Each of these was a function of the reservoir variable that they translated. We used that same logic to construct all the translation variables in this model. We assumed that all reservoir variables changed between the values 70 and 130, with 100 the equilibrium and initial value. Translating this range to factors that impacted on other variables in the model was based on a curve that was almost neutral around 95 to 105, and then slowly increased or decreased depending on the value of reservoir variable (Figure 12). In the model all factors were the same translation of reservoir variables.

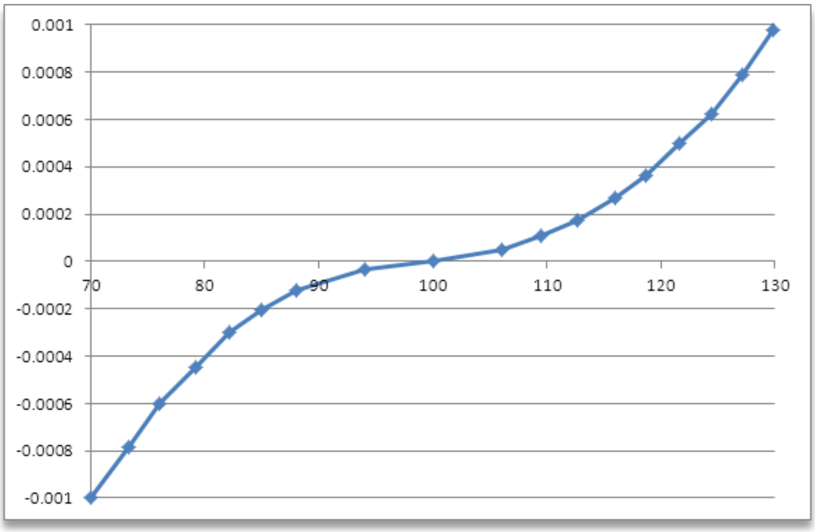


Fig. 16. Standard translation function across the model

Putting all these variables together provides a picture of the model with all its variables and links. This model is presented in Figure 13. Exogenous variables are colored orange and reservoir or level variables are yellow.

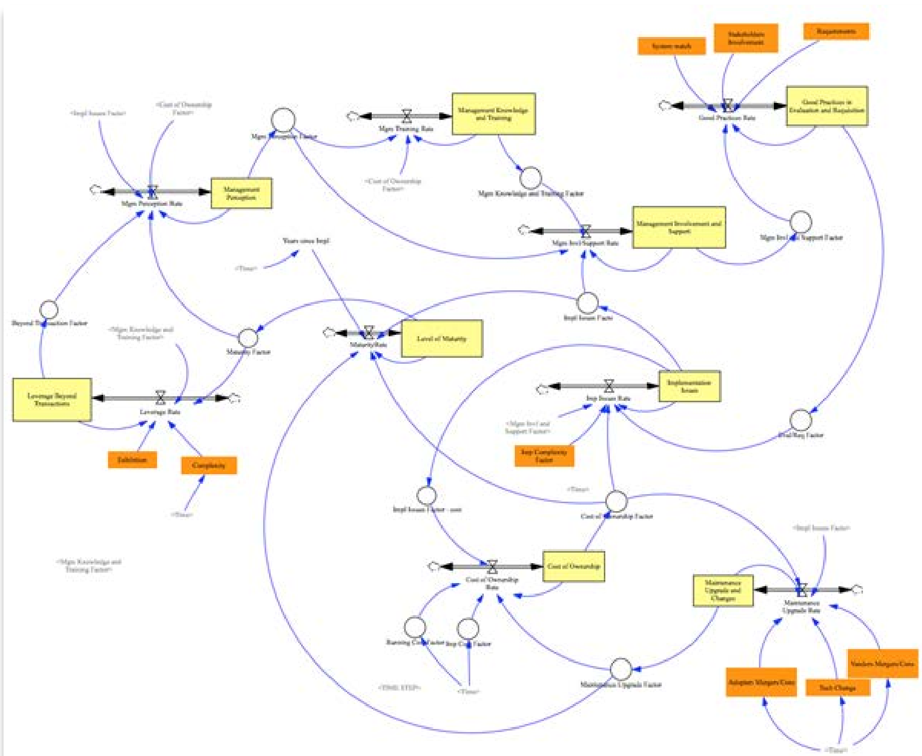


Fig. 17. Integrated level and rates diagram

Reference mode

The first step of experimenting with the constructed model was to define the problem this model represents. This problem definition in SD terminology is called the reference mode. The reference mode may contain actual variables from collected data and abstract variables representing qualitative information. In the reference mode we assumed that exogenous variables “technology changes”, “vendors’ merger and consolidation” and “adopter merger and consolidation” followed an upward trend, represented in Figure 14. This trend was not based on any historical quantitative data and purely represented past experience and expected trends. In the reference mode we could not make similar assumptions for other exogenous variables because all could have different values based on system adopters and environmental circumstances. Therefore we left the other six exogenous variables as 0, and leave their impacts to be discussed in the sensitivity analysis section.

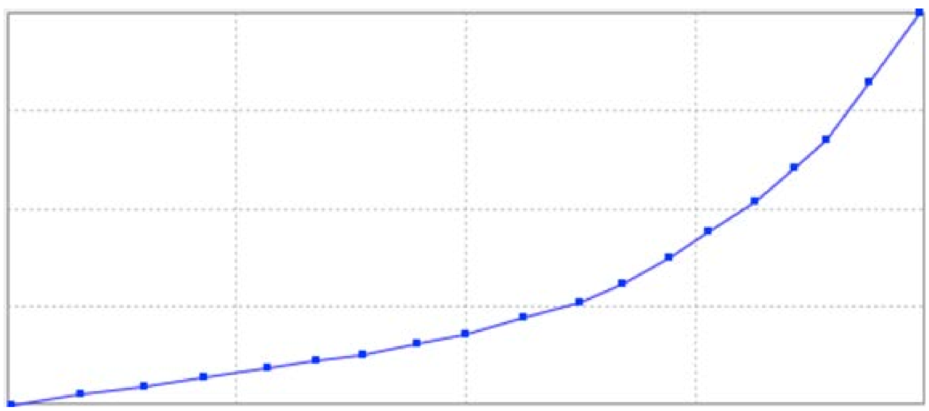


Fig. 18. Exogenous variables (technology changes, merger and consolidation) over time

Another two exogenous variables with initial inputs for the reference mode were “implementation cost factor” and “running cost factor”. Implementation cost factor represented the initial cost of adopting the system, which reached a maximum in the first few years and gradually reduced to 0. This is represented in Figure 15. This trend was not based on any historical quantitative data and purely represented past experience and expected trends.

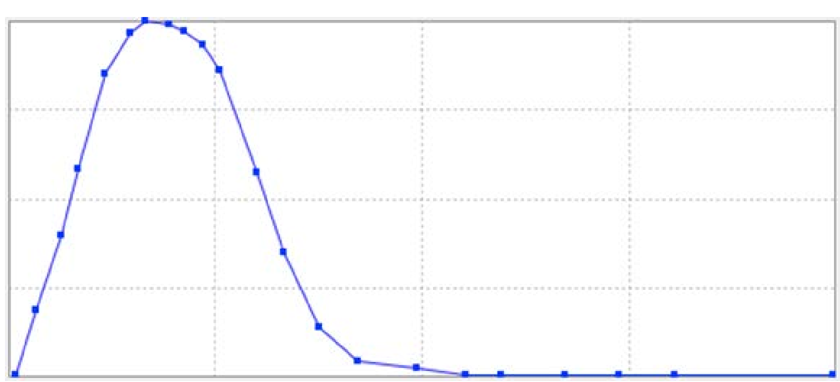


Fig. 19. Exogenous variables (implementation cost) over time

Running cost factor represented the ongoing cost of adapting the system. This cost could go up the first few years and then stabilised for the rest of system's life (Figure 16). Once again this trend was not based on any historical quantitative data, but represented past experience and expected trends.

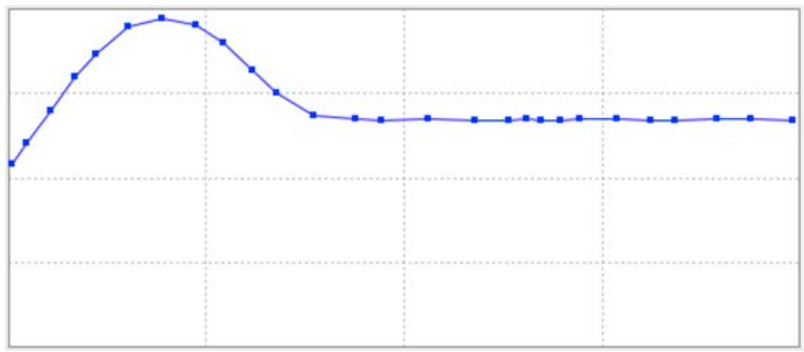


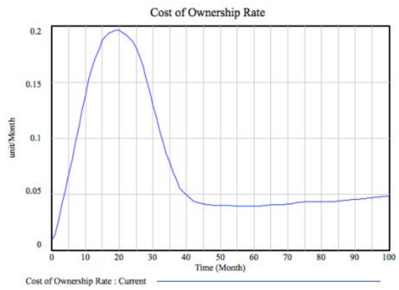
Fig. 20. Exogenous variables (running cost) over time

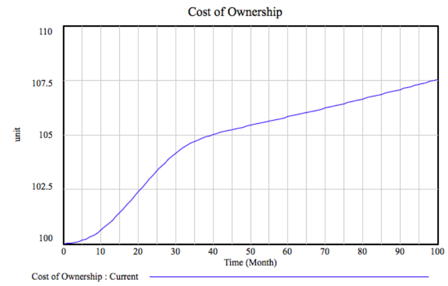
Simulating reference mode.

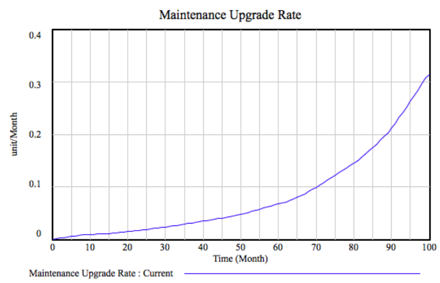
We ran the model for 100 months in the reference mode, with exogenous variables values as described in this section. Most variables behaved as per expectations, verifying that the model structure had no major defect and could be used to analyze the impact of other variables as they were added individually into the simulations. Figure 17 shows the system outputs for the reference mode.

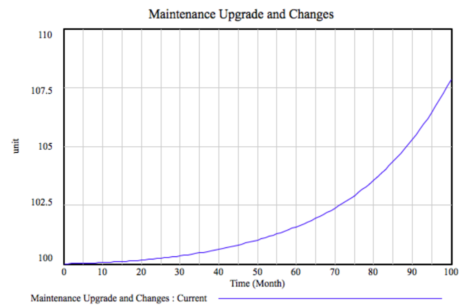
Cost of evaluation, acquisition and implementation initially increased rapidly in the first few years and then dropped to a level of ongoing cost. This started to increase from period 50 again as more system change, maintenance and upgrade was required due to the age of the system.

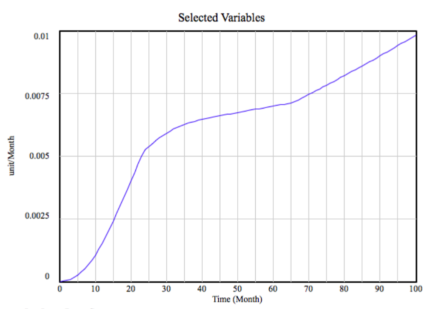
Increasing cost of maintenance and upgrade level variable was a result of an increase in three exogenous variables: "technology changes", "vendors' merger and consolidation" and "adopter merger and consolidation". The impact of increasing cost of maintenance, upgrade and change, along with the cost of ownership initially caused implementation issues to increase exponentially, which in turn had a negative impacts on maturity. This in turn caused a decline management perception, management support, management knowledge and training, and eventually led to less chance of leveraging the system beyond its transactional capabilities (Figure 17).

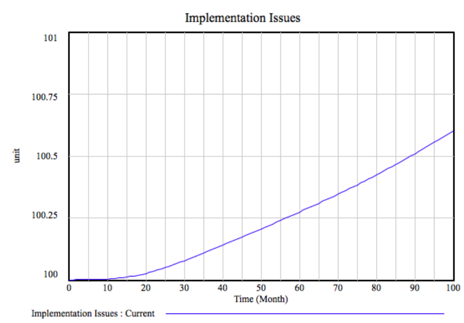

Cost of Ownership Rate
unit/Month
Time (Month)
Cost of Ownership Rate : Current

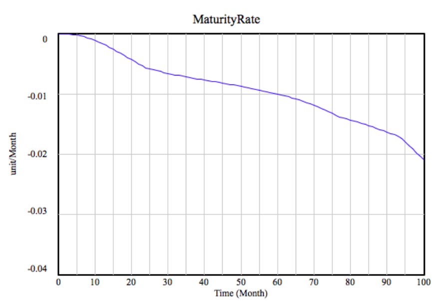

Cost of Ownership
unit
Time (Month)
Cost of Ownership : Current

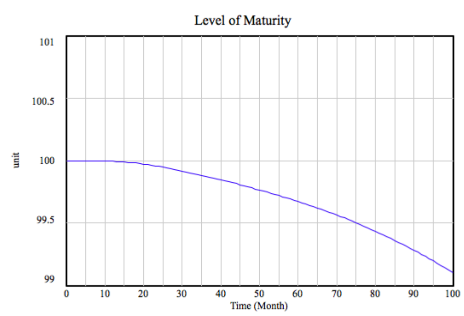

Maintenance Upgrade Rate
unit/Month
Time (Month)
Maintenance Upgrade Rate : Current

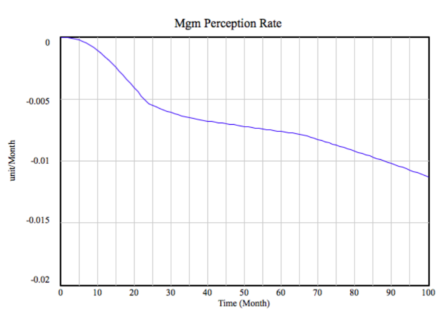

Maintenance Upgrade and Changes
unit
Time (Month)
Maintenance Upgrade and Changes : Current

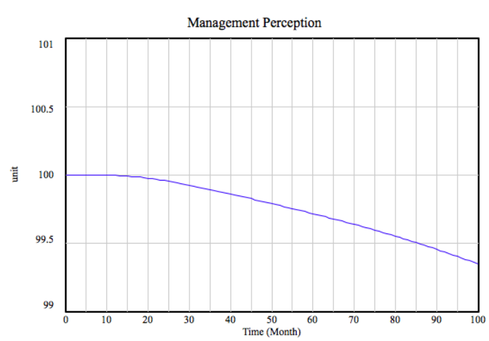

Selected Variables
unit/Month
Time (Month)
Imp Issues Rate : Current


Implementation Issues
unit
Time (Month)
Implementation Issues : Current


MaturityRate
unit/Month
Time (Month)
MaturityRate : Current


Level of Maturity
unit
Time (Month)
Level of Maturity : Current


Mgm Perception Rate
unit/Month
Time (Month)
Mgm Perception Rate : Current


Management Perception
unit
Time (Month)
Management Perception : Current

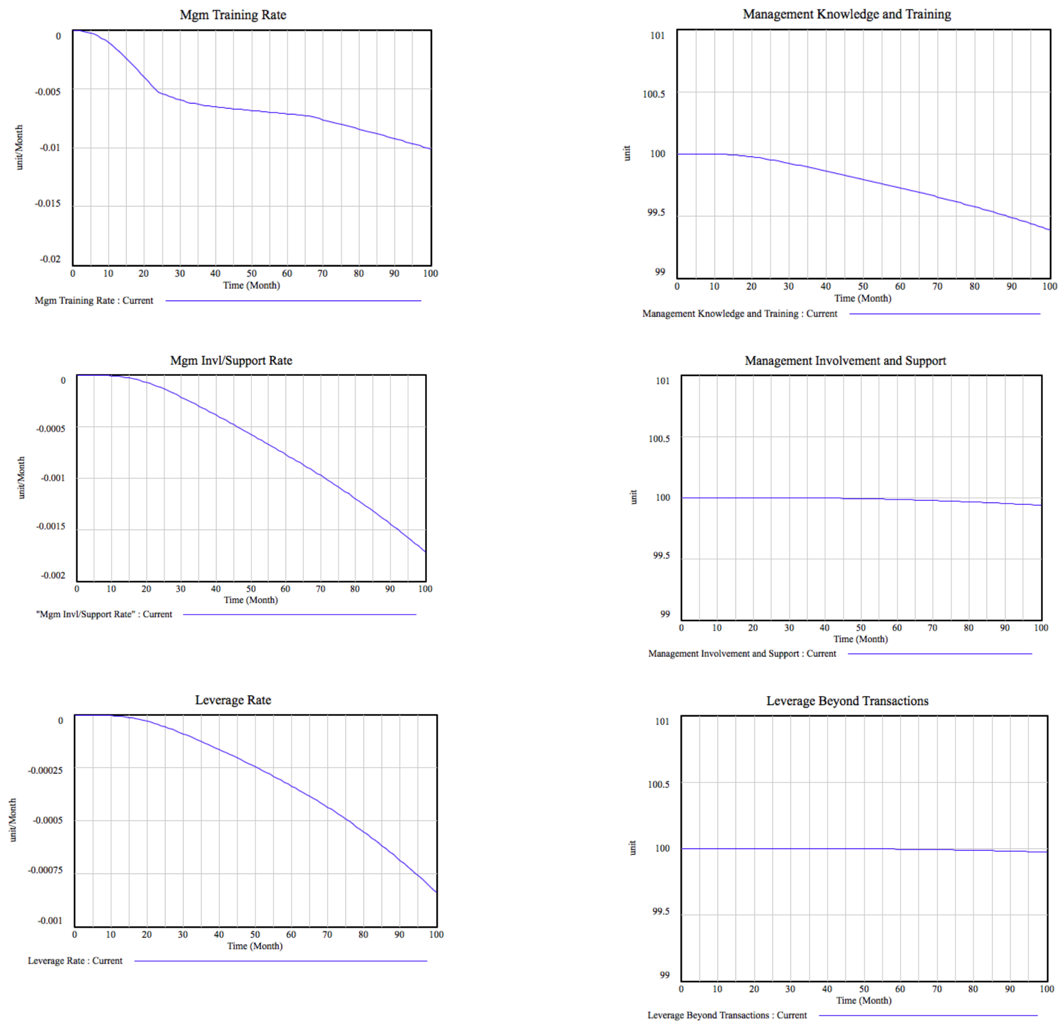


Fig. 21. Variables behavior in reference mode

Scenarios

The reference mode presented in the previous section provided a realistic result based on the findings in the early part of the research. Using the SD model we tried to run different scenarios in which we changed this situation based on different values/trends given to variables. We considered the reference mode as a non-ideal situation, although it more or less represented what we had found in the qualitative and quantitative data analysis.

We conducted two simulated scenarios, which we called “ideal” and “promising”. The ideal scenario presented a situation where all variables were moving in the right direction, system implementation was done with reasonable cost and effort, and it had matured by the time its strategic benefits, such as helping management to make better decisions, were realized. In the promising scenario we tried to improve the reference mode so that it more closely represented the current situation, with realistic and reasonable strategies. This scenario should be the one to be used for practical improvements in real-life implementation.

Sensitivity Analysis

We used sensitivity analysis tool in our SD modeling tool. The screen shot in Figure 18 displays a portion of the model in this mode. By examining all variables, it was evident that implementation complexity factors and exhibition of decision support functionality and features were having major impact in changing the system output towards positive territory.

This result indicated once again the importance of successful implementation on all other variables in the process of adaptation between organization and enterprise systems. It was also clear that the tool and its functions and features played a significant role in achieving higher degrees of utilization of ERP systems towards decision making. At the same time, maintenance and upgrade policy and changes made to the model didn't seem to significantly impact on trends.

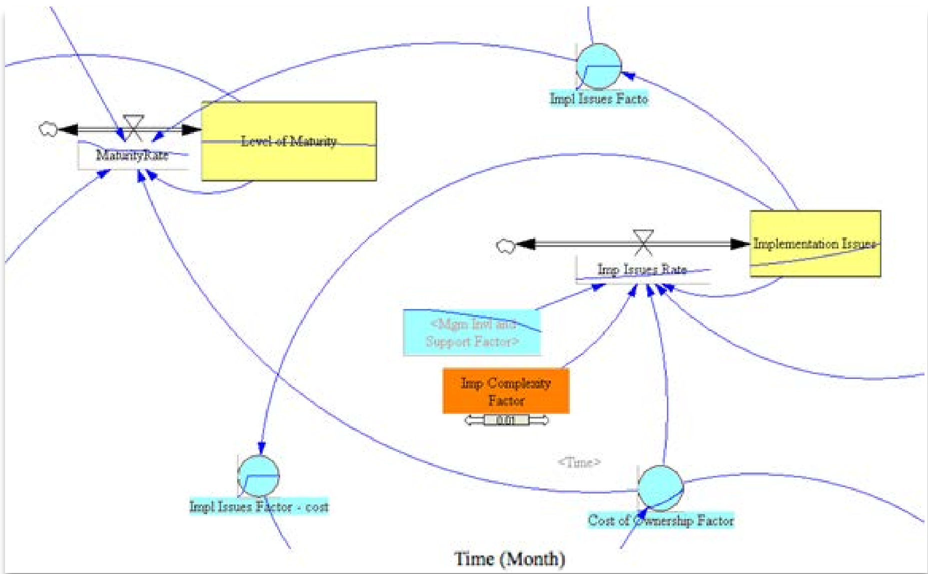


Fig. 22. Sensitivity analysis

Contribution

This research was designed to investigate the topic from three different perspectives: expectations, exhibition and realization. Based on our findings stakeholders and users of enterprise systems perceive substantial importance in the potential of ERP to improve the decision-making process, at both strategic and operational levels, by providing necessary information and the tools and capabilities necessary to enhance the decision-making process (expectations). However, in practice, this positive perception doesn't materialize to an acceptable degree among first-tier ERP adopters in Australian organizations (realization). Also, from participants' perspectives, ERP systems provide few capabilities and features for decision support (exhibition). Further investigations into these three main categories revealed some of the factors that prevent the realization of these benefits. These factors and their potential impacts and interactions were discussed previous sections and are briefly summarized here.

Users and stakeholders expressed their high expectation of enterprise systems and the potential impact on the decision-making process and decision quality. However, this expectation has not generally led to the inclusion of ERP decision-support features and capabilities among the main objectives for investment in ERP. In another words, decision-support features of ERP do not play an important role in the evaluation and requisition process.

In addition, participants do not perceive that ERP systems provide capabilities that help improve their decision-making process or that provide information to help managers and users make more informed decisions. In the context of this research, adopters' high expectations do not match the exhibition of capabilities and features in ERP systems. This is despite the fact that an increasing number of enterprise systems have been introducing business intelligence modules and decision-support capabilities in recent years. Future research could investigate the barriers and obstacles preventing organizations from using these tools in practice.

Although a lack of exhibition of decision-support features and capabilities was among the reasons found for not realizing such benefits in practice, further investigation into the problem suggested that the numerous obstacles and difficulties of the ERP adaptation process are among the main factors preventing utilization of ERP towards more strategic benefits. One of the greatest obstacles is probably achieving a reasonable level of integration across enterprise processes and data. In many cases this has led to decoupled or semi-integrated ERP implementation, a major compromise on one of the main objectives of investing in ERP. Decoupled modules, along with a department-centric mentality, contribute to the downgrade of valuable ERP data; rather than being utilized in organization-level strategic decision making, these data are being used for departmental day-to-day operations.

One of the exogenous factors having impacts on the research topic is the increasing numbers of ERP vendors and customers being merged, bought or consolidated. As a result, continuous changes in ERP systems, the need for integration between different ERP systems and the consolidation of data from different sources consume a good portion of allocated budgets to ERP programs, preventing organizations reaching the maturity stage in their adaptation process.

Other major factors affect management training and systems' user-friendliness. Although most participants recognized the impact of ERP systems for making better decisions, the majority of managers and decision makers had no official training in using EPR, interpreting data or recognizing the potential benefits to be gained by using BI modules. In addition, although many ERP vendors have invested in making their systems user friendly and have equipped them with intuitive report writers and BI modules, most legacy systems and older versions of enterprise systems used by first-tier ERP adapters lack any such features. Even for those systems with effective user-interface and BI modules already in place, these features are not easily accessible due to users' lack of training or awareness.

Building the SD model served to provide better understanding of the phenomenon in its entirety, using a systematic approach. In addition, the sensitivity analysis highlighted the strength of the model's sensitivity towards implementation. This means efforts in reducing complexities in both implementation and the ongoing adaption process will successfully reduce the cost of ownership in the long term, eventually leading to an increased rate of maturity and greater utilization of the system for decision making. Such a situation happens only with favorable conditions in exogenous variables, such as the exhibition of decision-making capabilities and features. A system that exhibits features and capabilities for decision making with manageable implementation issues could lead to the exponential growth of utilizing such systems towards their strategic benefits.

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Impacts of Enterprise Resource Planning implementation on decision making processes in Australian organisation

Abstract - *This paper reports on findings from the first phase of research investigating Enterprise Resource Planning (ERP) and its impacts on decision making process in Australian organisations. The focus of the study is to reveal if and how the vast amount of data which is generated by ERP systems could improve decision making process on strategic and tactical levels. The findings are based on data consists of information collected by fifteen semi-structured interviews and observation in fifteen medium-size organisations in different industries operating in Australia who have been using ERP systems for at least five years.*

Keywords: ERP, Decision Making, Decision Support Systems

Introduction

ERP Definition and evolution

In recent decades, the term ERP has been used by both practitioners and academics in divergent applications and as a result it has acquired number of different meanings and also allowed for confusion regarding the meaning of the term. In fact, the term ERP itself could have contributed to the confusion, as 'Resource Planning' is not the main purpose of acquiring ERP systems.

ERP is a set of integrated, configurable information systems applications software that can be bought 'off-the-shelf' and tailored by an organisation in order to integrate and share its information and related business processes within and across functional areas [1]. Such off-the-shelf packages (as opposed to applications built in-house) help organisations manage important aspects of their business, such as accounting, finance, manufacturing, distribution, human resources and sales [2, 3]. ERP eventually enables organisations to achieve inter-organisational supply chains [4,5] by evolving into Extended ERP systems that can exploit technological advances in the areas of internet and electronic commerce, and support inter-organisational processes on an extended network of supplier and distributors [6].

The fundamental capabilities of ERP systems come from transaction processing and structured record keeping of those transactions, and not 'planning' as the name Enterprise Resource Planning suggests. Although planning and decision support applications can be optional add-ons, they are not the core capabilities of the system [7].

Research Method

This research is a preliminary step to examine the extent to which adapters of ERP systems benefit from potential decision support characteristics of such systems. The aim is to investigate the problem from different perspectives such as user expectations, exhibition of decision support features in ERP systems and actual realisation of such benefits in practice within Australian organisations.

Decision support characteristics of ERP systems and its utilisation in practice has not been the focus of notable number of research both in industry and academia spheres.

The lack of knowledge and theory on the underlying research question is the main reason to design this research as a two-stage study based on qualitative and quantitative methods. In the first stage of this research qualitative methods are utilised to investigate the current status of Australian organisations and industry practitioners in regards to utilising ERP systems towards decision making process. In this stage, semi-structured exploratory interviews with purposefully selected participants were conducted in order to cater for the lack of underlying knowledge and theories and comprehensive studies on the main subject of the research in the Australian context.

In the second stage, gained insight from the qualitative stage is utilised to provide necessary foundation to make effective use of qualitative methods to investigate the subject in more depth and details.

This paper represents findings from the first stage of the research. Paradigm advocated in this paper is qualitative and culminates to assumption that reality is subjective and multiple, and the world can be understood best from the point of view of the individuals directly involved in the activities in question. The emphasis is on understanding the unique features of the phenomenon in subjective reality rather than its totality in objective reality. As a result, managers and senior managers involved with ERP systems in Australian organisations were regarded as the most appropriate informants. Semi-structured interview approach with open-ended questions was utilised to collect data consisted of real stories, experiences and insights. Researchers' personal experience with ERP systems also contributed to the construction of meanings throughout the research process [8].

Participants

Research participants were purposefully selected from Australian organisations in technology, defense, finance, logistics and telecommunications sectors. All of these organisations are in the first tier ERP market and have been using at least two of the main ERP modules (manufacturing, financials, and human resources) for the last five years. Participants were senior managers and middle managers and professionals who can potentially benefit from ERP decision making capabilities or have been involved with implementation and day to day use of ERP systems in those organisations.

Data collection

For the first stage of this study data consists of material collected from semi-structured interviews with open-ended questions which were conducted with twenty participants, reflection notes which were taken during interviews and researchers' personal experience with ERP systems. In order to enhance interview process and to improve interviewer's skills and questions quality, few pilot interviews were conducted with researcher's colleagues. After pilot interviews, interviews with participants were conducted in participants' offices and in two cases by phone.

Prior to each interview, interviewee was briefed of the study objectives. Also information statement and consent form were presented to each participant for their review and signature. Also, with participants' permission all interviews were digitally recorded and interview transcripts were produced after each interview. Reflection notes were attached in each interview transcript as an appendix. Audio files were repeatedly listened to ensure no omissions. Final transcripts were emailed to participants for their review and approval.

Data Analysis

Interview transcripts were analysed according to an open coding technique [9]. Data was first broken down by taking apart sentences, paragraphs, reflection notes and observations. Each separate idea or event was given a name. Data were then regrouped into categories that pull together groups of ideas and events that become subcategories. The next step was the axial coding which aims to identify main categories and to make connections between them and their subcategories. At this stage of coding researchers' personal experience reflected upon the way these categories and relationship between them was shaped.

Interviews emerging themes

The followings were the main themes emerging from the interviews. Emerged themes cover a wide spectrum of issues surrounding ERP implementation and usage and it might seem not being directly related to the main question of this research. However, documenting these themes, identifying key parameters and establishing relationship between them, provided valuable fundamental data to build a Systems Dynamic model which is the methodology for studying behaviour of complex feedback systems over time. The System Dynamics model uses quantitative data collected from second phase of data collection. The model, quantification and simulation of this system will be presented in a separate paper.

A summary of emerged themes was communicated with interviewees via email to validate the findings. The validation process raised some discussions and feedbacks helping researchers to increase the validity and reliability of findings and increase the researchers' confidence that these themes are major factors playing roles in ERP implementation and its effects on decision making process within Australian organisations.

Decision support as an objective for ERP adoptation

There are different views in the literature in regards to decision support as an objective for ERP adoption. For instance, Davenport [10] identifies the 'need to make sound and timely business decisions' as a major reason for adopting ERP systems. However, this view is not supported by research and based on most of the current literature decision support is not explicitly recognised as a major reason for implementing ERP systems [11]. Literature suggests that expectations will change as organisations reach certain stage of maturity in their adaptation process. Hawking et al. [12] argue that companies who are becoming mature in their ERP implementation by achieving operational objectives, start exploring the possibility of leveraging their investment on ERP towards more strategic benefits such as supporting decision making process and information analysis activities. It is only at this stage that the anticipated benefits from the investment in ERP will eventually be realised [1, 11, 13, 14, 15]. However this proposition has not been investigated vigorously and it is not supported with empirical evidence.

Based on different studies, the first tier ERP market in Australia is highly saturated with estimated 75 to 95 percent of potential ERP rollouts already completed. This includes organisations which could be categorised under the first tier ERP market and most of them completed their ERP rollouts before year 2000. Based on the literature this community of mature ERP users who are entering the final stage of their evolutionary process of maturity should now be looking for ways to leverage their investment in ERP to the next level by utilising ERP capabilities towards decision making and information analysis activities [14, 15]. Our interview participants were mainly from this category of organisations.

In line with the literature, an emerging theme in our interviews data analysis is that decision support is not an objective for implementing ERP.

Despite what is suggested in the literature that stakeholders and decision makers' expectations change towards more strategic benefits by going through maturity process, our data analysis shows that their expectations do not change by going through maturity process. In fact, the notion of maturity process was questioned and rejected. Based on our finding, organisations do not get matured in their ERP implementation in the same way as assumed in the literature. Many factors such as operational obstacles, upgrade spirals and integration complexity emerged as affecting maturity process preventing organisations to exploit the use of ERP for more strategic benefits such as decision making, data analysis and business intelligence (BI). These factors will be discussed in coming paragraphs in more detail.

ERP decision making features is not an important factor in evaluation process

An emerging theme from our data analysis is that decision support features are not considered to be an important factor in evaluation and selection process. This finding comes as no surprise as we also found that these features were not objectives for ERP implementation and as a result they have no role to play in the evaluation and selection process. This is in line with the findings of limited number of research that investigated the subject [1, 11, 13].

Stakeholders’ low expectation of ERP decision support features could play a role in the lack of utilisation of existing features and capabilities and also lack of improvement on such features from the vendors side.

Perceived importance of ERP for decision making process

Although decision making was not found to be an objective for implementing ERP, however, one of the strong emerged themes from our data analysis indicates the substantial level of importance that participants perceived for using ERP data for decision making. However such strong perception that ERP could potentially improve decision quality and timing by providing required data and process fails to materialise as it is explained in the next finding.

The role of decision support features of ERP in strategic and operational decision making process

One of the perceived benefits of implementing ERP systems is increased efficiency and effectiveness in business processes permeating managerial processes such as planning and decision making at all levels. Benefits such as real-time data availability and integration are thought to have positive impacts on decision support process [16, 17]. However, most of these propositions are based on the assumption that integration, data availability and data accuracy which are immediate benefits of a successful ERP implementation should automatically lead to better decision making process across an organisation. In fact none of the above propositions is based on empirical research.

An emerging theme in our data analysis is that information provided by ERP and decision support features of ERP are not playing an important role in strategic decision making, however, we found that in some instances operational decision makers partially benefit from features such as standard and ad-hoc reports and queries. In both strategic and operation decision making processes we did not observe ERP decision making features to be utilised to facilitate the process.

Participants who were senior managers in their organisations indicated that their decisions in the boardroom and their day to day decision are not directly affected by information extracted from ERP system let alone utilising ERP as a decision making facilitator.

Integration and Business Intelligence (BI)

Chou and Tripuramalu [18] argue that more and more organisations are turning to BI tools that make data collected by ERP and other data-intensive enterprise application meaningful for decision makers and in order to justify their return-on-investment. BI was coined by Howard Dresner of Gartner Group in 1989 to describe a set of concepts and methodologies designed to improve decision making by proving easier and faster access to corporate data across ERP and other enterprise systems. They argue that while ERP systems are designed to capture transactional data, BI tools provide analytical features to examine large volumes of data and generate essential information for decision making. Integration of BI and ERP systems contributes additional values by providing meaningful analysis such as online analytical processes (OLAP) and data mining tools to discover trends and patterns. Such capabilities increase decision making effectiveness and quality through utilising analytical capability of BI on ERP data which ultimately help organisations to gain competitive advantages [18].

Despite the literature and marketing materials indicating the rise of BI as a decision support tool and its acceptance at all levels of the organisation, we found that BI is not utilised in the first tier ERP organisations and is not one of the management priorities in their ERP program.

Many reasons were expressed as contributing factors preventing organisations to utilise BI and to benefit from potential strategic benefits. Operational difficulties such as implementation issues, integration difficulties, spiral upgrades as a result of technology enhancements and rapid waves of merger-acquisition among ERP vendors were some of the issues expressed as these obstacles. These obstacles consume available resources and take first priorities over "non-critical" features such as BI constantly. However as an emerging theme, integration between ERP modules and between ERP and other enterprise systems suck as CRM were identified as the main obstacle to BI utilisation. BI can provide real strategic benefits and decision making support when utilised on enterprise level across all departments and functions and this is only achievable if ERP modules are integrated and sufficient links between other enterprise systems and ERP are established. We found that none the organisations achieve acceptable level of integration between ERP modules and between ERP and other enterprise systems.

Decoupled ERP modules

Integration realisation at enterprise level is considered to be one of the main justifications for investment on ERP. In different ERP related studies integration has been directly linked to gaining strategic competitive advantage as a result of leveraging EPR to its full extent [16, 17, 19]. However, integration on enterprise data and process levels are proved to be a challenging task for most organisations.

The complexity of integration has forced many organisations to answer such a complex question with a simple answer: "decoupled ERP". When companies who invested millions of dollars to integrate their processes and data across the whole organisation find themselves in integration battlefield, they tend to compromise integrated systems for the sake of functional decoupled modules in different departments. Degree of decoupling could be different in different organisation: in some cases there is no real-time connection between any two ERP modules and in some instances vital links exists and only hard to achieve integration goals are compromised.

As an emerging theme in our investigation we observed that ERP systems have been implemented and being used in decoupled model in first tier ERP market in Australian organisations. In these cases implementation complications have forced management to accept decoupled model as a compromise to provide at least operational and transactional functionality across different functions.

Such decoupled ERP modules provide the minimum core transaction functionality across different departments. Usually these departments come up with procedures and mechanisms to pass information between decoupled modules to establish necessary data flow. However, with such compromised setup one of the main objectives of ERP implementation which is integrated real-time data availability across organisation [16, 17] never materialises.

As integration between ERP module is a vital necessity in order to utilise enterprise system data for decision making [20], decoupled ERP systems dose not provide such a vital platform for decision making and to utilise Business Intelligence (BI) modules of ERP.

In addition to decoupled ERP systems, departmental centric mentality also seem to be a contributing factor to downgrade ERP valuable data from being utilised in organisational level strategic decision making to departmental data useful for day to day operational use.

Adaptation process

The majority of the ERP literature is concerned with ERP adaptation. The term 'adaptation' is borrowed from the six-stage model of Kwon and Zmud [21]. In this model adoption refers to acquiring resources, technology and installation and the term adaptation refers to the process of adjustments and changes following the installation of such technology [21, 22]. The term adaptation signifies the importance and complexity of adaptation between the organisation and ERP which includes process, technical and cultural issues. While ERP vendors advocate that ERP embodies universally-applicable best practices, in reality adaptation between a company and ERP involves a process of change in both the ERP and the company via customisation, business process review and cultural changes. Numerous studies have investigated adaptation issues including evaluation, implementation, project management, success and failure factors, usage and maintenance, upgrade and extension, change management, business process review and socio-cultural factors affecting ERP implementation and usage.

An emerging theme in our data indicates that one of the main obstacles preventing the utilisation of ERP towards decision making is adaptation process. Numerous implementation issues are among main factors preventing ERP program managers to plan for utilising ERP towards more strategic benefits. The same factors reflected in dollar figures prevent top level management to support spending on decision making features while the main objectives of ERP has not been met yet.

Implementation and operational issues are diverse and covers a broad spectrum from evaluation to business processes and cultural issues. In this research we do not investigate these factors and only investigate them in the context of decision making process and the role they play in that process.

Upgrade Spiral

Technological advancements, ever increasing rate of merger-consolidation and acquisition among ERP vendors and increasing rate of merger and consolidation among organisations that use ERP systems have contributed to create an upgrade spiral which prevents ERP users to achieve reasonable level of maturity in their adaptation process. As an emerging theme, we found that never ending upgrade spiral consumes most of allocated budget to enterprise systems programs, preventing program managers to plan for utilisation of ERP in decision making process.

Other emerging themes

In our data analysis, the following themes were emerged which are categorised under other factors preventing the utilisation of ERP systems in decision making process:

Selective use of information: in the absence of uniform and standard decision making and business intelligence tools which provides unbiased visibility to organisational data, decision makers and managers give particular weight to information supporting their ideas and actions. At the same time they ignore information which does not support their ideas and actions. This tends to contribute undermining the importance of ERP data for decision making among managers and stakeholders.

Training: in our findings the potential importance of ERP data for decision making was recognised by all participants anonymously, however, we found that majority of managers and decision makers never had any official training on using EPR, interpreting data and the potential benefits gained by using BI modules.

User friendliness and cognitive: many ERP vendors have already invested on making their systems user friendly and equipped with intuitive report writers and BI modules, however, most of legacy systems and older versions of enterprise system which are in use in first tier ERP adapters suffer from the lack of user-friendliness, intuitive report and query generators or any BI modules.

Findings and discussions

There has been little examination on the extent to which decision-support benefits accrue to ERP adopters, or the extent to which they relate to various objectives in an ERP implementation [11]. Such study in the context of Australian organisations is particularly rare. In this research we utilised semi-structured interviews to gain insight to the current status of Australian organisations and industry practitioners in regards to utilising ERP systems towards decision making process. Based on our data analysis, ERP stakeholders and users perceive ERP to have strong potentials to improve decision making process on strategic and operational levels. However, such important potentials are not among main objectives for investment on ERP. Also we found that these potential benefits are not materialised in practice. Some of the main barriers and factors having effects on this are discussed in this paper and based on these finding some correctional actions are suggested which could be beneficial to both customers and vendors of ERP systems.

Based on our findings ERP adapters perceive substantial level of importance and potentials for utilising ERP data in order to improve decision making process on strategic and tactical levels. Perceived importance of decision support features is also recognised and been identified as a critical feature of such systems in the literature [11, 7]. However, supporting decision making process is not among stakeholders' objectives for adopting ERP.

We also found that decision support features of ERP systems do not play an important role in evaluation process which could contribute to minimal materialisation of such benefits in practice. This finding is supported by prior findings that supporting decision making process is not among stakeholders' objectives for adopting ERP. As supporting decision making process is not an objective then it is not part of evaluation process.

We found that although ERP is perceived to have an important potential role to support decision making process, these benefits are not materialised among first tier Australian ERP adapters. Some of the barriers and contributing factors preventing materialisation of these benefits are discussed in this paper. However, identification of all contributing factors or cause and effects relationship has not been an objective of this research.

We found that ERP adaptation process with its numerous obstacles and difficulties reported in the vast amount of research is among main factors preventing utilisation of ERP towards more strategic benefits. Probably the biggest obstacle of all is achieving reasonable level of integration across enterprise processes and data which in many cases lead to decoupled or semi-integrated ERP implementation. Decoupled or semi-integrated ERP modules implementation is a major compromise on one of the main objectives of investing on ERP. Decoupled modules along with departmental centric mentality also seem to be contributing factors to downgrade ERP valuable data from being utilised in organisational level strategic decision making to departmental data useful for day to day operational use.

In addition to issues related to adaptation process and integration, we found that upgrade spirals as a result of technology advancements, ERP vendors and customers' merger-acquisition consumes most of ERP program allocated resources and prevent BI implementation to be taken seriously among top management and operational teams. In the absence of uniform and standard decision making and BI tools selective use of information to support or reject individual actions and ideas leads to increased mistrust on ERP data and lack of confidence that ERP can provide vital information and can provide necessary process for better decision making.

We found that although potential importance of ERP data for decision making is recognised by all participants anonymously, the majority of managers and decision makers never had any official training on using EPR, interpreting data and the potential benefits gained by using BI modules. Also, although many ERP vendors have already invested on making their systems user friendly and equipped with intuitive report writers and BI modules, most legacy systems and older versions of enterprise systems which are in use in first tier ERP adapters suffer from the lack of user-friendliness, intuitive report and query generators or any BI modules.

Conclusions

Overall, the need for decision support functionality in ERP systems is widely recognised and, in principle, ERP should support decision-making processes. However operational issues and especially integration complexity prevents organisations to achieve any of the above. In this situation, organisations should consider more manageable implementation scenarios which are suitable for their requirements and could minimise their risk of being trapped in integration battleground. By taking advantage of new technological advancements in integration techniques, integrating separate systems does not seem to be as difficult as before and building interfaces between these systems does not require huge amount of investment. Also many ERPs are being implemented in a decoupled fashion and as such the real benefits of highly priced integration never gained.

As a result, despite the perception that integration is only achievable through native modular integration which is available in ERP, we argue that Best of Breed (BoB) solutions could be a viable option for many organisations and they should certainly consider BoB as an option in their evaluation process. By considering BoB, these organisations could minimise their implementation risk and cost. Also they could distribute implementation cost and efforts over a period of time which is suitable for the business. Taking advantage of BoB could save organisations thousands of dollars by utilising their current system in the new implementation by investing in integrating them with the new systems rather than scraping them all together. The end result could be a cheaper system with even higher degree of integration compare to a decoupled ERP.

For most organisations that are struggling to overcome their operational issues, BI implementation seems to be highly idealistic. However, utilising available data in ERP does not need to be waiting for a complex BI implementation. Using new integration, web and programming techniques building data marts based on ERP and other disparate systems which eventually lead to data warehouse and potentially BI are practical steps towards utilising ERP data for decision making.

Management commitments and support is one of the main success factors to any BI programs. By providing necessary training to management on using EPR, interpreting data and the potential benefits gained by using BI, organisations could increase their chance for utilising valuable ERP data towards gaining competitive advantage. Increasing management knowledge could contribute to high expectations of ERP decision support features which could have positive impacts on utilisation of existing features and capabilities within the organisation.

ERP vendors could have positive contribution to utilization of ERP data for decision making by increasing their investment in integration techniques and building more intuitive BI modules.

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Appendix 9: Macquarie University Human Research Ethics Committee Approval

Dear Sir/Madam,

This is to confirm that the following ethics application/s cited below received final approval from the Macquarie University Human Research Ethics Committee:

Chief Investigator: Mr Mohammad Javad Bahrami
Ref: HE25AUG2006-D04856
Date Approved: 15 September 2006
Title: Impacts of Enterprise Resource Planning (ERP) on decision making process in Australian Organisation".

Please do not hesitate to contact me if you have any questions.

Yours sincerely,

Dr Karolyn White
Director, Research Ethics
Chair, Macquarie University Human Research Ethics Committee