Enterprise Strategy Requirements Engineering Framework: Towards Completeness of System Requirements

Abdul Razzaq Babar

BSc, MCom, ME

A thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy in Software Engineering

Faculty of Engineering and Information Technology

University of Technology Sydney, Australia

July 2013

Abstract

Empirical evidence shows that the success of a project depends on the completeness of system requirements. Although requirements engineering literature demonstrates how important strategic business goals are for the development of requirements models, it does not examine their effect on the completeness of system requirements.

The objective of this research is to propose and test a framework that shows the influence of strategic business requirements on the completeness of system requirements. The framework integrates strategic business requirements with the functional requirements, non-functional requirements and completeness of system requirements to measure their direct and indirect influence.

This framework (the Enterprise Strategic Requirements Engineering Framework) has been evaluated and validated by two studies. In the first study, business analysts collected lists of requirements from system stakeholders. In the second study, business analysts assessed those lists in terms of their completeness. More than 100 business analysts with varying degrees of experience participated in these studies. Structured equation models were used to analyse the data in order to show the effects of strategic business requirements on the completeness of system requirements. The results support the proposed framework and show that it is a true representation of the relationship between strategic business requirements, functional requirements, non-functional requirements and the completeness of requirements lists.

This thesis contributes to the field of requirements engineering in various ways. It highlights the importance of collecting a list of strategic business requirements and it demonstrates why this should be treated as an individual list, rather than simply a sub-set of a list of non-functional requirements. The results also show that strategic business requirements influence both non-functional and functional requirements, as well as the completeness of system requirements. Finally, the research found that business analysts

play a critical role in capturing requirements. The results show that novices did not approach many stakeholders and did not consider any business strategy requirements, whereas more experienced business analysts collected requirements from many stakeholders, including senior management, where strategic business requirements were available.

This framework will be extremely valuable in giving support to the many approaches that highlight the importance of strategy. It clarifies the importance of collecting strategic business requirements and it will be valuable for the education of requirements engineers, business analysts and others who perform the task of collecting requirements.

Declaration of Originality

I certify that this thesis does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any university; and that to the best of my knowledge and belief it does not contain any material previously published or written by another person except where due reference is made in the text.

Signed: _____ On: _____/____/_____

Acknowledgements

First, I would like to acknowledge the University of the Technology Sydney, Australia for funding my PhD research. I am grateful to Professor Jie Lu (head of school) for having believed in my potentials as a researcher and vigorously supported me throughout my candidature. I would like to thank Associate Dean (research) Professor Mary-Anne Williams for the thoughtful advice at various stages of my candidature. I am grateful to A/Professor Mao Lin Huang for his support to complete my research.

I have been privileged to have Dr. Bernard Wong, as my supervisor. I would like to express my sincere gratitude to Dr. Bernard Wong for providing me the opportunity to work with him on this research project. His highly valuable guidance, support, encouragement and constructive feedback helped me to complete this research project.

A special thanks goes to my parents, whose encouragement, career experience and wisdom have been invaluable to me. Other thanks go to friends and family members, too numerous to list here. Finally, I owe the most to my wife Nighat, who has patiently and steadfastly supported me all the way.

Contents

List of Figures

List of Tables

List of Abbreviations

CEO	chief executive officer
CFI	comparative fit index
CIO	chief information officer
EA	enterprise architect
ESRE	enterprise strategy requirements engineering
GFI	goodness of fit index
IEEE	Institute of Electrical and Electronics Engineers
IT	information technology
MCAR	missing completely at random
MVA	missing value analysis
R&D	research and development
RMSEA	root mean square error of approximation
SEM	structural equation model
SRMR	standardised root mean square residual
UTS	University of Technology Sydney

Chapter 1: Introduction

This chapter provides a brief overview of the research presented in this thesis. Section 1.1 presents the motivation behind this research. Section 1.2 discusses the background of this research. Section 1.3 describes the aims and objectives, and Section 1.4 lists the contributions of this research to the body of knowledge.

1.1 Motivation

The motivation of this research was based on the industry experience of the researcher. As a business analyst, the researcher worked on various projects related to the improvement of different organisation's IT systems. The team was often directed to visit client sites to collect business requirements from the systems' stakeholders. When meeting stakeholders, the researcher often questioned whether the team had collected enough requirements, and whether the requirements obtained from the systems' stakeholders could be considered complete if not all important stakeholders had been approached.

With these questions in mind, the researcher consulted the scholarly literature on software engineering to examine how software projects are completed and to discover the main issues related to this. This literature review was conducted to determine how important requirements engineering is, to examine the role of business analysts in the collection of requirements from system stakeholders, and to evaluate how this collection relates to the success of a project. Exploration of various databases provided a number of articles describing the importance of requirements engineering for the success of a project. Further articles were found describing the role of business analysts in the collection of requirements and the completeness of system requirements.

After many years of experience in the industry, the motivation for this research derived from the researcher's involvement in many projects—involvement that led the researcher to question the pre-existing processes of requirements collection. For example, why is a

suitable amount of requirements never collected? Why are requirements specifications criticised for their incompleteness? These questions were important to the researcher and were also raised in many pieces of literature in software engineering.

1.2 Background

During the last two decades, requirements engineering research has introduced a number of approaches, including:

- KAOS (Dardenne & Lamsweerde 1996);
- GBRAM (Anton 1996);
- Non-functional requirements (Chung & Nixon 2000);
- The INSTAL method (Thevenet & Salinesi 2007);
- B-SCP (Bleistein 2006);
- Map (Rolland & Salinesi 2005);
- The business modelling approach (Samavi, Yu & Topaloglou 2009); and
- The multidisciplinary approach (Singh & Woo 2009).

The main purpose of these approaches is to develop requirements models in the context of business strategies for specific organisations. They are necessary because the role of information technology (IT) has evolved from supporting internal business operations to providing an external business view of the organisation. These approaches create alignment between the strategic business goals and the technical considerations of systems.

Unfortunately, these approaches do not consider the completeness of system requirements with respect to the strategic business goals of the organisation. A number of studies (Hammer et al. 1998; Kamata & Tamai 2007) have provided empirical evidence on the relationship between the completeness of requirements and project success. However, the above approaches do not explain the role of strategic business requirements in terms of their influence on technical considerations (functional and non-functional requirements) for the completeness of system requirements.

Therefore, the research presented in this thesis was motivated by the need for a framework that demonstrates the role of strategic business requirements in terms of their influence on the functional requirements, non-functional requirements and completeness of system requirements.

1.3 Aims and Objectives

The main objective of this research was to develop and test a framework that incorporates the role of strategic business requirements in terms of their influence on the functional, non-functional and completeness of system requirements. The majority of requirements gathering approaches acknowledge the importance of strategic business requirements. Strategic business requirements need to be connected with functional requirements, non-functional requirements and completeness of requirements in such a way that the effects of strategic business requirements on the completeness of system requirements specification can be measured.

Much of the novelty of the requirements engineering approach presented in this thesis lies in how the strategic business requirements affect the completeness of system requirements, both directly and indirectly, via the functional and non-functional requirements of the system. In developing a requirements engineering framework, the aims of this research were as follows:

- Discovering important dimensions of the framework and then focusing on four main dimension coming from requirements engineering literature;
- Develop a requirements engineering framework with a scope that encompasses strategic business requirements, functional requirements, non-functional requirements and completeness of system requirements; and
- Create links between the four variables so that the effects of the strategic business requirements on the functional, non-functional and completeness of the system requirements can be measured.

In testing the requirements engineering framework, the aims of this research were as follows:

- Conduct studies in order to rigorously test the framework;
- Conduct a study to collect the requirements from the stakeholders of the system;
- Conduct a study to assess the requirements lists; and
- Obtain empirical evidence to evaluate the usefulness of the framework.

1.4 Contributions

The research presented in this thesis offers several contributions to requirements engineering research and practice in the context of the aims and objectives described in Section 1.3. This research:

1. Compliment the existing research by highlighting the importance of strategic business requirements in requirements engineering;
2. Compliment the existing research that strategic business requirements affect the functional and non-functional requirements of the system;
3. Demonstrates that strategic business requirements affect the completeness of the system requirements;
4. Demonstrates that strategic business requirements are important and thus should not be treated as one of the elements of the non-functional requirements and subsequently 'forgotten';
5. Introduces a framework that can be a guide to determine the completeness of system requirements;
6. Introduces the elements of requirements engineering that can be taught to novice business analysts;
7. Introduces theoretical underpinning to support the existing requirements engineering approaches;
8. Provides empirical evidence to evaluate the framework;
9. Provides a framework that is an important foundation to BABOK and for education regarding collecting the requirements; and
10. Validates the approach used in the framework.

1.5 Thesis Structure

The rest of this thesis is organised as follows. Chapter 2 reviews and analyses requirements engineering, particularly from the perspective of strategic business requirements and their importance to the completeness of system requirements. This chapter also describes the importance of completeness of requirements for project success, and the importance of understanding the influence of strategic business requirements on the completeness of system requirements. A number of requirements engineering approaches are discussed in this chapter to demonstrate their weakness in this regard. This chapter concludes with a broad research question that realises the need to demonstrate the role of strategic business requirements in relation to the completeness of system requirements.

Chapter 3 proposes a framework, based on the literature review, to demonstrate the role of strategic business requirements in terms of their influence on the functional and non-functional requirements for the completeness of system requirements. Chapter 4 discusses a research methodology to test and validate the framework proposed in Chapter 3. It explains how two studies can help test the framework effectively.

Chapter 5 presents Study 1, which involves the collection of requirements from a number of stakeholders of the system. This involves business analysts with varying degrees of experience collecting requirements, which is the basic factor tested in this framework. This study produces a number of requirements lists comprised of the strategic business requirements, functional requirements and non-functional requirements of the system. Chapter 6 presents Study 2, which involves assessing the requirements lists with the purpose of testing the framework. It involves a large number of business analysts for this purpose and the empirical data are used to measure the influence of strategic business requirements on the functional, non-functional and completeness of system requirements.

Chapter 7 discusses the results of Study 1 and Study 2 in terms of the value of the framework and the issues related to the business analysts involved in this research. Chapter

8 presents the study's conclusion, as well as suggestions for future research. The research questions provided in Chapter 3 are revisited, and the contributions of this research are elaborated. Following this, the limitations and possible applications of this framework are discussed.

Chapter 2: Literature Review

This chapter begins by describing the statistics of project failure and the reasons behind this failure. It continues by describing the importance of collecting requirements from key system stakeholders to ensure the quality of requirements specifications and, subsequently, the success of the project. Following this, this chapter discusses the various requirements engineering approaches that are used to develop requirements models in the context of enterprise strategy. This chapter concludes with the summary realising the need of a framework that includes enterprise strategy and demonstrates its influence on the completeness of requirements.

2.1 Software Project Failure

The software industry is littered with failed projects, with no organisation being immune to this failure (Bishop 2009; Charette 2005; Marx 2008). Both small and large organisations have experienced the effects of failed projects (Cerpa & Verner 2009). According to the Standish Group Report, the success rate of IT projects per year is around 20 to 30%, whereas the failure rate of IT projects is between 70 to 80% (Bishop 2009). Although the validity of the Standish Report has been questioned by various researchers (Glass 2006; Jorgensen & Molokken-Ostvold 1997), a vast number of articles have cited this report when discussing software project success and failure (Cerpa & Verner 2009; Lamsweerde 2000; Verner, Cox & Bleisten 2005). The cost of IT project failures has grown over the past decade (Charette 2005). While in previous years, these failures cost the industry billions of dollars, they now cost trillions (Krigsman 2009). Such projects can take 180% of the targeted completion time and can consume in excess of 160% of the estimated budget (Ellis 2009).

2.1.1 Poor Requirements Gathering

According to the Standish Group Report, various factors contribute to the failures of IT projects. These include budgets and timeframes being exceeded, lack of planning, unclear vision and objectives, unrealistic expectations, reduced user involvement and so forth. However, poor requirements gathering is considered the most influential factor for project failure (Bishop 2009; Ellis 2009; Galorath 2008; Stafford 2009). A number of research articles have described poor requirements engineering as the major cause of project failures (Lamsweerde 2000; Yu 1997). Poor requirements gathering and analysis is so influential that companies with poor requirements have three times more project failures than successes, as shown in the IAG Consulting report (Charette 2005; Ellis 2009). Sixty-eight per cent of companies are more likely to have a marginal or outright failure, instead of a success, due to poor requirements collection (Ellis 2009). Companies pay a premium of as much as 60% on time and budget when poor requirements practices are performed, thereby delivering under 70% of the project's required functionality. This means that a significant portion of the trillions of dollars is wasted because of poor requirements gathering.

2.1.2 Role of Business Analysts

IAG Consulting produced a business analysis benchmark report (Ellis 2009) that presents the findings from a survey of over 100 companies. This report provides definitive statistics regarding the importance and effect of business requirements on enterprise success in technology projects. Ellis (2009) states that the survey focused on large organisations and examined development projects in excess of US $250,000, where significant new functionality was delivered to organisations. This current study does not provide details of the survey study. However, the results of the survey study highlighted that, for the average company using average analysts (rather than an optimal organisation), over 41% of the IT development budget for software, staff and professional external services is consumed by poor requirements gathering (Ellis 2009).

The report further describes that it is unlikely that average business analysts will be able to deliver on goals that are fundamental to the business case, such as restructuring to enable financial improvement and cost cutting. The data indicate that, for 63% of cases in which a significant change to business processes was a primary or secondary consideration for the project, average business analysts failed to deliver business targets. In 56% of cases in which cost cutting was a primary consideration for the project, average analysts failed to achieve the goals. The data of 88% of projects show that process change and cost cutting objectives were achieved effectively with high competency analysts. This indicates that competent business analysts are more effective than average business analysts for requirements collection and analysis. This is also highlighted by various researcher articles.

In relation to the role of business analysts in effective requirements gathering, Glinz and Wieringa (2007) describe that, to build a useful system, a business analyst needs to know its requirements. To know its requirements, a business analyst needs to know the stakeholders' desires and needs (Glinz & Wieringa 2007). Identification of stakeholders is crucial to contemporary requirements engineering, in which business analysts must first determine who are the stakeholders and then how important these stakeholders are (Freeman 1984; Sharp, Galal & Finkelstein 1999). According to Glinz and Wieringa (2007), to develop requirements specification, it is necessary to locate the people or organisations who have an active interest in the system, such as the developers, customers, managers and so forth.

Glinz and Wieringa (2007) point out that not all stakeholders are equally important for requirements collection. Based on the stakeholders' importance, they can be categorised into critical, major and minor stakeholders. It is necessary to categorise stakeholders in this manner because:

- Ignoring a minor stakeholder can have a marginal effect on the project;
- Ignoring a major stakeholder can have a significant effect on the project; and
- Ignoring a critical stakeholder can destroy a project or render a project useless.

This highlights the importance of the role of a business analyst in collecting requirements from the stakeholders of a system. A business analyst should approach the key stakeholders

of the system who represent all the stakeholders of the system. Ignoring a key stakeholder can have negative effect on the success of a project.

2.1.3 Complete Requirements Specification and Project Success

Project success is directly associated with complete requirements specification. A vast amount of software engineering literature (Bhat, Gupta & Murthy 2006; Hammer et al. 1998; Kamata & Tamai 2007; Sommerville & Ransom 2005; Sommerville & Sawyer 1997; Verner, Cox & Bleisten 2005) argues that requirements engineering is a critical phase of a software project and that completeness of requirements specification affects the outcome of the software project. Some studies have provided empirical evidence of this. For example, Kamata and Tamai (2007) investigated 32 software projects that were started and completed within 2003 to 2005 to find relationship between the requirements quality and the project success. To assess requirements quality, they assessed the completeness of the requirements specifications on more than 100 check items recommended by Institute of Electrical and Electronics Engineers (IEEE) standards. The statistical analysis of the data showed that a relationship between completeness of requirements specification and project success exists. Hammer et al. (1998) state that 'complete, concise, and clear requirements will give the implementer a precise blue print with which to build the system'. They argue that completeness, conciseness and clarity of requirements is a fundamental tenet of software engineering. They state that the success of a project, both functionally and financially, is directly affected by the completeness of requirements.

Verner, Cox and Bleisten (2005) conducted a survey study with software practitioners, and found that completeness of requirements is highly correlated to the success of project. They also found that it is not necessary to have complete requirements at the start of the project. Rather, completing requirements during the project is helpful to the success of the project. This indicates that requirements collection is not a one-off event, but is an activity that must be repeated during the project's lifecycle in order to ensure the requirements list is complete.

In short, according to these articles, poor requirements gathering and analysis is a major hurdle in the success of projects. Business analysts play a crucial role in the collection of correct and sufficient requirements from the stakeholders of the system. A comprehensive list of requirements leads to the success of a project.

2.2 Requirements Engineering

In the light of the above, this study evaluated the mainstream requirements engineering approaches to determine how the requirements models are completed. Do the existing approaches consider all types of requirements and show pattern of influence among them for the completeness of requirements models?

Before the requirements engineering approaches are evaluated to answer these questions, a brief overview of the mainstream approaches used in the requirements engineering literature is provided. The existing requirements engineering literature highlights that there are three types of requirements, functional requirements, non-functional requirements and strategic business requirements and all of them are related to the completeness of requirements (Chung & Leite 2009; Jackson & Zave 1995; Singh & Woo 2009; Zave 1997). The existing approaches, which are discussed below often consider requirements types individually to develop requirements models instead of considering all of them and showing how they influence each other for the completeness of requirements.

2.2.1 Functional Requirements Models

Requirements engineering has introduced a number of methods such as use case (Jacobson 1992), communication analysis method (Espana, Gonzalez & Pastor 2009) and Jackson's context diagram (Jackson 2001) that predominantly focus on functional requirements for elicitation and completeness purpose of the requirements models. These methods capture 'what' aspect of a system which means what action needs to be performed by the system. This aspect is generally understood as functional aspect of a system in requirements engineering and a number of researchers such as (Cox & Phalp 2000; Espana et al. 2009; Espana, Gonzalez & Pastor 2009; Menzel et al. 2010) have used these methods to develop

functional requirements models. For example, Espana et al. (2009) used two techniques, use cases and communication analysis, to develop functional requirements specifications and then compare them in terms of completeness to argue that communication analysis method provides greater completeness to requirements specification than use cases. In other example, Cox et al. (2000) proposed CREWS use case authoring guidelines to improve the completeness of use case descriptions. In addition, many requirements capturing approaches (including the ones discussed above) have been discussed in the following article (Kavakli & Loucopoulos 2003). They are also functional requirements gathering approaches for developing requirements specifications.

According to Yu (1995) it is not enough to capture 'what' aspect of a system, we must capture 'why' aspect of a system too. Processes and activities of software engineering have been described in terms of what – what is a process or activity (Horkoff 2006). There is a need to understand process rationale in terms of Why – why a process or activity is needed. In modelling process rationale in the context of organisational environment (Yu & Mylopoulos 1997). For example, in a health care system, approve treatment and process claim are the two processes (Yu 1993, 1995). But these types of processes or activities do not capture why aspect of the activities, for example why a treatment needs to be approved. Yu (Yu 1993) claimed that why aspect of a process is important to be captured along with what aspect of a process to have better understanding of the process and/or activity of a software development. According to (Yu 1997; Yu, Strohmaier & Deng 2006), to build an effective software system one needs to capture its environment in which the system intends to operate and the environment is captured in which organisational actors work cooperatively to deliver goals (Yu 2009).

2.2.2 Non-Functional Requirements Models

Seminal requirements engineering work has already put 'why' concerns at the very heart of the requirements engineering process (Lamsweerde 2004; Ross & Schoman 1977). Yue (1987) was probably the first to argue that explicit representation of goals in requirements models provides criteria for requirements pertinence and completeness (Yue 1987).

Requirements engineering has increasingly recognised the leading role played by goals in the completeness of requirements specification (Lamsweerde 2004; Ross & Schoman 1977; Yu 1995; Yue 1987; Zave 1997). In this regard, requirements engineering researcher has introduced a number of modelling approaches such as i* (Yu 1995), Tropos (Bresciani et al. 2004), Knowledge Acquisition in Automated Specification (KAOS) (Dardenne, Lamsweerde & Fickas 1993), Goals Based Requirements Engineering Method (GBRAM) (Anton 1996), Non-Functional Requirements (NFR) Framework (Chung & Nixon 2000) and Strategy Driven Process Modelling Approach (Bresciani et al. 2004; Bubenko et al. 1994; Champion & Moore 1996; Gordijn & Akkermans 2003b; Kavakli & Loucopoulos 1996; Kavakli & Loucopoulos 2003; Loucopoulos 2003; Nurcan et al. 2005; Yu 1995) to develop requirements specification in the context of goals.

Motivation of these approaches is that the requirements specification must address the contextual goals, why a software system is needed, the functionality of the software system has to achieve contextual goals and the constraints restricting how the software systems accomplish the contextual goals. Goals ranging from high-level "strategic concerns" to low-level technical requirements are structured through AND/OR refinement mechanism for the development of software system (Lamsweerde 2000, 2009).

According to Chung et al. (Chung & Leite 2009) system's utility is determined by both its functionality and its non-functional characteristics such as useability, flexibility, performance, interoperability and security. They (Chung & Leite 2009) say that the non-functional requirements are quality characteristics of functionality of a software system which can not be considered separate from the functionality of the systems at requirements gathering stage (Chung & Leite 2009; Chung & Nixon 2000; Mylopolous, Chung & Nixon 1992). However NFR framework develops a quality graph by using predefined taxonomy of early requirements and same as the other approaches indicated above, support capturing of functional and non-functional requirements together at the software requirements gathering stage. In short, these approaches recognise the importance of quality requirements and their influence on the completeness of functional requirements specification.

According to Bleistein et al. (2006), requirements engineering research has introduced several approaches that focus on the functional and non-functional requirements of the system (Bleistein et al. 2006a). However, the collection of strategic business requirements has been ignored by the approaches indicated above. For example, Bleistein et al. (2006) argue that Tropos is an agent-oriented methodology that uses i* to collect requirements from the system stakeholders. The CREWSL'Écritoire project combines goal modelling with scenario analysis to map the requirements of the information system of a large organisation. Similarly, other appraoches take the view that the requirements of an information system can only be understood in the context of an enterprise model, and thus propose approaches to model the enterprise system (Bubenko et al. 1994; Eriksson & Penker 2000; Finkelstein 1992; Kavakli & Loucopoulos 1996; Loucopoulos 2003). Gordijn and Akkermans (2003a) proposed an approach that conducts value analysis in the context of e-commerce applications (Gordijn & Akkermans 2003a). Unfortunately, these approaches do not consider enterprise strategy in the development of requirements models. Bleistein et al. (2006) state that 'while each of the approaches claim to address strategic aspects of organisational IT, each approach addresses business strategy either in only a perfunctory manner, or otherwise fail to address business strategy at all'.

2.2.3 Strategic Business Requirements

The literature discusses a variety of requirements engineering approaches for modelling enterprise strategy (Bleistein et al. 2006a; Nurcan et al. 2005; Samavi, Yu & Topaloglou 2009; Singh & Woo 2009; Thevenet & Salinesi 2007). Each approach acknowledges the importance of business strategy in system requirements elicitation.

For example, Bleistein et al. (Bleistein et al. 2006a) proposed a requirements analysis approach for verification and validation of requirements in terms of alignment with and support for business strategy. The proposed B-SCP requirements analysis approach is based on three themes: business strategy, context, and processes which were originally proposed by (Walsham 1993), for strategic alignment of enterprise software systems. To operationalise these three themes in requirements engineering, Bleistein et al. (Bleistein et

al. 2006a) proposed integration of the three requirements modelling approaches: i* (Yu 1995), Jackson's context diagram (Jackson 2001) and Role Activity Diagram (RAD) (Ould 1995). However the approach does not highlight how the startegic business requiremnts.

An other example is that INSTAL framework (Thevenet & Salinesi 2007) proposes dividing IT requirements into two levels: strategic-level and operational-level (Thevenet & Salinesi 2007). According to the framework, strategic level should capture the decision makers' strategy in terms of high-level requirements however operational-level refers to technical requirements supportive to achieve strategic goals. INSTAL framework uses maps as an intermediate formalism to define links between strategic and operational levels activities of a system (Thevenet & Salinesi 2007). The primary objective of these approaches is to create alignment between strategic business goals and technical considerations of the system. Unfortunately, these approaches do not highlight what improvement the strategic business requirements bring to the requirements models and how do the strategic business requirements impact functional and non-functional requirements of the system.

2.2.3.1 The Concept of Business Strategy

It is important to understand the concept of business strategy. To do this, the management information system literature was explored and a number of frameworks were identified (Avison et al. 2004; Birnik & Moat 2008; Henderson & Venkatraman 1993; Kaplan & Norton 2004; Luftman & Brier 1999; Porter & Millar 1985; Velcu 2010). These frameworks depict the elements of business strategy of the organisation. Many of the above researchers consider business strategy in terms of strategic moves regarding the following three aspects:

- Organic growth deals with launching new products and introducing lifestyle accessories for products. This also concerns investing research and development (R&D) in new product areas;
- Alliances and partnerships deal with entering partnerships with companies to cross-sell products with a partner company's product. This also includes partnering with a company to leverage distribution and marketing capabilities; and

- Mergers and acquisitions deal with acquiring a company in an adjacent and fast-growing industry. This also includes acquiring a company that has strong R&D capabilities in a particular business area.

Some researchers (Anderson, Narus & Rossum 2006; Jr. & Goodstein 1996; Kaplan & Norton 2004; Nustini 2006; Ray, Barney & Muhanna 2004; Schwarz et al. 2010; Woodruff 1997) view business strategy in terms of identification of a clear and meaningful set of objectives and measures, agreed upon by the senior executives. They include two main elements: precise financial targets and customer value proposition.

In terms of the financial objectives, according to the researchers, a business strategy should state precisely the shareholders' value, revenue growth and productivity objectives of the organisation. For example, in the context of revenue growth, a business strategy can describe a company's targets associated with selling more or cross-selling products and services to customers. This can relate to selling an entirely new product to customers. In terms of productivity targets, strategies should state how the cost structure can be improved through lowering direct and indirect expenses. This is about producing the same quality of products while spending less.

In terms of customer value, researchers argue that customer value is the central element of a business strategy because financial targets can be achieved when an organisation creates differentiated, sustainable value to its targeted customers. Many researchers (Anderson, Narus & Rossum 2006; Jr. & Goodstein 1996; Libin 2009; Parasuraman 1997; Woodruff 1997) share this view and describe 'customer value' as the new source of competitive advantage for organisations. For these researchers, not every benefit to the customer is a customer value proposition, and best practice organisations base their value proposition on the few elements that matter the most to their target customers, thereby demonstrating the value of their superior performance. According to these researchers, once an organisation has a clear picture of these financial and customer objectives, the organisation can develop internal processes and learning and growth targets that describe how financial and customer value targets can be achieved.

The management information systems literature, which is discussed in this section, argues that IT needs to support organisational business strategy. This is because the systems are expected to support strategic direction of the organisation.

2.2.4 Types of Requirements

The majority of requirements engineering approaches (discussed above) collect requirements in terms of the goals of the system. According to Lamsweerde (2001), goals represent different types of requirements—functional requirements are associated with the services to be provided, and non-functional requirements are associated with the quality of services, such as safety, security, accuracy, performance and so forth (Lamsweerde 2001). Both types of requirements—functional and non-functional—are considered important for the development of software system architecture (Sim˜ao & Belchior 2003).

In terms of the association between these two types of requirements, Chung and Leite (2009) state that a system's utility is determined by both its functional and non-functional characteristics, such as useability, flexibility, performance, interoperability and security. (Chung & Leite 2009) argue that non-functional requirements are the quality characteristics of the functionality of a software system that cannot be considered separately from the functionality of the systems during the requirements gathering stage (Chung & Leite 2009; Chung & Nixon 2000; Mylopolous, Chung & Nixon 1992). In terms of relationships between the two types of requirements, Lamsweerde (2000) states that:

> requirements engineering must address the contextual goals why a software is needed, the functionalities the software has to accomplish to achieve those goals and the constraints restricting how the software accomplishing those functions is to be designed and implemented.

This definition highlights the need to collect strategic business goals in terms of the context of the software system.

According to the approaches discussed in Section 2.2.3, strategic business goals are driven by the vision and mission of the organisation, and influence the technical considerations of

the system (Barone et al. 2010; Bleistein 2006; Samavi, Yu & Topaloglou 2009; Singh & Woo 2009). Singh and Woo (2009) describe that this level of goals represents various aspects of the organisation, such as market positioning, innovation, productivity, reduction in manufacturing cost and improvement in profit. These types of goals are collected from the top management of an organisation and aligned with the lower level technical requirements of the system. Therefore, there are three types of requirements of systems that are generally highlighted in the requirements engineering literature: strategic business requirements, functional requirements and non-functional requirements.

2.3 Other Approaches

Model Driven Development (MDD) is a software development approach in which abstract models of software systems are created and then systematically are transformed to concrete implementation (France & Rumpe 2007; Selic 2003). Model driven software development approach defines system functionality through computation independent model (CIM), platform independent model (PIM) and platform specific model (PSM). Since this approach (MDD) focuses on the later part of the system development process which is the designing and implementation stages of software development, we ignore this area of research. To contain the research scope, the focus of this research is early stage, requirements collection stage, of software development.

2.3.1 Lack of Empirical Evidence

The most serious deficiency in the existing requirements engineering approaches is the lack of empirical justification. Most of the frameworks are either justified based on theory or the author's experience (Moody et al. 2003). Theoretical justification is limited because methods have no truth value. The validity of the method is an empirical rather theoretical question (Ivari 1986; Rescher 1977). According to Moody et al. (2003) the software engineering is full of methods which are theoretically sound but do not work in practice and vice versa. Experiential justification is limited because personal experience is subject to bias (Moody et al. 2003).

Empirical evaluations are a strong need in requirements engineering area (Wieringa & Heerkens 2004). Most authors act as designers of the proposed methods, whereas there are only a few researchers who validate their or others' artefacts actually improving RE practices (Wieringa & Heerkens 2006). In most studies, completeness assessment consists of a reviewer judging the completeness of specification subjectively (Menzel et al. 2010). Requirements engineering approaches, discussed above, do not consider empirical evidence of effects of strategic business requirements on the functional and/or non-functional requirements of the system for the completeness of requirements specification. Empirical evidence can provide various benefits to the development of requirements specification. It can show clearly and concisely in which way the effect occurred, and can investigate issues such as whether the functional and non-functional requirements increased or decreased due to this effect.

Table 1: Summary of RE Approaches

Requirements engineering approach	Purpose of the each approach is	Does the approach capture functional requirements?	Does the approach capture non-non-functional requirements?	Does the approach capture strategic business requirements?	Does the approach address completeness of requirements?	Does the approach show how SBRs provide influence on FRs and NFRs?	Does the approach provide empirical evidence?
i* (Yu 1995)	To capture organisation wide goals crucial to the success of enterprise IT systems.	✓	✓	✓	✓	×	×
Tropos (Bresciani et al. 2004)	To capture stakeholders of the systems and understanding their business goals in the specification models.	✓	✓	✓	✓	×	×
B-SCP (Bleistein et al. 2006a)	To capture organisation's competitive business strategy and align it with IT requirements via refinement and traceability mechanism.	✓	✓	✓	✓	×	×
Multidisciplinary approach (Singh & Woo 2009)	To capture strategic business goals and align them with technical requirements in the requirements model.	✓	✓	✓	✓	×	×
Business modelling approach (Samavi et al. 2009)	To analyse goals, roles and rationale behind the strategic actions of each participant that motivates the change in the business environment.	✓	✓	✓	✓	×	×
INSTAL (Thevenet & Salinesi 2007)	To capture IT requirements at strategic level and operational level for system development.	✓	✓	✓	✓	×	×
Use case (Jacobson 1992)	To develop applications addressing wider spectrum of the organisations.	✓	×	×	✓	×	×
Problem frames (Jackson 2001)	To capture the environment in which the system intends to operate.	✓	×	×	✓	×	×
KAOS (Lamsweerde 2000)	To capture goals ranging from strategic concerns to low level technical problems of systems.	✓	✓	✓	✓	×	×
GBRAM (Anton 1996)	To capture high level business goals in requirements specification.	✓	✓	✓	✓	×	×
NFR (Chung & Nixon 2000)	To capture quality requirements of IT systems	×	✓	✓	✓	×	×

2.4 Summary of the Literature Review

The summary of each approach, discussed above, is presented in Table 1. Requirements engineering research has introduced a number of approaches that have the main purpose of conducting requirements analysis to align the goals and technical requirements of the system. The requirements models developed by the approaches highlight that some approaches have conducted requirements analysis in the context of quality goals (such as security, privacy, safety and performance), while others have conducted requirements analysis in the context of the enterprise-wide business goals of the organisation. The main purpose of both groups of approaches is to align the high-level goals of the organisation with the functional requirements of the system. However, the approaches have failed to show how strategic business requirements influence functional and non-functional requirements of the system. This alignment is established through qualitative means, such as contribution links, to demonstrate that the high-level goals contribute to the technical considerations, and that the technical requirements contribute to the high-level goals.

Unfortunately, none of these approaches provide empirical evidence regarding the contribution of high-level goals, such as strategic business requirements, to the functional and non-functional requirements of the system. Empirical evidence would demonstrate precisely how and what contribution strategic business requirements provide to the functional and non-functional requirements of the system. For example, it would demonstrate whether strategic business requirements influence the non-functional requirements at all. It would also investigate whether this influence led to an increase or decrease in the functional and non-functional requirements.

A significant question relates to how complete the requirements specification is when strategic business requirements influence the functional and non-functional requirements of the system. The completeness of requirements is a crucial aspect of requirements, and many empirical studies (Kamata & Tamai 2007) have demonstrated a correlation between the

completeness of requirements and the success of the project. Empirical evidence would also demonstrate the contribution of the strategic business requirements to the requirements specification, both directly and indirectly (via the functional and non-functional requirements).

There is no framework in requirements engineering that demonstrates how these aspects of requirements engineering fit together. As discussed previously in this chapter, the existing requirements engineering literature has introduced approaches that adopt modelling techniques to develop requirements models potentially for the purpose of alignment. However, these approaches do not focus on measuring the impact of strategic business requirements on functional and non-functional requirements for the purpose of completeness. This led this study to propose a new framework.

Chapter 3: Proposed Framework

As discussed in the literature review chapter, a number of approaches have been introduced in requirements engineering research with the purpose of developing requirements models in the context of strategic business goals. However, these approaches do not demonstrate how complete the requirements specification has become due to the influence of strategic business goals. This issue led the researcher to realise the need for a framework to demonstrate the role of strategic business requirements in terms of their influence on the completeness of system requirements.

It is important to examine the elements of the proposed framework and how these elements related to each other for the development of the framework. As discussed in Section 2.2.2.1, the elements of the framework fall into three types of requirements: strategic business requirements, functional requirements and non-functional requirements. The requirements engineering literature has discussed them in a different capacity, so they were considered different from each other for the development of the framework. The completeness of requirements and project success were the two other elements considered for the development of the framework. The completeness of requirements was part of the main research question, and the success of the project was included because previous studies (Kamata & Tamai 2007) have shown a relationship between these two elements. Therefore, project success was considered an important element of the proposed framework.

In terms of the relationship between these elements, the requirements engineering literature has introduced various approaches that use a methodical approach to create alignment between the strategic business requirements and technical considerations of the system. As discussed in the literature review chapter, technical considerations—referring to functional and non-functional requirements—are shown to support the business strategies of organisations. That is, strategic business requirements influence the technical considerations of the system. How complete the system requirements are and what

influence the strategic business requirements have on the functional and non-functional requirements—and consequently on the completeness of requirements—were the main characteristics of the proposed framework. Before describing the graphical approach of creating the framework, the difference between this research and the existing research is highlighted below.

Davis et al. (2002) assert that a requirements engineering researcher must be able to compare and contrast his or her research with current research, and demonstrate how his or her research can be used practically. The literature review in Chapter 2 highlights that requirements engineering researchers have introduced methodical approaches for developing requirements models mainly to align the technical requirements and strategic business requirements of the system. The completeness of system requirements, which is considered crucial to the success of a project (Kamata & Tamai 2007), has not been considered by these approaches. This current research realises the need to demonstrate the role of strategic business requirements in terms of their influence on the functional, non-functional and completeness of system requirements. This issue has practical implications because, as the literature has shown, the completeness of requirements correlates with the success of the project (Hammer et al. 1998; Kamata & Tamai 2007). Thus, there is no pre-existing framework or empirical evidence in the requirements engineering literature to demonstrate the role of strategic business requirements in relation to the completeness of system requirements.

Webster et al. (2002) assert that a coherent literature review requires a guiding theory, a set of competing models, or a point of view about the phenomenon under discussion. The guiding theory of the literature review in this thesis is that the strategic business requirements influence functional and non-functional requirements, and consequently influence the completeness of requirements specification. In this context, the literature review discussed a variety of approaches that conduct requirements analysis in order to align strategic business goals and technical considerations. However, the requirements engineering literature does not offer a framework to empirically demonstrate the role of strategic business requirements for the completeness of requirements.

This study's perspective about the phenomenon is that the effect of strategic business requirements on the functional and non-functional requirements for the completeness of system requirements specification should be measured empirically. Similar to these assertions, Creswell (2003) describes the development of a research artefact in terms of answering this question: what knowledge claims are being made by the researcher (including the theoretical perspective)? Knowledge claims refer to the phenomenon in which researchers begin their projects with certain assumptions regarding how they will learn and what they will learn during their enquiry (Creswell 2003; Guba & Lincoln 1994; Mertens 1998). The current study's knowledge claim is that strategic business requirements influence the functional and non-functional requirements for the completeness of requirements specification, which has been argued by various requirements engineering researchers (Bleistein 2006; Lamsweerde & Letier 2000; Sutcliffs 2003; Zave 1997). However, the approaches introduced in the requirements engineering approaches do not focus on the completeness of requirements in their models.

The concept of requirements engineering, proposed through this study's framework, is highlighted in a definition of requirements engineering (Zave 1997). Zave (1997) states that:

> Requirements engineering is the branch of software engineering concerned with the **real world goals** for, **functions** of and **constraints** on software system. It is also concerned with the relationship of these factors to the **precise specifications** of software behaviour and to their evolution over time and across software families.

This definition clearly highlights that functional requirements (functions) and non-functional requirements (constraints) are collected to support business goals, and that these three types of requirements relate to the completeness of requirements. Therefore, an enterprise strategy requirements engineering (ESRE) framework was developed in this research to demonstrate the role of strategic business requirements in terms of their influence on the functional and non-functional requirements, as well as the completeness of system requirements. This framework is called an ESRE framework because strategy-related goals and their influence on the completeness of requirements was the main focus of this research.

3.1 Development of ESRE Framework

The following sections describe the ways the elements of the proposed framework are related to each other, and the debates of researchers regarding these relationships.

3.1.1 Strategic Business Requirements Affect Completeness of Requirements

Yue et al. (1987) describe completeness of requirements as a major requirements engineering concern. Yue et al. (1987) highlights that the 'goals' contribute to the completeness of requirements because goals provide a precise criterion for sufficient completeness of system requirements. A specification is considered complete with respect to a set of goals if all the goals can be proved to be achieved from the specification. The influence of the goals on the completeness of system requirements is shown in Figure 1, with one arrow headline in the framework. This indicates that strategic business requirements affect the completeness of requirements.

3.1.2 Strategic Business Requirements Affect Functional Requirements

This effect has been highlighted by various requirements engineering approaches, such as KAOS (Lamsweerde 2001), B-SCP (Bleistein et al. 2006b) and the INSTAL method (Thevenet & Salinesi 2007). These approaches recognise that strategic business requirements influence the functional requirements of the system. Yu, Strohmaier and Deng (2006) state that 'in KAOS (functional) system requirements are derived from goals'. In their approach, strategic business requirements are essentially refined to the level at which the technical requirements of the system are achieved. The approaches show the effect—through traceability links—through which the technical requirements are related to the strategic business requirements of the system. In Figure 1, this influence is represented with a single arrowhead line originating from strategic business requirements and entering the functional requirements of the system.

3.1.3 Strategic Business Requirements Affect Non-functional Requirements

This effect was shown in the business requirements models developed by Samavi, Yu and Topaloglou (2009), who created two layers in their requirements models: a strategic layer and an operational layer. In the strategic layer, the enterprise-wide business goals were captured, whereas in the operational layer, the functional and non-functional requirements of the system were collected (Samavi, Yu & Topaloglou 2009). These two levels of requirements were integrated with each other through a modelling technique, i*. This relationship is represented in Figure 1 with an arrow headline originating from strategic business requirements and entering the non-functional requirements in the framework.

3.1.4 Functional and Non-functional Requirements Affect Completeness of Requirements

Zave (1997) states that:

> requirements engineering is the branch of software engineering concerned with the **real world goals** for, **functions** of and **constraints** on software system. It is also concerned with the relationship of these factors to the **precise specifications** of software behaviour and to their evolution over time and across software families.

This definition clearly highlights the association of the functional and non-functional requirements, in addition to the business goals, with the completeness of requirements specification. This definition provides the premise on which the functional and non-functional requirements are associated to the completeness of requirements, as shown with the arrow headlines in Figure 1.

3.1.5 Completeness of Requirements Affects Project Success

Software engineering research has already provided empirical evidence on this effect (Hammer et al. 1998; Kamata & Tamai 2007); thus, measuring the effect of the completeness of requirements on the success of a project is beyond the scope this research. The purpose of showing this effect in the framework is to highlight the relationship between the effect of the strategic business requirements on the completeness—and

consequently the success—of the project. The terms ‘effect’ in Figure 1 refers to the concept of cause and effect which means e.g. ‘a’ effects ‘b’.

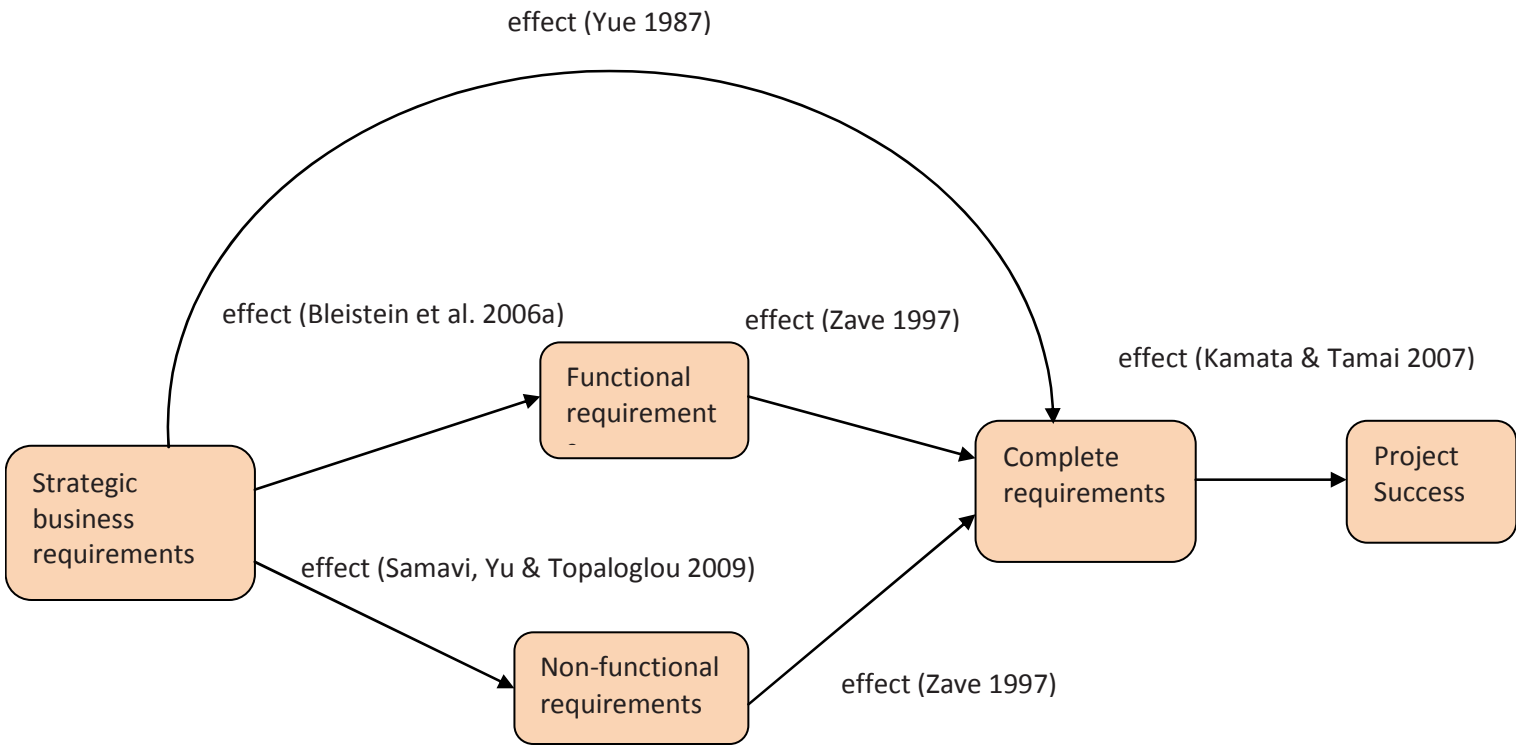


Figure 1: ESRE Framework

In this project, the completeness of requirements refers to the comprehensive list of requirements, as discussed in Section 2.1.3. The completeness of requirements is a subjective matter in the requirements engineering literature, which means that it is possible to improve requirements specification, but there will not be 100% completeness of requirements specification. Therefore, completeness of requirements specification is a relative term in which improvement in system requirements specification can be shown with a collection of factors, such as enterprise-wide business goals.

3.2 Summary

During the last two decades, the requirements engineering literature has introduced a number of approaches that offer methods to develop requirements models in the context of organisational business strategies. These approaches use modelling techniques to develop requirements models in which the strategic business requirements are associated with the technical requirements through traceability links. However, the requirements engineering literature has not introduced a framework that includes the role of strategic business requirements in terms of their influence on functional requirements, non-functional requirements and completeness of system requirements. In addition, the existing approaches do not consider providing empirical evidence on the effect of strategic business requirements on the functional and non-functional requirements for the completeness of the requirements list. Therefore, this research sought to address this aspect of requirements engineering though the framework proposed in Figure 1. Following from this, the important research question to ask was:

> Do the strategic business requirements affect the completeness of system requirements?

Chapter 4: Methodology

The framework provided at the end of Chapter 3 considers strategic business requirements and their relationship with the completeness of system requirements. It recognises both direct and indirect relationships via the functional requirements and non-functional requirements of the system. All the relationships, which have been described in terms of 'effects', needed to be tested empirically to ensure the validity of the framework. To test the framework, suitable methods were needed. Software engineering research has introduced a variety of methods—such as experiments, case studies, action research and surveys—that are applicable to empirical research (Easterbrook et al. 2008; Kitchenham et al. 2002). However, choosing the appropriate method for a research problem is a daunting task, particularly when an empirical study is required. According to Easterbrook et al. (2008), one of the first steps in selecting a method is clarifying the research questions. The terms and phrases used in the research questions must be clearly defined because this is crucial for empirical research.

As introduced at the end of Chapter 3, the main research question of this research was:

> Do the strategic business requirements affect the completeness of the system requirements?

In this research question, 'strategic business requirements' and 'completeness of system requirements' are the two main phrases. These phrases have been thoroughly discussed in Sections 2.2.1 and 2.1.3, respectively, of the literature review chapter. As also discussed in the literature review chapter, the requirements engineering literature has introduced several approaches to develop requirements models for the purpose of alignment; however, these approaches do not consider the completeness of the requirements. Therefore, this research proposed a framework that involves the role of strategic business requirements in terms of their influence on the functional, non-functional and completeness of the system requirements. The focus of this research was on testing and validating an ESRE framework.

4.1 Collection of Three Types of Requirements

In order to test the framework, the collection of requirements was the first basic step to be investigated. The collection of requirements must include three types of system requirements: strategic business requirements, functional requirements and non-functional requirements. Since the main research question related to strategic business requirements and their effects on the completeness of system requirements, strategic business requirements had to be collected. This was crucial for the validity of the framework, as can be observed in Figure 2.

Given the importance of strategic business requirements for the validity of the framework, it was important to understand who collects strategic business requirements and from whom the strategic business requirements are collected. In addition, it was important to consider whether the strategic business requirements are collected at all. It was also important to know whether the strategic business requirements are collected from top managers, operational staff or both levels of staff within the organisation, in the requirements lists. The requirements collected by a subject from a stakeholder were called a requirements list. It was also interesting to know who collects more strategic business requirements than functional and non-functional requirements in their requirements lists. As highlighted in Section 2.1.2, the collection of requirements is influenced by the experience of the requirements collectors; thus, it was important to understand how much the experience of a collector affects the collection of requirements, particularly for the strategic business requirements of the system. Answers to these questions were important for the validity of the requirements lists and empirical testing of the framework.

The requirements engineering literature has highlighted a number of practitioners who play roles in the collection of requirements, including business analysts, project managers, system analysts and enterprise architects. This research did not investigate all possible roles involved in requirements collection due to containment reasons. Rather, this research focused on business analysts, who are generally considered to play a mainstream role in requirements collection. The importance of business analysts in requirements collection in

the industry was discussed in Section 2.1.1. Therefore, the first three questions (RQ 1, RQ 2 and RQ 3) were proposed in relation to the role of business analysts in requirements collection.

4.2 Testing the Relationships

In order to test the framework, this research needed to test the relationships between the four variables or elements of the framework: strategic business requirements, functional requirements, non-functional requirements and completeness of system requirements. The relationships were tested in terms of the effects of one element on another. This effect was measured in terms of increase or decrease of the value in statistical analysis (Meyers, Gamst & Guarino 2006).

Since this research sought to provide empirical evidence on the contribution of the strategic business requirements on the completeness of system requirements, the relationships between the elements of the framework were measured in terms of the influence an element exerts on other elements. For example, what influence do the strategic business requirements have on the completeness of system requirements? Do the functional and non-functional requirements increase or decrease with the strategic business requirements of the system? As a result of this, what influence do the functional and non-functional requirements have on the completeness of system requirements?

Thus, the relationships between the elements of the framework were tested in terms of the contribution of the strategic business requirements, functional requirements and non-functional requirements on the completeness of the system requirements. In relation to testing the five relationships in the framework, five specific research questions (RQ 4, RQ 5, RQ 6, RQ 7 and RQ 8) were raised, as indicated in the framework presented in Figure 2.

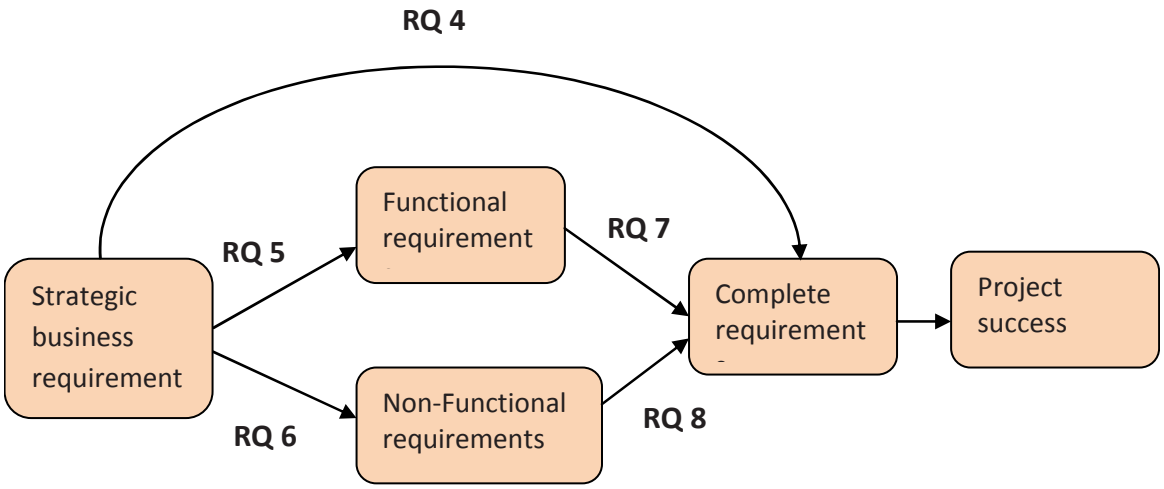


Figure 2: ESRE Framework with Questions

This study's research questions were as follows:

- RQ 1: Do the business analysts collect strategic business requirements?
- RQ 2: From whom do the business analysts collect the strategic business requirements?
- RQ 3: How do the business analysts behave when approaching stakeholders for the collection of requirements?
- RQ 4: Do the strategic business requirements affect the completeness of system requirements?
- RQ 5: Do the strategic business requirements affect the functional requirements of the system?
- RQ 6: Do the strategic business requirements affect the non-functional requirements of the system?
- RQ 7: Do the functional requirements affect the completeness of the system requirements?
- RQ 8: Do the non-functional requirements affect the completeness of the system requirements?

Thus, the first three questions (RQ 1, RQ 2 and RQ3) were related to the collection of requirements—strategic business requirements, functional requirements and non-functional

requirements—as indicated in the framework. However, the rest of the five research questions (RQ 4, RQ 5, RQ 6, RQ 7 and RQ 8) were essentially about measuring the completeness of system requirements affected by the strategic business requirements, functional requirements and non-functional requirements of the system. It should be pointed out that empirically measuring the influence of the strategic business requirements on the completeness of system requirements was within the scope of this research. For this, five specific questions needed to be answered. However, measuring the effect of the completeness of system requirements on project success was beyond the scope of this research because empirical evidence on this effect has already been provided in previous research (Hammer et al. 1998; Kamata & Tamai 2007).

In order to investigate the first three questions (RQ 1, RQ 2 and RQ3), a collection of requirements needed to be performed, as discussed in Section 4.1. There were various ways of collecting these requirements, including via case study, action research and scenario-based approaches. The requirements engineering literature argues that scenarios are appropriate to present an intuitive picture of the business system (Damas et al. 2005; Gough et al. 1995; Roland, Souveyet & Achour 1998; Rosson & Carroll 2002; Sutcliffs 2003) and this has been adopted for several decades, as Gough et al. (1995) describe. Originally, professional organisations started using a scenario-based approach to develop the systems, which led researchers to adopt it for requirements engineering.

4.3 Development of a Business Scenario

In software engineering research, scenarios are widely recognized as an effective way of collecting and completing requirements specifications (Damas et al. 2005; Rosson & Carroll 2002). According Jarke et al. (1998) a scenario is a "description of a possible set of events that might reasonably take place" (Jarke, Bui & Carroll 1998). The main purpose of developing scenarios is to stimulate thinking about possible occurrences, possible opportunities and risks and courses of actions (Jarke, Bui & Carroll 1998). Researchers and practitioners have long been using scenarios and scenarios have attained centre stage of

problem area across many disciplines, i.e. strategic management (Godet 2001; Postmaa & Lieblb 2005) and human computer interaction (Jarke, Bui & Carroll 1998).

Development of a scenario depends on a scope it is addressing and therefore scenarios can be categorized into different levels (Jarke, Bui & Carroll 1998; Postmaa & Lieblb 2005; Rolland & Grosz 1999). In an example, Anthony (Anthony 1985) has shown scenarios of strategic, tactical and operational levels in his hierarchical model. Individual scenarios have been well accepted in the research community and they are easy to use (Jarke, Bui & Carroll 1998). Small "chunks of best scenario practice" is possible and they are often well structured. Practitioners generally complaint about large scenarios which are often complex and not well structured (Achour, Rolland & Souveyet 1998; Godet 2001; Rosson & Carroll 2002). It is not necessary that the scenarios should be complete as still they can give a reader an intuitive picture of a business system. This is possible when a reader focuses on critical issues of a system without really requiring complete description of the system. Scenarios are very fluid and large scenarios can overlap each other easily making it difficult observing the difference between scenarios. Therefore smaller scenarios in limited numbers can help to develop a structure between the scenarios.

Various ways of developing scenarios have been reported in the literature. For example rich picture, text and images (Potts, Takahashi & Anton 1994; Rolland & Salinesi 2009). According to a saying reported in (Jarke, Bui & Carroll 1998) that "there is never just one way of doing something. Never has been, never will be, and never should be." Out of many ways of developing scenarios, narrative structure of scenarios appears to be well appreciated by the research community (Jarke, Bui & Carroll 1998; Potts, Takahashi & Anton 1994; Rolland & Salinesi 2009; Sutcliffs 2003). This is a textual form of a scenario in which scenarios are developed in the form of stories and it can be based on one's practical experience (Jarke, Bui & Carroll 1998; Potts, Takahashi & Anton 1994; Sutcliffs 2003).

The collection of requirements in this research began with the development a business scenario that meant different things to different business analysts—business analysts can

have different understandings of business systems during the collection of requirements. Therefore, when a business scenario is created, this provides a base for business analysts to collect requirements. In this research, a fictitious organisation called Five Star was introduced. The development of this scenario was important to begin with because it presented an intuitive picture of the business system for the business analysts.

The business scenario, which was developed based on the researcher's practical experience, was described in the form of a story, presenting the external and internal perspectives of the organisation. The business scenario was described in the textual form so that business analysts of varying experience could focus on the collection of requirements, rather than on other aspects, such as graphical notations used in the development of the scenarios. The scenario of the Five Star organisation, which can be found in Appendix A, did not present a complete picture of the business system. However, it highlighted critical aspects of the system that were necessary for the collection of requirements. This scenario was created to simulate the real situation of a business environment in which various business analysts collect requirements for a business system.

The business scenario of two pages, developed by the researcher, was reviewed by four practitioners: two were senior business analysts working in financial industry whereas the other two were senior lecturers working at University of Technology Sydney, Australia. Each of them reviewed the scenario individually based on the senior management approach in requirements engineering introduced by this article (Jarke, Bui & Carroll 1998). In the light of their feedback, I had to remove overlapping statements and identified main path of the business story.

4.3.1 Developing Viewpoints

When developing the business scenario for this research, viewpoints representing many stakeholders were created. Viewpoints have been used in requirements engineering for various reasons, such as to represent entities in a system's environment and to represent different classes of stakeholders (Easterbrook et al. 2005; Sommerville & Sawyer 1997).

Therefore, based on the business scenario of Five Star, this research developed viewpoints representing the perspectives of various stakeholders in the business system. This included top management, middle managers and operational level staff within the organisation. These viewpoints are included in Appendix B. So, as the three questions tend to know where do the strategic business requirements come from, how do the business analysts behave in the collection of the requirements, this research developed viewpoints to represent the perspective of stakeholders at various levels in the organisational hierarchy. The business analysts consulted the viewpoints for the collection of the requirements lists.

4.4 Conducting Two Studies

As depicted in Figure 3, two studies were conducted to test the framework. The first study dealt with the collection of requirements lists, while the second study dealt with assessing the requirements lists to test the relationships between the four variables of the framework. The collection of requirements was performed to address the first three questions (RQ 1, RQ 2 and RQ3) related to the framework. In this regard, a business scenario was created to present an intuitive picture of the business system of Five Star. This scenario helped to create viewpoints representing many stakeholders in the system. The viewpoints were visited by a number of business analysts for the collection of requirements. This approach simulated the real situation of a business organisation, in which business analysts collect requirements from the stakeholders of the system. The performance of the business analysts in the collection of the requirements, particularly the strategic business requirements, was evaluated to address the first three questions related to the framework.

In order to answer the rest of the questions (RQ 4, RQ 5, RQ 6, RQ 7 and RQ 8), a second study was conducted, in which the requirements lists collected in the first study were assessed. This assessment was performed in terms of how well the business analysts had collected the requirements—strategic business requirements, functional requirements and non-functional requirements—of the system. In addition, it examined how complete the requirements lists were with respect to the business scenario. This assessment was performed on a quantitative scale so the empirical evidence on the influence of the strategic

business requirements on the functional, non-functional and completeness of requirements could be provided. As discussed above, the last five questions were related to the influence of the strategic business requirements on the other variables of the framework. This is why the requirements lists collected in Study 1 were fed into Study 2, as shown in Figure 3. Thus, two studies were sufficient to investigate the eight questions related to the testing the framework.

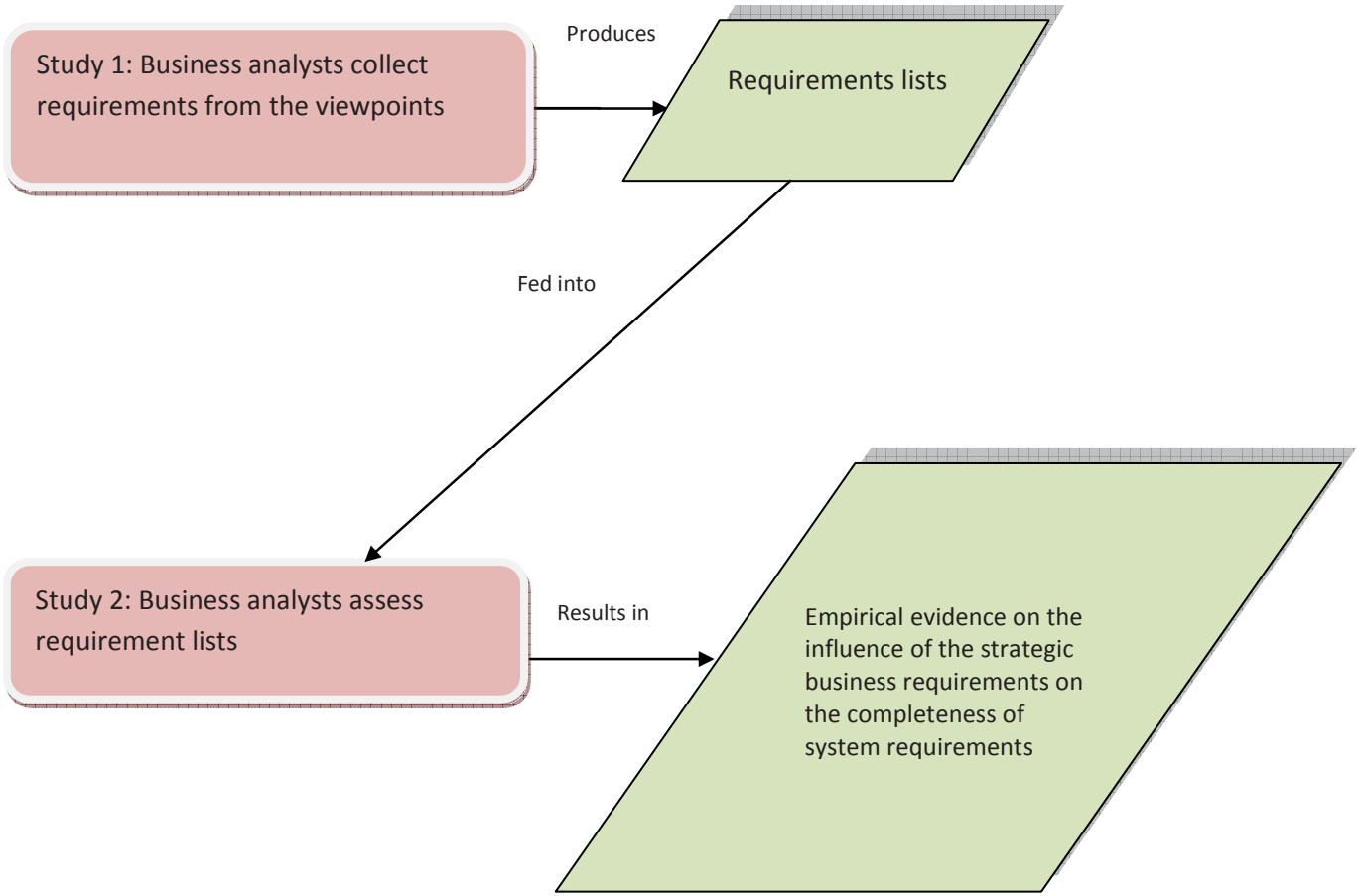


Figure 3: ESRE Framework Testing Approach

4.5 Study 1: Collection of Requirements Lists

This study was conducted to provide insights into the behaviour of business analysts involved in the collection of requirements. This was crucial to establish the context of a framework in which strategic business requirements can be collected. In this regard, the business analysts were provided with viewpoints representing the various stakeholders of the system from which the requirements were collected. Of the eight research questions mentioned above, the first three questions related to the collection of requirements:

- RQ 1: Do the business analysts collect strategic business requirements?
- RQ 2: From whom do the business analysts collect the strategic business requirements?
- RQ 3: How do the business analysts behave when approaching stakeholders for the collection of requirements?

Investigation of these questions helped understand the role of business analysts with varied experience in the collection of requirements, particularly strategic business requirements. This study facilitated a flexible requirements engineering approach for the business analysts, in which they chose viewpoints of the business scenario for the collection of requirements. This study produced qualitative data in terms of requirements lists, comprised of various combinations of strategic business requirements, functional requirements and non-functional requirements. The results of Study 1 are considered inconclusive because the requirements lists do not show how the strategic business requirements influence the completeness of system requirements, which was the main research question of this research.

4.6 Study 2: Assessment of the Requirements Lists

The purpose of this study was to test and validate the framework in terms of measuring the influence of the strategic business requirements on the functional requirements, non-functional requirements and completeness of system requirements. Of the eight research questions mentioned above, the last five questions related to this objective:

- RQ 4: Do the strategic business requirements affect the completeness of system requirements?
- RQ 5: Do the strategic business requirements affect the functional requirements of the system?
- RQ 6: Do the strategic business requirements affect the non-functional requirements of the system?
- RQ 7: Do the functional requirements affect the completeness of the system requirements?
- RQ 8: Do the non-functional requirements affect the completeness of the system requirements?

To investigate these questions, assessment of the requirements lists was performed in Study 2. The requirements lists were assessed in terms of how well the business analysts performed when collecting the strategic business requirements, functional requirements and non-functional requirements, and how complete each requirements list was. This assessment was performed on a quantitative scale so that empirical evidence on the contribution of the strategic business requirements to the completeness of the system requirements could be attained. Multivariate analysis techniques, with the support of the software program IBM SPSS 19, were applied to test the effects of the strategic business requirements on the functional, non-functional and completeness of system requirements.

A survey approach was adopted to assess the requirements lists. Experimentation and surveys are considered appropriate methods for the collection of empirical data—the majority of software empirical studies consider them suitable data collection methods for the generalisation of results (Humphrey 2000; Kitchenham et al. 2002; Pfleeger & Kitchenham 2002; Sjoberg et al. 2002; Sjoberg et al. 2005; Wohlin et al. 2000). While experimental study is useful for conducting empirical research, for this research, it was not useful because it measures the cause and effect relationship between the variables, and inferences are subsequently drawn about these cause and effect relationships. In survey studies, variables are not manipulated; rather, correlational conclusions are drawn to measure associations between variables, rather than causal links. As indicated in the

framework, this research measured the associations between the elements of the framework; therefore, a survey was the more appropriate method to assess the requirements lists.

Surveys are appropriate for collecting quantitative information about the perceptions and opinions of a sample of people who adequately represent the population of interest (Easterbrook et al. 2008), which was the objective of assessing the requirements lists. Generally surveys can be conducted with many stakeholders in a relatively short timeframe, and are generalisable to the entire population (Pfleeger & Kitchenham 2002). Surveys mainly use a standardised, structured questionnaire to minimise interviewer bias. They can be completed via telephone, mail or in person. In this regard, experimentation provides limited support. Thus, overall, a survey was considered an appropriate method to use to assess the requirements lists and produce conclusive and generalisable results.

4.7 Choosing Subjects

Given the importance of the experts and novices as subjects of studies, this research involved people from both categories to collect the requirements and assess the requirements lists. As highlighted in Section 4.6, the main purpose of involving people of both categories was to provide conclusive and generalisable results. In this research, experts were considered to have at least five years of industry experience, whereas novices had only completed training at university. Generally, final year students at university are considered novices because they are about to complete their course and are ready to enter the industry. Experts and the novices have been the subject of studies in many disciplines, including social science (Burton & Mazerolle 2011; Tajfel 1982), psychology (Shaffer, Vogel & Wei 2006) and software engineering (Kitchenham et al. 2002; Sjoberg et al. 2005; Wohlin et al. 2000).

The novices in the current study were final year students of business and IT at the University of Technology Sydney (UTS), Australia. They met the selection criteria (presented below) because they were the final year students of a business and IT course at a

university in which they had completed subjects related to the collection of requirements and the development of system requirements specification. In addition, they had studied subjects related to the business strategies of organisations and the way IT supports these goals, which are considered the strategic business requirements of the system.

A large number of business analysts, with varying levels of experience, were acquired from different industries. The business analysts met the study criteria if they had completed an undergraduate degree in business and/or IT, and had many years of industry experience in business analysis and design.

4.7.1 Addressing Selection Bias

To avoid bias in selection, the novices and experts were selected in the following manner. To select the novices, all students of the business and IT course at the UTS, Australia, were informed of this study during a lecture, and were requested to participate in this study. A large number of students, representing people from different ethnic backgrounds, were willing to participate in the study. They showed their interest to participate the study by raising hands in the lecture, verbally, and sending emails to the researcher. The students had different levels of learning and, most importantly, represented an almost equal balance of male and female students. Through this selection procedure, males and females of various backgrounds were selected to participate in this study.

In terms of the experts, the researcher used his contacts in the industry and academia to approach business analysts in various industries. In order to avoid bias in the selection of the subjects, the researcher approached business analysts from six industries: software development, insurance, banking, transportation, law and academia. The experts were from companies such as IBM, Hewlett Packard, Commonwealth Bank, ANZ Bank, ING Insurance, AAMI Insurance and NSW State Transit. These also included males and females in both senior and junior categories of business analysts from these industries in Sydney, Australia. Approximately half of the sample was female (52%), and males comprised the remainder (48%). The subjects were from various ethnic backgrounds, with approximately

45% being European Australians, 25% Chinese Australians, 15% sub-continental Australians and 10% Japanese Australians.

4.7.2 Selection Criteria

Based on consultation with three experienced academics of the requirements engineering discipline, the following basic criteria were developed to select the subjects. These criteria helped select subjects whom were appropriate for the collection of requirements and assessment of requirements lists comprising the strategic business requirements, functional requirements and non-functional requirements of the system:

1. The subjects should have a basic understanding of collecting requirements from the stakeholders of the system. *Explanation:* this criterion was important because, in both studies, the subjects collected requirements and assessed the collected requirements against the corresponding business scenario;
2. The subjects should have graduated or be about to graduate from a university in which they have learnt about various types of requirements, such as strategic business requirements, functional requirements and non-functional requirements. *Explanation:* the subjects needed to know the difference between various types of requirements. This would help the subjects decide on stakeholders for the collection of requirements. Understanding various types of requirements also helped the subjects effectively assess requirements lists comprising of strategic business requirements, functional and non-functional requirements;
3. The subjects should have an understanding of using requirements modelling techniques (use cases). *Explanation:* this criterion provided support to Criterion 2. Subjects who had modelled requirements using various techniques had a stronger understanding of requirements gathering and their types; and
4. The subjects should have experience in developing software requirement lists. *Explanation:* this criterion meant that the subjects knew the purpose of the collection of requirements, as well as how to complete the requirements lists. This criterion was crucial with respect to assessing the completeness of the requirements lists.

4.8 Survey Validity

As discussed above, Study 1 involved collection of requirements, while Study 2 involved assessment of the requirements lists collected in Study 1. The collection of requirements was performed with an unstructured and flexible approach, while the assessment of requirements lists was performed with a structured survey approach. Therefore, the survey validity needs to be discussed. Validity of the survey results depends on the instrument used to collect the survey data. Validity was a necessary entity of this instrument for this research to report the testing and validity results of the framework with confidence. Validity refers to the degree to which an instrument actually measures what it is designed or intended to measure. There are four common procedures for establishing the validity of an instrument:

1. Face validity;
2. Content validity;
3. Criterion validity; and
4. Construct validity (Burton & Mazerolle 2011; Kitchenham & Pfleeger 2002a).

Face validity and content validity refer to qualitative measures of validity and often are easy to achieve. In this research, face validity and content validity were secured via a panel of experts who evaluated the instrument's appearance, relevance and representativeness of the four variables, strategic business requirements, functional requirements and non-functional requirements of the system. Face validity and content validity were important first steps towards establishing the construct validity of the framework because they provided details on the accuracy and correctness of the questions asked and variables measured. The survey instrument was assessed by the panel of experts during a pilot test, which is reported in Chapter 6.

Survey researchers must also establish an instrument's criterion-related validity and construct validity before using it for analysis (Burton & Mazerolle 2011; Kitchenham & Pfleeger 2002a). Criterion-related validity demonstrates the accuracy of the measure by

comparing it with previously established and valid instruments. Requirements engineering research has not previously offered a survey instrument to collect empirical data; therefore, this validity could not be applied to this study.

Construct validity is the degree to which an operational measure correlates with the theoretical concept being investigated (Burton & Mazerolle 2011; Kitchenham & Pfleeger 2002a). Construct validity was tested in the following four-step procedure, which is argued for by researchers (Burton & Mazerolle 2011; Kitchenham & Pfleeger 2002a). Step one involved defining the four variables: strategic business requirements, functional requirements, non-functional requirements and completeness of system requirements. Step two involved generating items for the four variables mentioned in step one. Step three involved designing and conducting a pilot study to test the framework. Step four involved finalising the framework based on the empirical data collected in step three. In this study, the construct validity was established before the survey study was conducted. Multivariate analysis played a crucial role in the construct validity, in which the framework was tested against its theoretical stance and validated against the claimed relationships between its four variables.

4.9 Summary

In summary, testing the framework was completed through two studies. In the first study, business analysts collected requirements from viewpoints representing the stakeholders of the system. This study addressed three of the eight research questions provided above in this chapter and produced qualitative data in the form of requirements lists. The requirements lists were then assessed by a large group of subjects comprised of novices and experts in a survey study, thus answering the last five research questions, which were related to the associations between the variables of the framework. This assessment was performed on a quantitative scale so that conclusive and generalisable results could be produced.

Chapter 5: Study 1—Collection of Requirements Lists

5.1 Purpose

The main purpose of this study was to collect requirements from various stakeholders of the system and evaluate the performance of business analysts in relation to collecting three types of requirements: strategic business requirements, functional requirements and non-functional requirements. Since the role of strategic business requirements in relation to the completeness of system requirements has been shown to be crucial in the framework, it was important to know the performance of the business analysts in relation to the collection of the strategic business requirements. In this regard, the following three main research questions were investigated in this research:

- RQ1: Do the business analysts collect strategic business requirements?
- RQ2: From whom do the business analysts collect strategic business requirements?
- RQ3: How do the business analysts behave when approaching stakeholders for requirements?

This study involved dozens of experienced practitioners and academics to collect the requirements of various stakeholders of the system. Viewpoints that represented the perspectives of the stakeholders were used to collect the requirements. The subjects developed a large number of requirements lists from the viewpoints representing the perspectives of the stakeholders. A requirements list is defined as the requirements collected from a stakeholder by a subject. The data collected in terms of the requirements lists were assessed to provide the answers to the above three questions.

5.2 Designing the Study

This section begins with an introduction to the concept of a viewpoint because this approach was adopted to represent the perspectives of the stakeholders of the system. The

following sections discuss what a viewpoint is and how viewpoints were adopted in this study.

5.2.1 What is a Viewpoint?

A viewpoint is essentially described as an idea of an actor about an intended system (Easterbrook et al. 2005; Finkelsetin et al. 1992; Finkelstein & Sommerville 1996). It refers to the partial knowledge about the system. Viewpoints have been used in requirements engineering for various reasons, including as entities in a system's environment, to represent different classes of users, to distinguish between stakeholder terminologies and to partition the requirements engineering process into loosely coupled work pieces (Easterbrook et al. 2005; Sommerville & Sawyer 1997).

5.2.2 Identifying Viewpoints

Developing the largest and most complex systems necessarily involves many people, each with their own perspective on the system, as defined by their skills, responsibilities, knowledge and expertise (Easterbrook et al. 2005; Finkelsetin et al. 1992; Sommerville & Sawyer 1997). A viewpoint-based approach to requirements engineering recognises this concern and argues that the system requirements cannot be discovered from a single perspective. Instead, a number of different viewpoints are needed to collect the requirements effectively (Easterbrook et al. 2005). It is important to understand that system usage is heterogeneous and there is no such thing as typical users. A viewpoint-based approach organises system requirements from various stakeholders of the system. Requirements collected from various viewpoints are integrated to form the system requirements specification (Easterbrook et al. 2005).

5.2.3 Business Context of the Stakeholders

This section outlines the business context of the fictitious organisation from which the stakeholders of the system were identified. This organisation was named Five Star. It has

dozens of stores around the world and its head office is in the United States (US). Most of its daily operations—such as raw material procurement, merchandise production and delivery, product sales and in-store services—are conducted via a comprehensive network of stores and cooperating companies. Progress and success working with local suppliers is not possible without understanding and cooperation. Five Star has a comprehensive hierarchy of leadership involved in defining business strategies that align with the vision and mission of the organisation.

Top management, such as chief executive officers (CEOs) and business executives, expect the IT system to support the company's strategic direction. The chief information officer (CIO) defines the global IT strategy and local IT strategy. The global IT strategy helps expand the business by opening new stores and creating new partnerships and alliances. The local IT strategy helps stores manage store business more efficiently, including better support for the sale and marketing of products. At the store level, managers expect IT to support supplies and provide better inventory control. Thus, the different perspectives of this business scenario's 10 stakeholders were considered important for the collection of requirements. These stakeholders were a CIO, an enterprise architect (EA), an accountant, a business executive, a business director, a sales manager, a marketing manager, a store manager, direct users and suppliers.

The business context of the stakeholders indicates that there is the possibility of having more than 10 stakeholders. However, only 10 stakeholders were identified because, if too many viewpoints are used, it becomes difficult to manage the large quantity of information generated and prioritise the requirements (Sommerville & Sawyer 1997). The most critical viewpoints are suggested to be developed for requirements gathering (Easterbrook et al. 2005; Sommerville & Sawyer 1997). Viewpoints were developed from the perspectives of these 10 stakeholders of the organisation's system. The viewpoint-based approach does not provide any criteria for selecting stakeholders. Thus, selection of the 10 stakeholders was based on the researcher's understanding of the organisational hierarchy of the business organisation of Five Star.

5.2.4 Dividing the Stakeholders into Two Groups

The subjects dedicated two hours for this study; however, approaching 10 stakeholders for requirements was a task that took longer than two hours. Therefore, the stakeholders were divided randomly into two groups, each containing five stakeholders, so that the subjects could complete the requirements collection in two hours. The two groups of stakeholders are shown in Table 2. Group-A had the CIO, EA, accountant, business executive and business director, while Group-B had the sales manager, marketing manager, store manager, direct users and suppliers.

Table 2: Two Groups of Stakeholders

Group-A stakeholders		
Stakeholder 1	CIO	Viewpoint 1
Stakeholder 2	EA	Viewpoint 2
Stakeholder 3	Accountant	Viewpoint 3
Stakeholder 4	Business executive	Viewpoint 4
Stakeholder 5	Business director	Viewpoint 5
Group-B stakeholders		
Stakeholder 1	Sales manager	Viewpoint 1
Stakeholder 2	Marketing manager	Viewpoint 2
Stakeholder 3	Direct users	Viewpoint 3
Stakeholder 4	Suppliers	Viewpoint 4
Stakeholder 5	Store manager	Viewpoint 5

5.2.5 Subjects

This section explains how the subjects were involved in collecting requirements from the stakeholders shown in Table 2. Fifty-two business analysts working in various Australian companies were pursued via email and telephone calls to participate in collecting requirements from the stakeholders. The researcher used his contacts in academia and industry to pursue these subjects. In the first contact, the business analysts were briefly informed that, in this study, the subjects had to collect requirements from the viewpoints of various stakeholders of the system. They were informed that the purpose of this study was to investigate the performance of business analysts in collecting requirements. It was also indicated that this study should not take more than two hours.

Twenty-five business analysts provided consent in the first contact via emails and phone calls, and five more became available to participate in the study when a reminder email was sent the following week. The remaining business analysts were not reminded a second time in order to avoid bias in the subject selection. Therefore, 30 business analysts from various industries were able to participate in the study. These business analysts had varying levels of industry experience, as presented in Table 3.

Table 3: Business Analysts and their Experience

Number of subjects	Job title	Years of industry experience
14	Business analyst	8–12
6	Business analyst	3–7
4	Software engineer	5–8
3	Senior lecturer	7–11
3	PhD research student	4–5 years of research experience + 3–4 years of industry experience

The subjects were from various industries, including telecommunication, finance and transportation; however, the majority were from the software development industry. In addition, some academics and research students who had a great deal of teaching and research experience in business analysis and design were also considered legitimate subjects of this study. These subjects addressed the inclusion criteria effectively (as is described in Chapter 3).

Since there were two groups of stakeholders—Group-A and Group-B—the subjects were divided into two equal groups, each having 15 subjects, so that an equivalent level of focus could be provided to each group of stakeholders for the collection of the requirements. This was crucial to minimise bias in the behaviour of the subjects when collecting requirements. This meant that one group of subjects could collect requirements from one group of stakeholders. Table 4 shows that the experience of the 30 subjects was considered when dividing them into two groups. Table 4 also shows that both groups were almost at equivalent levels in terms of their job titles, although there were more academics in Group-A than Group-B, and more PhD students in Group-B than Group-A. Thus, the groups

appeared to be at equivalent levels. These two groups of subjects were given arbitrary numbers—Group 1 and Group 2—to recognise them in this study.

Table 4: Composition of the Two Groups of Subjects

Group 1	Group 2
7 senior business analysts (8–12 years of experience)	7 senior business analysts (8–12 years of experience)
3 junior business analysts (3–7 years of experience)	3 junior business analysts (5–6 years of experience)
2 software engineers (5–7 years of experience)	2 software engineers (3–6 years of experience)
2 senior lecturers	1 senior lecturer
1 PhD research student	2 PhD research students

5.3 Conducting the Study and Data Collection

This study was conducted in the common room of the UTS with the mutual agreement of all 30 subjects regarding the time, date and place. All 30 subjects gathered in the room and were given two pages with a brief of the retail company, Five Star, so they could develop an understanding of the business. This included an introduction to Five Star's business (vision, mission and operations) and the rationale of conducting this study. The subjects were given 30 minutes to read the brief, which they completed within this timeframe.

In the next step, the subjects were divided into two groups based on their background information, as shown in Table 4. Randomly, Group-A stakeholders were given to subject Group 1 for requirements, while Group-B stakeholders were given to subject Group 2 for requirements. Each subject from both groups had the option to choose between one and five stakeholders from the given set of five stakeholders. The subjects of both groups were not allowed to cross-check the groups of stakeholders. To address the greater purpose of this research, which was completeness of requirements, the subjects were required to collect requirements from their dedicated group of five stakeholders. Each subject was required to capture at least five requirements from a stakeholder. The reason for requesting five requirements per viewpoint was that the subjects could capture the focal paths, and the requirements capturing could finish within two hours. However, if a subject collects less than five still be considered and analysed accordingly. The requirements captured by a

subject from a stakeholder were called a 'requirements list', which meant that, if a subject collected requirements from two stakeholders, they would be considered two requirements lists. This was importance in terms of assessing what was captured, from whom it was captured, and who captured it. Thus, the requirements collected from stakeholders in this study were recognised by the requirements lists.

Both groups of subjects were given two hours to collect the requirements. The majority of subjects completed the requirements gathering in between one and two hours. Interestingly, none of the subjects could complete the requirements gathering in less than one hour—even those who selected only one or two stakeholders for requirements gathering. No unusual events were recorded during this study. To reiterate, the requirements collected by a subject from a stakeholder were called a 'requirements list' in this study.

5.4 Results and Discussion

Altogether, 60 requirements lists were developed by the two groups of subjects. Of these 60 requirements lists, 26 lists were developed from the Group-A stakeholders and 34 from the Group-B stakeholders. The requirements collection range was between nine and three for all 60 requirements lists. The requirements lists were assessed for their completeness and clarity. This was important before the requirements lists were assessed in Study 2.

5.4.1 Quality of Requirements

Each requirement of the 60 lists was assessed by the researcher and a volunteer researcher. Both were final year PhD students in Faculty of Engineering and IT at UTS. Both had more than five years of industry experience in business analysis and design. Several requirements in both groups were found to be vague or incomplete and were subsequently removed from the lists. Details of the requirements removal from the lists are provided in Tables 5 and 6.

As indicated in Table 5, 150 requirements were collected by the subjects dedicated to the Group-A stakeholders. Eighteen requirements were considered too vague or unclear to

understand (some examples are provided in Table 5); thus, they were excluded from the lists. Following the removal of these 18 requirements, the total number of requirements collected from the Group-A stakeholders was 132. The requirements in the lists appeared to be meaningful, as illustrated in Appendix C.

Table 5: Statistics of Requirements from Group-A

Unclear requirements	Number of requirements (150)
Ten requirements were found to be vague because it was difficult to understand their meanings. For example, 'linking software systems with management goals' and 'start small, not big/giant business'. Such requirements were excluded from the study.	150 – 10 = 140
Eight entries were found to be suggestions, instead of requirements. These were also excluded from the study. For example, 'improve gradually (start with single digit)'.	140 – 8 = 132

Similar to the requirements lists from the Group-A stakeholders, the requirements lists from the Group-B stakeholders had ambiguous requirements that did not make sense to the researchers. As indicated in Table 6, 210 requirements were collected from the Group-B stakeholders, from which 20 requirements were too vague or not meaningful. These were removed from the lists to ensure the lists were of a high quality.

Table 6: Statistics of Requirements from Group-B

Unclear requirements	Number of requirements (210)
One subject's data was disregarded because it presented very trivial requirements. For example, 'add and delete items from stock' and 'add and delete customers from the system'.	210 – 5 = 205
Fifteen requirements were found to be ambiguous because it was difficult to understand what they meant. For example, 'based on the population item can be provide'. It was unclear whether this referred to forecasting demands or home delivery service. Another example is 'sync 3 against 2, build ordering system'. This was also a vague requirement that was excluded.	205 – 15 = 190

Removal of the vague and ambiguous requirements from the lists improved the quality of requirements lists to some extent. Thus, the requirements lists were ready to be used in the survey study to test and validate the framework. However, before beginning that work, it

was necessary to identify how the subjects approached stakeholders for the requirements—what was their behaviour? It was crucial to investigate this to ensure the validity of the requirements data for the study 2.

5.4.2 Collection of Requirements

This section discusses the requirements lists of the Group-A stakeholders separately from the Group-B stakeholders to demonstrate the difference in behaviour of the subjects when approaching stakeholders of the system. The results shown in Table 7 indicate that the behaviour of the subjects of both groups was similar when approaching stakeholders for requirements. Table 7 shows that 14 out of 15 subjects dedicated to the Group-A stakeholders believed it was sufficient to approach a maximum of three stakeholders to attain the requirements. Only one subject considered meeting with four stakeholders. Surprisingly, none of the subjects considered meeting with all five stakeholders for the requirements.

Similar to Group-A, 13 out of 15 subjects assigned to meet the Group-B stakeholders believed it was sufficient to approach a maximum of three stakeholders to attain the requirements. Of the remaining two, one subject considered meeting four, and the other considered meeting all five stakeholders. These results highlight that the majority of subjects did not make an effort to meet all the available stakeholders for the requirements—they tended to approach only a small number of stakeholders. This trend was similar across both groups of subjects. Only a few subjects from both groups met with the maximum number of available stakeholders for the requirements.

It was important to examine why this trend existed, and whether it was associated with the subjects' experience. Thus, the experience data of the subjects were analysed, and it was found that the subjects who met with four or five stakeholders, across both groups, were highly experienced, whereas the subjects who met with less than four stakeholders were less experienced. These results indicate that senior business analysts tend to meet with more

stakeholders of the system for requirements, while junior business analysts tend to meet with less stakeholders for requirements.

Table 7: Details of the Collected Requirements Lists

Subjects collecting requirements from Group-B stakeholders		Subjects collecting requirements from Group-A stakeholders	
Subjects × stakeholders	**No. of requirements lists**	**Subjects × stakeholders**	**No. of requirements lists**
6 subjects × 2 stakeholders	12 requirements lists	8 subjects × 1 stakeholder	8 requirements lists
4 subjects × 1 stakeholder	4 requirements lists	4 subjects × 2 stakeholders	8 requirements lists
3 subjects × 3 stakeholders	9 requirements lists	2 subjects × 3 stakeholders	6 requirements lists
1 subject × 4 stakeholders	4 requirements lists	1 subject × 4 stakeholders	4 requirements lists
1 subject × 5 stakeholders	5 requirements lists	0 subjects × 5 viewpoints	0 requirements lists
Total	**34**	**Total**	**26**
Grand total = 60 requirements lists			

Another way of analysing the data was from the perspective of the stakeholders, as shown in Table 8. It was found that 38% of subjects wanted to meet the EA for requirements, but none wanted to meet the accountant. This was a large variation (38%) in meeting frequencies compared to the Group-A stakeholders. Similarly, the meeting frequencies of the subjects with the Group-B stakeholders also showed have considerable variation such as 26% for the sales manager and 14% for the supplier. Despite seeking reasons regarding why the subjects met with some stakeholders more than others, the data did not suggest any particular reason, even after being analysed from various perspectives, including the experience, gender and age of the subjects. Unfortunately, no correlation was found between these variables and the variation in the meeting frequencies of the stakeholders. This was a limitation of this study, but investigating it further was beyond the scope of this study. It is important to highlight that the primary purpose of this study was to produce requirements lists, which was performed effectively by developing the 60 requirements lists. Therefore, variation in the meeting frequencies did not affect the assessment results in the next study.

In terms of the behaviour of the subjects, the results indicated that the business analysts generally tended to approach less stakeholders for requirements, while the experienced business analysts tended to approach more stakeholders than the junior business analysts. The results do not conclude why the business analysts met some stakeholders more than other stakeholders, and their personal data did not help in this regard. This aspect of their behaviour was analysed from the perspective of what the business analysts captured and from whom they captured it. This analysis also helped address the greater objective of this research, which was focused on the collection of strategic business requirements. It was important to examine whether strategic business requirements were captured in the lists, and, if so, who captured them and from whom were they captured. Answers to these questions were crucial to complete this study and provide suitable requirements data for the survey study.

Table 8: Stakeholder Meeting Frequency

Group-A stakeholders		
Stakeholder	**Number of subjects who met with a stakeholder**	**Frequency**
EA	10	38%
CIO	9	34%
Business executive	4	15%
Board member	3	11%
Accountant	0	0%

Group-B stakeholders		
Stakeholder	**Number of subjects who met with a stakeholder**	**Frequency**
Sales manager	9	26%
Direct user	8	23%
Marketing manager	6	17%
Store manager	6	17%
Supplier	5	14%

5.4.3 Do the Requirements Lists Contain Strategic Business Requirements?

This section discusses the requirements lists of Group-A separately from Group-B to answer the questions provided at the end of the previous section. Some of these questions were:

- Do the requirements lists contain the strategic business requirements?
- If so, then from whom were these captured?

Answers to these questions were sought to help understand why the business analysts approached some stakeholders more than others. However, before these requirements lists

are analysed, it is necessary to outline the criteria on which the strategic business requirements will be distinguished from functional and non-functional requirements of the system.

The research literature of experts was explored to define the criteria. For example, Lawrence Chung's research work (Chung & Nixon 2000; Mylopolous, Chung & Nixon 1992; Mylopoulos et al. 2001) was explored to find items representative of non-functional requirements. According to researchers, non-functional requirements mainly involve the constraints and qualities of a system. How a system should function is described in terms of its non-functional requirements. Thus, 'how a system should function', 'qualities of the system' and 'constraints on the system' are the examples of items that represented non-functional requirements.

A vast amount of existing requirements engineering literature describes functional requirements in terms of the features of the system—that is, what a system should do (Anton & Potts 1998; Jackson 2001; Jacobson 1992). The literature also often describes functional requirements in terms of tasks to be performed. Therefore, the main items representing the variable of functional requirements were 'features of the system', 'what a system should do' and 'tasks to be performed.

The items related to the strategic business requirements are 'management goals', 'organisation's longer-term directions' and 'goals that drive to market leadership'. These requirements were enterprise-level goals that were found in the business strategy literature in the management information system discipline (Birnik & Moat 2008; Lei & John W. Slocum 2005). Thus strategic business requirements refer to the longer-term goals of an enterprise, which are generally defined by the top managers of the organisation (Chan & Huff 1992; Kaplan & Norton 2004). They are often described as clear and precise goals referring to the future of the organisation (Kaplan & Norton 2004). Such goals help the organisation gain competitive advantage over their rivals. The requirements lists were analysed to identify whether they had these types of goals as the strategic business requirements of the system.

5.4.3.1 Group-A Requirements Lists

Twenty-six requirements lists from the Group-A stakeholders were assessed. As indicated in Table 9, 10 requirements lists were collected from the EA of the organisation. These 10 requirements lists were developed by five senior business analysts, two junior business analysts, one software engineer, one senior lecturer and one PhD student. A requirements list that was developed by a senior business analyst contained an e-commerce strategy, an online business strategy, reducing operational cost, improving service quality, targeting new markets and exceeding the sales target of a competitor. From the perspective of the definition of business strategy, targeting a new market and exceeding the sales target of a competitor are strategic business requirements, while the others appear to be functional and non-functional requirements. This is displayed in Table 9. Please note that this section only discusses the strategic business requirements of the requirements lists. Two of the 26 requirements lists are shown in Table 9 and 10, however the remaining 24 requirements lists are attached in Appendix C.

Table 9: Requirements List 1

Requirements	Type of requirement
Use various channels for marketing	Functional
Follow customer's buying pattern	Functional
Enhance communication with customers	Functional
Improve service quality	Non-functional
Target new markets	Strategic
Exceed the sales target of a competitor	Strategic

The second requirements list, which was developed by a senior business analyst, contained increasing sales, doubling productivity, implementing high quality inventory control, providing efficient information related to logistics and providing a distribution and just-in-time delivery system. The majority of requirements were functional and non-functional; however, increasing sales and doubling productivity were strategic business requirements, as shown in Table 10. These requirements refer to the growth of the organisation.

Table 10: Requirements List 2

Requirements	Type of requirement
Increase sales	Strategic
Double productivity	Strategic
High quality inventory control	Functional
Provide efficient information related to logistics and distribution	Functional
Just-in-time delivery	Functional

The other three senior business analysts identified 10 strategic business requirements in the other three requirements lists. These strategic business requirements were as follows: increase shares of the company, 70% reduction in cost of operations, increase dividends, use IT to support global strategy, expand the business market, develop new partnerships, open new stores, target new markets, double sales in five years and increase global business performance. Based on the understanding of the business strategy concept, these requirements appear to be the strategic business requirements of the system because these requirements represent the longer-term goals for the future of the organisation.

Two requirements lists, collected by junior business analysts, comprised two strategic business requirements: increase market shares and double digit growth. The other requirements in the two lists appeared to be the functional and non-functional requirements of the system. Two requirements lists, one developed by a software engineer and one by a PhD student, did not contain any strategic business requirements. These subjects collected only the functional and non-functional requirements of the system from the EA. In contrast, a requirements list developed by a senior lecturer contained four strategic business requirements out of the nine requirements. The strategic business requirements referring to the longer-term goals of the organisation were as follows: exceed sales of the total number of retail stores, increase market shares, target new business markets and create alliances.

Assessment of the requirements collected from the EA indicated that the majority of requirements were functional and non-functional. Of the 64 requirements, 20 were strategic business requirements, which is 31%. The results also indicated that the senior business

analysts and the senior academics tended to capture the strategic business requirements more frequently than did the junior practitioners and academics.

It is now important to examine the rest of the requirements lists developed by the business analysts. As shown in Table 8, nine requirements lists were collected from the CIO of the organisation. Altogether, 49 requirements were collected, in which 18 were strategic business requirements, while the others were functional and non-functional requirements. The 18 strategic business requirements were as follows: pricing and merchandising, new partnerships, reducing operating costs, new alliances, new business markets, double digit profitability, increase shareholder value, increase growth target, new productivity target, increase dividends, reduce prices, new cost structure, new product markets, outsource IT, increase sales by double, gold standard, improve customer index and increase profitability.

Of these 18 strategic business requirements, 10 were identified by the five senior business analysts who collected them from the five requirements lists. The strategic business requirements were between three and one for the five requirements lists. The other four requirements lists—one collected by a software engineer, one by a junior business analyst, one by a senior lecturer and one by a PhD student—contained the remaining eight strategic business requirements, each having two strategic business requirements. Of the 49 requirements, the 18 strategic business requirements comprised 37% of the total number of requirements. These results indicated that the senior and junior business analysts collected the strategic business requirements from the CIO, whereas the previous results indicated that the senior business analysts collected the strategic business requirements from the EA more than did the junior business analysts. Thus, the results were inconclusive up to this point.

It is important to discuss the remaining seven requirements lists—four lists collected from the business executive and three lists collected from the business director of the organisation. The four requirements lists collected from the business executive contained 11 strategic business requirements that referred to the vision and mission of the organisation. These 11 strategic business requirements were as follows: expand business

market, increase market shares, increase sales more than the total sales of retail stores, reduce operating costs, select new sites, increase dividends, outsource, create competitive pricing, and develop new growth targets, new partnerships and a new customer base.

Six of these strategic business requirements were collected by the senior business analysts in two requirements lists—one having four strategic business requirements and the other having two. The remaining five strategic business requirements were collected by the two senior lecturers in their two requirements lists—one having three strategic business requirements and the other having two. Of the 26 requirements collected from the business executive, 11 were strategic business requirements, which comprised 42% of the total number of requirements collected from the business executive.

Of the 21 requirements in the three requirements lists collected from the business director, 10 were strategic business requirements that referred to the future goals of the organisation. These were as follows: increase organisational capabilities, increase profit margin, double sales in the next five years, increase net income target, increase market share, expand organisation globally, reduce operational costs, acquire companies, develop new partnerships and create a new customer base. As shown in the lists attached to Appendix A, the other requirements were functional and non-functional. Of the 10 strategic business requirements, three were captured by a senior lecturer, three were captured by a junior business analyst and four were captured by a PhD student. These 10 strategic requirements comprised 47% of the 20 requirements captured from the business director of the organisation. Surprisingly, no subject approached the accountant for requirements.

Assessment of the requirements lists collected from the Group-A stakeholders provided inconclusive results regarding the research questions raised earlier in this section. One of the main questions was: do the requirements lists contain strategic business requirements? Based on understandings of the concept of vision and mission of organisations, provided in the management information system literature, this study argues that many of the requirements in the lists were strategic business requirements because they referred to the future of the organisation.

The next question was: who captured the strategic business requirements? The results indicated that almost all of the 15 business analysts dedicated to the Group-A stakeholders collected strategic business requirements. However, the results also indicated that highly experienced practitioners collected more strategic business requirements than did junior practitioners. Of the 59 strategic business requirements, 44 were collected by senior business analysts and senior lecturers, while only 15 were collected by junior business analysts.

Another important question was: from whom were the strategic business requirements captured? The results indicated that the strategic business requirements were captured from all four stakeholders of the system. The fifth stakeholder, the accountant, was not approached at all. The 20 strategic business requirements were captured from the EA, 18 from the CIO, 11 from the business executive and 10 from the business director. This meant that the EA and CIO, who may not be considered top management, produced more strategic business requirements (38) than the top managers—the business executive and business director (21). Does this mean that middle level management generates more strategic business requirements than top management? This was not conclusive because the data showed that the EA and CIO were approached by more subjects for requirements, which resulted in gathering more requirements lists from them than from the top managers. However, when the data were analysed in terms of percentage, this indicated that the business executive and business director produced a greater percentage of strategic business requirements than did the CIO and EA.

As shown in Figure 4, 31% of the requirements collected from the EA were strategic business requirements, which was the lowest percentage of requirements collected from all four stakeholders. The CIO produced 37% of strategic business requirements, while the business executive and business director produced the highest percentage of strategic business requirements—42% and 47%, respectively. Thus, if the business executive and business director are considered the top managers of the organisation, it can be argued that, while strategic business requirements can be collected from the various stakeholders of the

system, top managers provide more strategic business requirements. Thus, it can also be argued that business analysts should approach EAs and CIOs to collect functional and non-functional requirements, as well as strategic business requirements. In addition, top managers should be approached to collect more strategic business requirements than functional and non-functional requirements. However, these results are not considered conclusive because of the low number of stakeholders and limited amount of data.

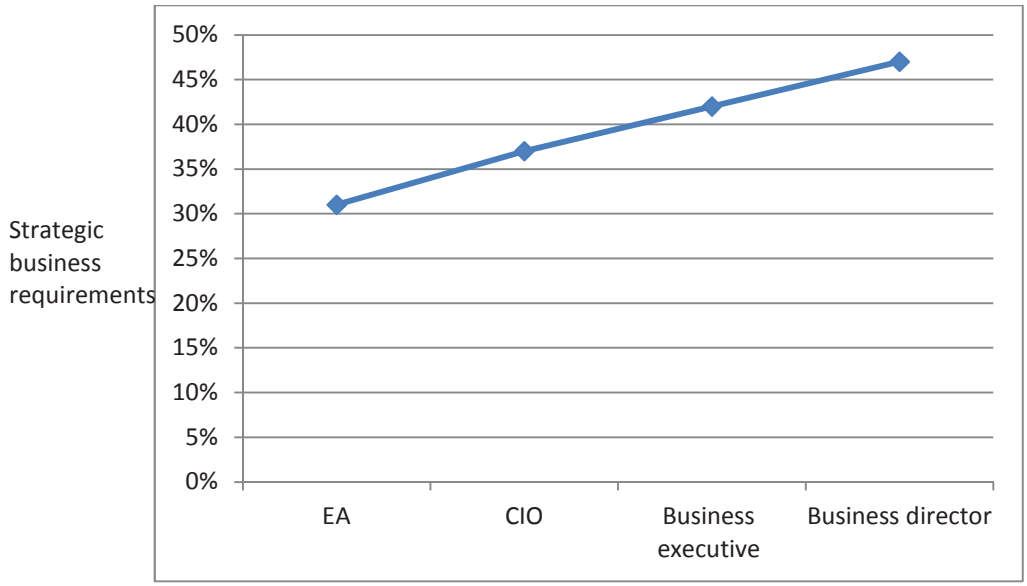


Figure 4: Performance of Group-A Stakeholders

5.4.3.2 Group-B Requirements Lists

The requirements lists collected from the Group-B stakeholders are assessed here against the questions provided at the beginning of this chapter. The Group-B requirements lists are provided in Appendix D. The 15 business analysts collected 190 requirements from the five stakeholders of Group-B: 47 requirements from the sales manager, 44 from the direct user, 38 from the marketing manager, 34 from the store managers and 27 from the supplier.

Of the 47 collected from the sales manager, 15 were strategic business requirements referring to the growth of the organisation. These included the following: increase sales by 200%, increase profit three times, extend business market, develop new customer base, develop five to 10 years of revenue growth, identify competitors, enhance global service

quality, increase speed to market, reduce IT costs by 50%, outsource, increase sales target, identify new business opportunities in the changing market, create stronger partnerships, attain high performance and build strong capabilities on strong foundations. These requirements appeared to be strategic business requirements, while the others were functional and non-functional requirements. These 15 strategic business requirements comprised 31% of the total requirements collected from the sales manager.

The requirements were collected in the following manner. Two senior business analysts collected four strategic business requirements from the sales manager—two in each requirements list. Two strategic business requirements were collected by a software engineer, and three strategic business requirements were collected by two PhD students. Two junior business analysts collected five strategic business requirements—one collected three and the other collected two. One strategic business requirement was collected by a senior lecturer. The results indicated that strategic business requirements were collected by all the business analysts of all groups, as shown in Table 7. The results also indicated that the junior business analysts collected more strategic business requirements from the sales manager than did the senior business analysts, which is opposite to the results of the Group-B stakeholders.

The business analysts collected 44 requirements from the direct user of the system. Surprisingly, there were only three strategic business requirements in the eight requirements lists collected from the direct user, which comprised just 7% of the total number of requirements collected from the direct user. The majority of the requirements were functional and non-functional. These three strategic business requirements were as follows: expand customer market, initiate a loyalty program and create partnerships. Two of these strategic requirements came from two senior business analysts, while one came from a senior business analyst.

Altogether, 38 requirements, in the form of six requirements lists, were collected from the marketing manager of the organisation. Of the 30, 10 were strategic business requirements, comprising 26% of the total number of requirements. These included the following:

develop new customer base, enhance relationships with customers, increase speed to the market, develop new products and services, create new business opportunities in the changing market, increase sales by 200%, create one-stop shopping, identify competitors, develop new alliances and reduce cost structure by 50%. The requirements related to the vision and mission of the organisation and appeared to be different from the functional and non-functional types of requirements. Three senior business analysts collected five of these strategic business requirements, and two junior business analysts collected two strategic business requirements—one each. The remaining three strategic business requirements were collected by a software engineer (one) and senior lecturer (two).

Six requirements lists were collected from the store manager, containing a total of 34 requirements. Of the 34 requirements, eight appeared to be strategic business requirements, thus comprising 23% of the total number of requirements. These included the following: increase sales, create partnerships, identify competitors, cross-sell, up-sell, increase profit, increase revenue growth and create relationships with customers. The junior business analysts collected four of these strategic business requirements in their three lists. Two of the strategic business requirements were collected by senior lecturers in two requirements lists, and the other two were collected by a PhD student and a software engineer.

The supplier was the fifth stakeholder in Group-B, who supplied 27 requirements. Of these 27, five were strategic business requirements, thus comprising 18% of the total. The strategic business requirements were as follows: reduce operational costs, increase productivity, increase the image of the organisation, develop partnerships and increase profit. Three of these were collected by the senior business analysts in their two requirements lists, and the other two were collected by two junior business analysts.

These results indicated that the strategic business requirements—the vision and mission related to the goals of the organisation—were captured by all 15 subjects in Group 2 who were dedicated to the Group-B stakeholders. By dividing the subjects into senior and junior categories, as was done for the Group 1 subjects, it was found that, of 41 strategic business requirements, 23 were collected by the senior business analysts and 18 were collected by

the junior business analysts. These results were consistent in showing that the senior business analysts collected more strategic business requirements than did the junior business analysts.

The results showed that the sales manager and marketing manager produced the greatest number of strategic business requirements—15 and 10, respectively—whereas the supplier and direct user produced the lowest number of strategic business requirements—five and three, respectively. The store manager was in the middle, with eight strategic business requirements. It was important to assess the strategic business requirements in terms of the percentage of the total number of requirements from each stakeholder, in order to see if the above results were true. The graph in Figure 5 indicates that the sales manager and marketing manager produced the highest percentage of strategic business requirements. Thus, if these stakeholders are considered the top managers of the organisation, it can be argued that they produced more strategic business requirements than did the other three stakeholders of the system because they were the top managers of the organisation.

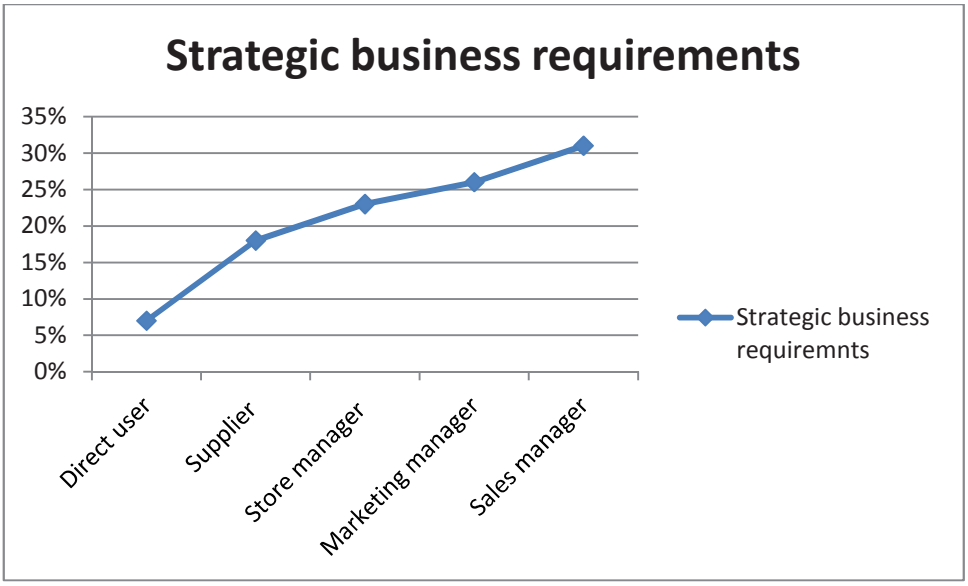


Figure 5: Performance of Group-B Stakeholders

The data were also assessed for all nine chosen stakeholders collectively to observe who produced the highest percentage of strategic business requirements. As shown in the graph

in Figure 6, the business executive and business director produced the highest percentage of between 42% and 47% strategic business requirements of the total requirements. The next category was comprised of the EA, CIO, sales manager and marketing manager, who produced between 26% and 37% of strategic business requirements. The store manager, supplier and direct users produced less than 20% of strategic business requirements in their total requirements, which was the lowest percentage.

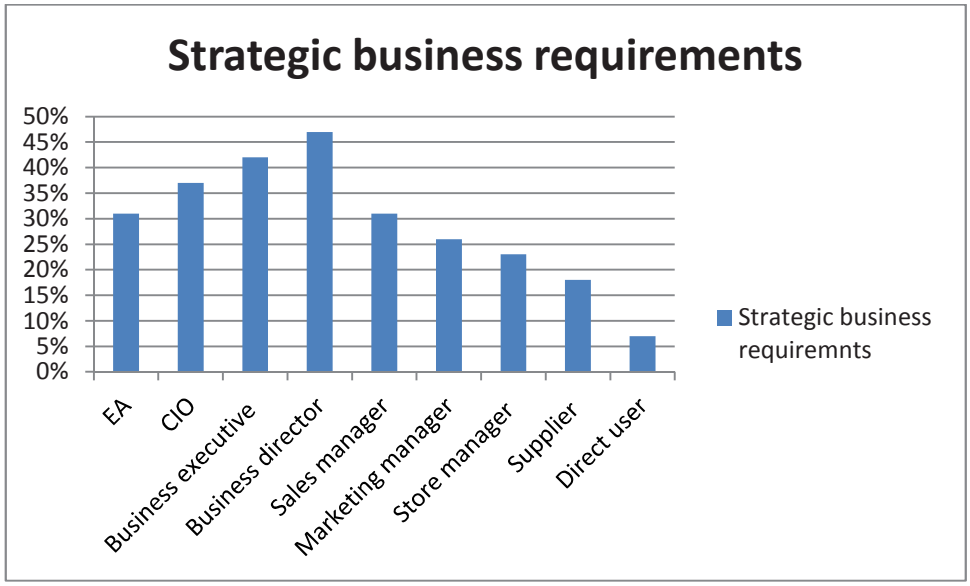


Figure 6: Performance of the Stakeholders

5.5 Summary of Study 1

The first question of this study was: do the business analysts collect strategic business requirements? The results showed that the business analysts with varying degrees of the experience did collect strategic business requirements in their requirements lists. Strategic business requirements refer to the longer-term goals of an organisation and are different to the functional and non-functional requirements of the system. In terms of the strategic business requirements, the results showed that the senior business analysts collected more strategic business requirements than did the junior business analysts.

The second question of this study was: how do the business analysts behave when approaching stakeholders for requirements? In terms of behaviour, the results indicated that the senior business analysts tended to approach more stakeholders of the system for requirements than did the junior business analysts. This is probably the reason that the senior business analysts collected more strategic business requirements than did the junior business analysts.

The third question of this study was: from whom are the strategic business requirements collected? The results highlighted that the strategic business requirements were collected from all the stakeholders approached by the business analysts. This included top managers, such as the business executive and business director, and operational level staff, such as the direct user and store manager. This indicated that strategic business requirements are not limited to top managers—they can be collected from operational level staff as well. However, the results also indicated that the top managers produced a higher percentage of strategic business requirements than did the operational level staff. These results were not conclusive because of the limited number of stakeholders and data.

At the end of this study, questions arose regarding whether the broader community would agree with the understanding of strategic business requirements provided in this chapter. For example, do they consider the longer-term goals of the organisation as the strategic business requirements of the system? Do they consider that the functional and non-functional requirements focus on the functions and qualities of the system, respectively, and thus are different from the strategic business requirements? More importantly, do the strategic business requirements affect the completeness of system requirements? To provide the answers to these questions, all 60 requirements lists were assessed in a second survey study so that conclusive and generalisable results, in relation to the framework, could be achieved.

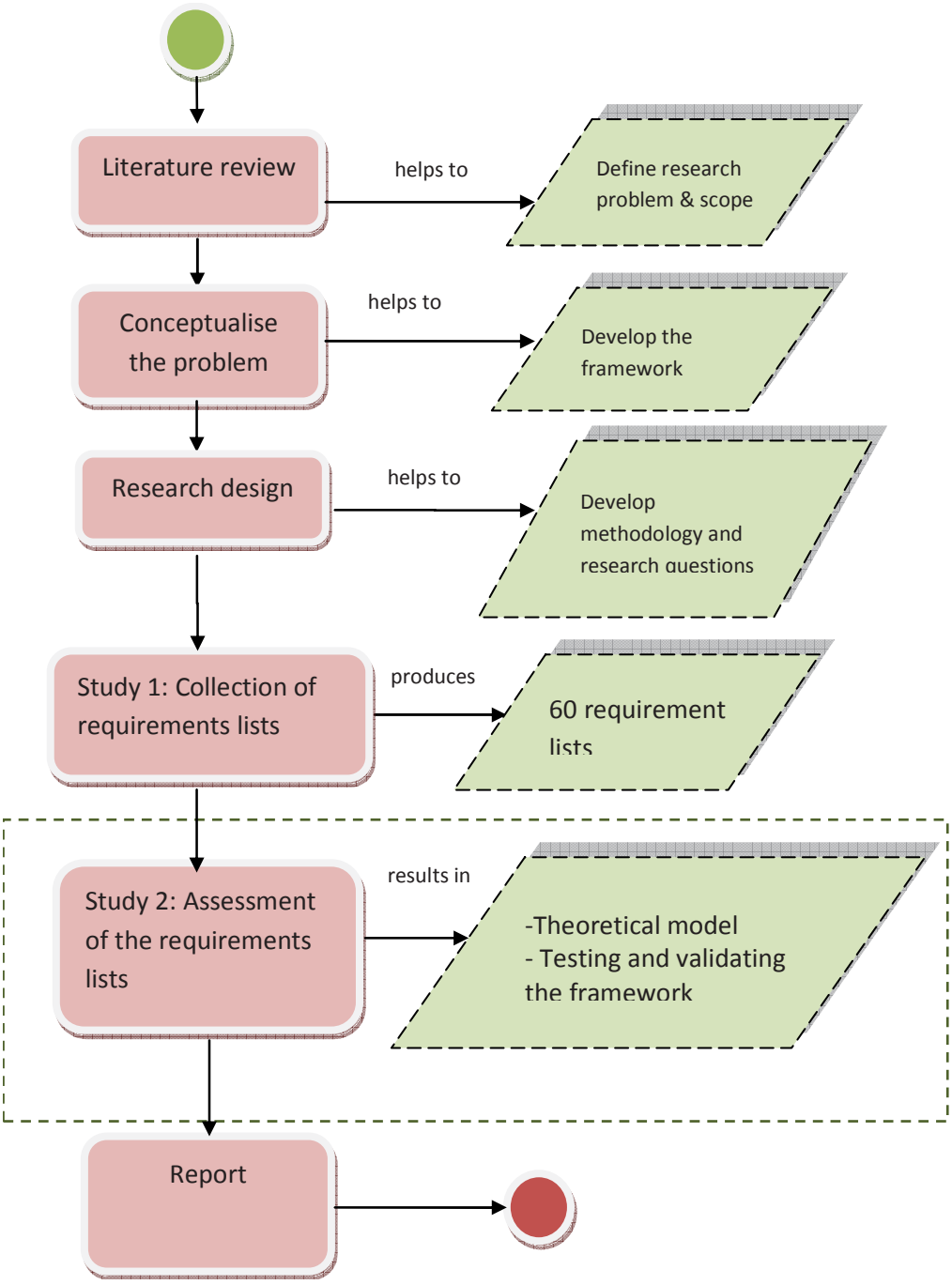
Chapter 6: Study 2—Assessment of the Requirements Lists

6.1 Purpose

The purpose of Study 2 was to assess the requirements lists collected in Study 1, and test whether the assessment data of the requirements lists addressed the following five research questions in relation to the framework that was proposed in Chapter 4:

- RQ 4: Do the strategic business requirements affect the completeness of the system requirements?
- RQ 5: Do the strategic business requirements affect the functional requirements of the system?
- RQ 6: Do the strategic business requirements affect the non-functional requirements of the system?
- RQ 7: Do the functional requirements affect the completeness of the system requirements?
- RQ 8: Do the non-functional requirements affect the completeness of the system requirements?

To achieve this, a survey approach was adopted, in which a large number of subjects assessed the requirements lists in a semi-controlled environment. This assessment was performed in terms of how well the business analysts had collected the requirements from the combined viewpoint of the Five Star business scenario. Multivariate analysis techniques were used to test how well the data explained the relationships between the variables of the framework in addressing the above five questions.



Note: The dotted line indicates the location of this chapter in the process.

Figure 7: Main Stages of the Research Process

6.2 Constructing Survey Instrument

The survey instrument is the basic requirement of a survey, and it must be appropriate for obtaining meaningful data in the context of the research questions (Kitchenham et al. 2002). Before constructing a survey instrument, a literature review is recommended to determine how previous studies collected data and which data collection mechanisms were used (Burton & Mazerolle 2011; Kitchenham & Pfleeger 2002b; Straub 1989). This enables exploration of whether a pre-existing instrument can be adopted, which can make the survey study easier to administer and validate.

As discussed in the literature review chapter, requirements engineering research generally adopts a qualitative approach for data collection and testing research artefacts (Barone et al. 2010; Samavi, Yu & Topaloglou 2009; Singh & Woo 2009). The majority of requirements engineering approaches use modelling techniques to collect and formalise requirements. The approaches are tested through qualitative feedback, in which experts provide general feedback on the quality of the requirements models for the purpose of alignment.

The approaches have never collected the feedback of experts on a quantitative scale. Some researchers have conducted quantitative studies; however, these studies were mainly related to the implementation aspect of the software development process (Briand & Basili 2008; Humphrey 2000; Wohlin & Wesslen 1998). The instruments used in these studies were not appropriate for this requirements engineering study; thus, there was no instrument available in requirements engineering research that could be adapted for this survey study. Therefore, a survey instrument was developed, based on the following four-step rigorous approach to construct and validate the survey instrument:

1. Define variables;
2. Generate items of the survey and judge appropriateness of the items;
3. Design and conduct the study to test the scale; and
4. Finalise the scale based on the data collected.

6.2.1 Defining Variables

As indicated in the framework and the five research questions, there were four variables of interest: strategic business requirements, functional requirements, non-functional requirements and the completeness of system requirements. These variables are well defined and understood in the requirements engineering literature and management information systems literature. As discussed in the literature review chapter, functional requirements are defined as tasks or actions to be performed, while non-functional requirements are defined as the qualities of the system, such as safety, security, accuracy and performance (Dardenne & Lamsweerde 1996; Horkoff 2006; Rolland & Salinesi 2005; Yu 1995). These two types of requirements are considered close to each other in requirements engineering approaches for the development of system requirements models.

To understand the concept of strategic business requirements, the management information literature was analysed. The literature shows that strategic business requirements, as goals of top management, are the longer-terms objectives of the organisation (Birnik & Moat 2008; Henderson & Venkatraman 1993; Kaplan & Norton 2004; Luftman 2000; Velcu 2010). The business strategy literature refers to revenue and growth targets, alliances, acquisitions and partnerships as the strategic business requirements of an organisation. Such requirements have been highlighted in the majority of requirements engineering models and are considered important for the completeness of system requirements (Zave 1997).

The requirements engineering literature uses various terms to represent the completeness of requirements, such as ‘completeness’, ‘correctness’ and ‘effectiveness’ (Hammer et al. 1998; Lamsweerde 2000; Zave 1997). As discussed in Section 2.1.3 of the literature review, completeness of requirements is not about 100% completeness of requirements. It is a relative term that refers to increases and decreases in system requirements. Therefore, for the purpose of completeness, this research measures increases and decreases in system requirements with the strategic business requirements of the system.

6.2.2 Generating Items of the Survey

To develop sound measures for each variable, a domain for each variable was identified. This was followed by generating items that captured the essence of the domains. This procedure of item generation was comprehensive to ensure that the measures, when examined together, had adequate context validity.

During the generation of the items, it was important to ensure that the items clearly represented the domain of the variables. To find appropriate items for the four variables—strategic requirements, functional requirements, non-functional requirements and completeness of the system requirements—the research literature of experts was explored. For example, Lawrence Chung's research work (Chung & Nixon 2000; Mylopolous, Chung & Nixon 1992; Mylopoulos et al. 2001) was explored to find three items representative of non-functional requirements. According to researchers, non-functional requirements mainly involve the constraints and qualities of a system. How a system should function is described in terms of its non-functional requirements. Thus, 'how a system should function', 'qualities of the system' and 'constraints on the system' were the three items that represented the variable of non-functional requirements. These are described in Table 11.

A vast amount of the existing requirements engineering literature describes functional requirements in terms of the features of the system—that is, what a system should do (Anton & Potts 1998; Jackson 2001; Jacobson 1992). The literature also often describes functional requirements in terms of tasks to be performed. Therefore, the three main items representing the variable of functional requirements were 'features of the system', 'what a system should do' and 'tasks to be performed', as shown in Table 11.

The three items related to the strategic business requirements were 'management goals', 'organisation's longer-term directions' and 'goals that drive to market leadership', as presented in Table 11. These requirements were enterprise-level goals that were found in the business strategy literature in the management information system discipline (Birnik & Moat 2008; Lei & John W. Slocum 2005).

The three items representing the variable of completeness of system requirements were 'effectiveness', 'appropriateness' and 'preciseness'. These items are often discussed in the literature that discusses completeness of system requirements (Hammer et al. 1998; Kamata & Tamai 2007; Lamsweerde 2000; Rolland & Salinesi 2005; Ross & Schoman 1977; Zave 1997). The items associated with the four variables are the essence of the domains, and are presented in Table 11.

Table 11: List of Variables and Associated Items

Variables	Items
Strategic business requirements	1. Management goals 2. Organisation's longer-term directions 3. Goals that drive to market leadership
Functional requirements	1. What the system must do 2. Tasks to be performed by the system 3. Features of the desired system
Non-functional requirements	1. How the system should function 2. Qualities of the system 3. Constraints on the system
Completeness of requirements	1. Effectiveness of requirements 2. Appropriateness of requirements 3. Preciseness of requirements

It is important to discuss here why three items for each variable were chosen. Adequate domain sampling is important to obtain content and construct validity, and total scale information is a function of the number of items in a scale (Bontis, Crossan & Hullanij 2002; Hinkin 1995). Restricting the number of measures helps reduce response bias (Schmitt & Stults 1985; Schriesheim & Eisenbach 1991); however, too few items may limit the content and construct validity, internal consistency and test reliability (Nunnally 1976). Single-item scales are often prone to such problems (Hinkin & Schriesheim 1989). Three items per variable has been argued to be sufficient to achieve adequate internal consistency and reliability of the scale (Cook et al. 1981).

The three items to each variable of the framework, as shown in Table 11, were simple, were at equivalent levels within the group and, most importantly, were the essence of the variables' domains. Expert advice on the appropriateness of the 12 items with respect to the four variables was sought to address face and content validities. In this step, a panel of

experts assessed the 12 items in terms of their appearance, relevance and representativeness of the variables. It is important to highlight here that establishing the face and content validities were important first steps in establishing the construct validity of the framework because the face and content validities helped establish the accuracy and connection between the questions asked and the variables measured.

6.2.2.1 Questions

The 12 items shown in Table 11 were transformed into questions. The subjects used these questions to assess the requirements lists against the combined viewpoints of the business scenario. The template comprised of the 12 questions can be found in Appendix E. In the assessment, the subjects measured how well the business analysts collected requirements with respect to the 12 items. The assessment was performed on a 10-point Likert scale (one = least likely and 10 = highly likely) to indicate the level of completeness of the requirement lists with respect to the combined viewpoint of the Five Star business scenario.

6.2.2.1.1 Response Format

The rating scale is one of the most widely used techniques in many disciplines, including market research (Dawes 2007), psychology (Shaffer, Vogel & Wei 2006) and management information systems (Chan, Sabherwal & Thatcher 2006). Rating scales typically require the respondent to choose their answer from a range of verbal statements or numbers. Research on many studies in various disciplines shows that the majority of studies use a five-point or seven-point Likert scale. However, a recent empirical study 'found that a 5-point or 7-point scale may produce slightly higher mean scores relative to the highest possible attainable score, compared to those produced from a 10-point scale, and this difference was statistically significant' (Dawes 2007). Therefore, to attain more realistic results, a 10-point Likert scale was used to attain the responses of the subjects. In the knowledge survey, the responses were standardised to an ordinal scale of the form: one = least likely and 10 = highly likely. The survey instrument is attached in Appendix E.

6.2.2.1.2 Question Type

Generally, survey questions can be open-ended or closed-ended. Open-ended questions 'leave room for misinterpretation and provision of an irrelevant or confusing answer. Thus open questions can be difficult to code and analyse' (Kitchenham & Pfleeger 2002b). By restricting the respondents' choice of reply through closed-ended questions, the responses become easier to analyse. Closed-ended questions are the preferred format for surveys, and allow a more streamlined analysis (Burton & Mazerolle 2011; Kitchenham & Pfleeger 2002b). Importantly, the questions should be neutral in language and non-leading. Therefore, close-ended questions were preferred for this survey.

6.2.2.1.3 Measurement Type

It is important to classify items in questionnaires according to the information the survey is trying to obtain (Burton & Mazerolle 2011; Kitchenham & Pfleeger 2002b). Questions can seek to acquire different types of responses, such as:

1. Attitude: what people feel;
2. Knowledge: what people know;
3. Belief: what people think is true; and
4. Behaviour: what people do or have done.

From this perspective, the information this study sought to obtain was the knowledge of the subjects—what the subjects knew about various types of requirements, such as strategic business requirements, functional requirements and non-functional requirements, and their completeness, with respect to a business scenario.

6.2.3 Designing the Study

6.2.3.1 Sampling

This research approached novices and experts in business analysis and design who belonged to different industries in Australia. The novices were final year students of a

business and IT course at the UTS, Australia, while the experts were business analysts working in the industry.

To address bias in the selection of the subjects, the researcher approached all the students (novices) of the business and IT course during a lecture to inform them of this study and request their consent to participate. In this way, a variety of novices, including males and females with different backgrounds and learning levels, were contacted. The experts were approached through the researcher's contacts in the industry and academia. In this way, a variety of expert business analysts, including males and females from six industries (software development, insurance, banking, NSW transportation, law and academia) were contacted. Companies such as IBM, Hewlett Packard, Commonwealth Bank, ANZ Bank, ING Insurance, AAMI Insurance and New South Wales State Transit were included in the six industries. In short, this research made every effort to avoid bias in the selection of the subjects. further details are provided in chapter 4. The procedure of the subject selection is described below.

Altogether, 302 people from the field of business analysis and design were approached via emails and telephone calls to request their participation in the survey. During the initial conversations, they were informed of the importance of the survey. They were informed that the purpose of the study was to assess the performance of business analysts in requirements gathering. It was also indicated that this study should not take more than two hours.

In response to the initial conversation, 255 people showed interest in participating in the survey. After one week, a first reminder was sent to the non-respondents, which resulted in 19 more people consenting to participate in this study. Thus, altogether, 274 people agreed to be the subjects of this study. They were sent the consent form of the UTS, Australia, with an information sheet describing the purpose of the study and the expected time involved to complete the survey. A demographic form was also included in the package. All 274 consent forms were signed by the subjects and returned within the following two weeks, along with the demographic information. It is important to point out that the

business analysts who participated in Study 1 for the collection of requirements were not approached for this study to avoid bias in terms of assessing their own work.

Of the 274 subjects, roughly half (52%) were female and 48% were male. The subjects were also from various ethnic backgrounds: approximately 45% of the subjects were European Australians, 25% were Chinese Australians, 15% were sub-continental Australians and 10% were Japanese Australians. The subjects met the inclusion criteria comfortably, which is provided in Chapter 3. Based on the details of their experience, the subjects were divided into four categories, as shown in Table 12.

Table 12: Subjects' Demographics

Number of subjects	Job title	Years of experience
19	Senior business analysts	8–12
22	Business analysts	5–7
9	Junior business analysts	3–4
224	Novices	No industry experience in business analysis and design

6.2.3.2 Assigning Subjects to the Treatments

Sixty requirements lists were collected in Study 1, comprised of various combinations of strategic business requirements, functional requirements and non-functional requirements, as discussed in Chapter 5. These 60 requirements lists needed to be evaluated by the subjects in terms of how well the business analysts collected the three types of requirements, and to what extent the requirements lists were complete in terms of the viewpoints of the business scenario.

For the assessment, each subject was provided four requirements lists. Based on extensive teaching experience, the researcher considered the assessment of four requirements lists an appropriate amount of work for each subject to complete within the specified timeframe of two hours. In addition, assessment of the four requirements by each subject provided empirical data that were sufficient to provide conclusive and generalisable results to test and validate the framework.

The 274 handouts were prepared for the 274 subjects of the survey. Each handout was a package of four requirements lists, a business scenario and the 12 questions that were created based on the 12 items. A sample handout is provided in Appendix E. A manual approach was adopted to prepare the 274 handouts. In this approach, it was ensured that no requirements list was assessed more than once by a subject. Distribution of the requirements lists led to the realisation that, of the 60 requirements, 44 would be assessed 18 times, whereas the remaining 16 would be assessed 19 times. The main reason behind this approach was to ensure that each subject assessed four requirements lists, which was crucial for the validity of the results. Assessment of the 16 requirements lists one less time than the other 44 requirements lists was a minor variation that did not affect the results of this study.

6.2.3.3 Pilot Study

A pilot test of the instrument was conducted with 10 subjects. The subjects, who were casual academics at the Faculty of Engineering and IT at the UTS, were involved in the assessment of the 10 handouts prepared for them. The requirements lists for these handouts were collected randomly from the pool of 60 requirements lists. In addition to the assessment of the requirements lists, the subjects were offered to provide feedback on the usefulness of the instrument. The subjects provided positive feedback on the usefulness of the instrument. The data collected showed that the subjects took one hour on average to complete the survey. All 10 subjects interpreted the questions in a similar manner. The results of this pilot study which were reflective, were not important enough to be reported in this thesis; however, the net result was that the questions did measure what they were intended to measure and the results were meaningful with respect to the objectives of the study.

6.3 Conducting the Study and Data Collection

The assessment of requirements was performed in the auditorium of the UTS, with mutual agreement of all 274 subjects regarding the time, date and place. Before the handouts were provided to the subjects, the subjects were briefly informed of the survey instrument being used to assess the requirements lists. During this 15-minute explanation, the subjects were informed that this was an individual assessment and that each subject had a unique group of requirements lists. They were informed that they were assessing the requirements lists developed by the business analysts, and that this assessment was in terms of how well the business analysts had collected the system requirements with respect to the combined viewpoints of the business scenario. They were further informed that their answers should be with respect to the 12 questions listed on the handout.

6.3.1 Task Duration

The subjects were given two hours to complete the assessment. The majority of subjects took the full two hours to complete the assessment; however, approximately 10% completed the assessment in about 90 minutes. No one could complete the assessment in less than one hour. There were no unusual queries from the subjects during the assessment. All subjects submitted the assessment to the researcher; thus, the response rate was 100%. No subject asked for extra time to complete the assessment.

As there were 274 subjects and each subject assessed four requirements lists, the research collected 1,096 (274 × 4) assessments of the requirements lists. Since each requirements list was assessed on 12 questions, each item had 1,096 assessment points, and thus 13,150 (1,096 × 12) assessments were collected for the 12 items, which was a large amount of data to provide conclusive results on the usefulness of the instrument and to map the items to their respective variables.

The data collected on the handouts were transferred into a software file spreadsheet so that quality tests on these data could be performed with the support of a software tool. A

spreadsheet was created in which 1,096 assessment points were entered for the 12 items provided in the top row. Data entry errors are possible when large quantities of data are shifted from one form to another; thus, to reduce entry errors, 20% of the data entry was verified by a volunteer researcher.

For the statistical analysis of the data, IBM SPSS Statistics 19 was used (Argyrous 2005; Meyers, Gamst & Guarino 2006). SPSS Statistics 19 is one of the most powerful computer programs for statistical analysis. It has been used in various disciplines, including business and social science (Aspelmeier, Aspelmeier & Pierce 2009; Brace, Kemp & Snelgar 2006; Pallant 2011). It is used by market researchers, health researchers, survey companies, governments, education researchers, marketing organisations and others. This tool was used to measure the quality of the survey data.

6.4 Initial Data Screening

The quality test of the data began with initial data screening, which is considered vital to ensure meaningful analysis of data (Argyrous 2005; Little 1988). All statistical tests make assumptions about the nature and quality of data; thus, if the quality of the data is poor, the analysis is likely to be meaningless. Therefore, data screening was considered essential before the analysis. From the perspective of this research, 1,096 data points of each of the 12 items were screened for possible statistical assumption violations, as well as for missing values and outliers. Altogether, 13,150 data points were screened for missing values on the 12 continuous items.

6.4.1 Missing Value Analysis

Visually, the data files showed missing values in many places, which meant that many subjects did not answer all 12 questions. To deal with this issue, missing value analysis (MVA) was conducted by using Little's (1988) test. This test first detects missing values from the data set in terms of whether they are missing in a random or non-random manner, then proposes an imputation technique to predict values for missing data.

6.4.2 Missing Completely at Random Test

According to statisticians (Little 1988; Meyers, Gamst & Guarino 2006; Myrtveit, Stensrud & Olsson 2001), if the missing values are less than 1.5% of the total data, they can be ignored and the procedure to replace the missing values can be aborted. However, if the missing values are above 1.5% of the total data, the procedure to replace the missing values must be performed. The results of the missing completely at random (MCAR) test in Table 13 showed that the missing values were between 1.6% and 2.7% for the 12 items. Therefore, they could not be ignored.

Table 13: MVA

Univariate Statistics							
Variables				Missing		No. of Extremes[a]	
	N	Mean	Std. Deviation	Count	Percent	Low	High
mgmetgoals	1069	6.65	2.500	27	2.5	0	0
longdir	1076	6.02	2.660	20	1.8	0	0
marketlead	1067	6.10	2.503	29	2.6	0	0
whatsystem	1070	6.11	2.553	26	2.4	0	0
taskperform	1075	5.90	2.589	21	1.9	0	0
features	1072	5.71	2.409	24	2.2	0	0
howsystem	1069	5.32	2.403	27	2.5	0	0
qualities	1077	5.43	2.204	19	1.7	0	0
constraints	1080	4.64	2.145	16	1.5	0	0
precise	1074	5.29	2.136	22	2.0	0	0
appropriate	1069	5.86	2.096	27	2.5	0	0
effective	1070	5.65	2.228	26	2.4	0	0

a. Number of cases outside the range (Q1 - 1.5*IQR, Q3 + 1.5*IQR).

The chi-square value of the MCAR test was 265.430 and the degree of freedom was equal to 295 and 0.891, thus indicating that the missing values were not statistically significant (appropriate significance value of chi-square = 0.001). The chi-square and degree of freedom were not statistically significant, which confirmed that the data were MCAR. This provided the opportunity to use some imputation techniques to address the missing values with predictive values to complete the data set.

6.4.3 Replacing Missing Values with Expectation Maximisation Technique

The expectation maximisation algorithm of SPSS is a powerful technique to replace missing values with predicted values (Meyers, Gamst & Guarino 2006). Since each variable had three items (see Table 14), the expectation maximisation technique was applied to three items separately to predict the missing values. This resulted in four datasets for the four variables, which were then merged to form a complete dataset. The reason for applying the expectation maximisation technique to each group of three items separately was that it increased the correlation between the items of each group because items within each group should be highly correlated when compared with items from different groups (Meyers, Gamst & Guarino 2006).

Table 14: Expectation Maximisation Technique and 12 Items

Items	Variables	Algorithm
Mgmetgoals	Strategic business requirement	Expectation maximisation
Longdir		
Marketlead		
Whatsystem	Functional requirement	Expectation maximisation
Taskperform		
Features		
Howsystem	Non-functional requirement	Expectation maximisation
Qualities		
Constraints		
Effectiveness	Completeness of requirements	Expectation maximisation
Appropriate		
Preciseness		

6.5 Testing Distribution for Normality

After addressing the missing values, the next step in evaluating the quality of the survey data was the normality test of the data. In statistics, normality tests are performed to determine whether a data set is well modelled by a normal distribution (Meyers, Gamst & Guarino 2006). The normality test computes the likelihood of an underlying random variable being normally distributed. In this project, the distribution of data of 12 items for normality was tested—that is, the data were tested to see whether they had been distributed normally for the 12 items. To do this, descriptive statistics of SPSS and requested

assumptions, such as outliers, stem-and-leaf, histogram and normality plots with tests, were used. The important findings are presented below.

Table 15 shows that the majority of the 12 items were negatively skewed and their kurtosis values were reasonably high. For normal distribution of data, both skewness and kurtosis are expected to be zero (Meyers, Gamst & Guarino 2006). The negatively skewed data indicated that the responses of the subjects were mainly on the higher end of the 10-point Likert scale, with a long tail to the lower scale values. Kurtosis refers to the shape of the data around the mean value. Negative kurtosis indicates that the data exhibit heavier 'shoulder' about the mean, and have shorter tails. This is normal on a 10-point Likert scale because the greater number of options for the respondents to choose leads to data having a heavier shoulder (Dawes 2007). Importantly, skewness and kurtosis were minimal and within the +1.0 and -1.0 range, which is an acceptable range in terms of data distribution (Meyers, Gamst & Guarino 2006).

Table 15: Normality Results with Skewness and Kurtosis

Items	Skewness	Kurtosis
Mgmetgoals	-0.853	-0.176
Longdir	-0.585	-0.850
Marketlead	-0.529	-0.659
Whatsystem	-0.499	-0.622
Taskperform	-0.426	-0.855
Features	-0.299	-0.865
Howsystem	-0.110	-0.852
Qualities	-0.263	-0.638
Constraints	0.061	-0.708
Precise	-0.019	-0.719
Appropriate	-0.344	-0.551
Effective	-0.322	-0.589

For data distribution, the Kolmogorov-Smirnov and Shapiro-Wilk tests of normality are also considered significant. The results of these tests (attached in Appendix F) showed that the distribution of data was normal around the 12 items of the four variables. Histograms help to understand the skewness and kurtosis of data. With a 10-point Likert scale assessment, it is considered a normal distribution of data when skewness and kurtosis are within the range of +1.0 and -1.0 (Dawes 2007). The histograms of the 12 items (attached in Appendix G) indicated that most of the respondents responded to the higher end of the

scale, mainly between five and 10 on the 10-point Likert scale. This is probably the reason that the data were negatively skewed, as shown in Table 15. The histogram of the constraints item showed a better distribution of data—in the middle of the scale. As a result, the skewness of constraints items was reasonably close to zero, as shown in Table 15.

Box plots of the 12 items (attached in Appendix H) provided further evidence of normality in the data distribution. They also indicated that the responses were on the higher end of the register, and that the mean values were also on the higher end of the register, which is reasonably normal for a 10-point Likert scale (Dawes 2007). There were no outliers, which meant that there was no extreme value found in the dataset. Q-Q plots of the 12 items are presented in Appendix I. These were also reasonably normal as the data points were close to the diagonal lines of each item.

Through these various modules, the results indicated that the data were reasonably normally distributed. The data points were within the range of +1.0 and -1.0, and there were no extreme data points in the dataset. Greater variance in data points is normal for assessments with a 10-point Likert scale. The above tests assessed the quality of the data associated to the items individually, and the results indicated that the distribution of data was consistent around the 12 items individually. It is important to examine here how consistent the data were when all 12 items were considered together. Cronbach's alpha test was performed on the data of 13,150 samples for the 12 items, and the score was 0.720. This is considered an 'acceptable' alpha on the data reliability parameter between 0.5 and one (Fornell & Larcker 1981). Therefore, the results indicated that the data were normal and consistent in relation to their distribution across the 12 items collectively. Overall, the above results indicated that the survey data were high quality and ready to be used for analysis.

6.6 Data Analysis and Reporting

There were two critical aspects of data analysis to consider when testing the framework:

1. Whether the 12 items (shown in Table 14) actually measured the variables they were proposed to represent; and
2. Whether the relationships between the variables, as shown in the framework, resembled the relationships between the variables in the observed dataset.

This analysis was crucial to establish the construct validity of the framework. Exploratory factor analysis and confirmatory factor analysis can be useful to answer the above two questions, respectively.

Exploratory factor analysis, which is generally considered a theory generation procedure, is used to reveal the underlying structure of relatively large sets of items (Bryant et al. 1996; Meyers, Gamst & Guarino 2006). It is exploratory in the sense that researchers use an inductive strategy to empirically determine the variable structure. In a statistical procedure, the relationship between the variables is examined and the structure is generated based on those relationships (Bryant et al. 1996; Meyers, Gamst & Guarino 2006). In this procedure, it is assumed that the items may be associated with some of the variables. This was the first objective of analysing the survey data, in which it was identified whether the items were associated with the variables they were proposed to represent, as shown in Table 14.

Confirmatory factor analysis, which is generally considered a theory testing procedure, allows researchers to use a deductive approach (Brown 2006; Loehlin 2004; Meyers, Gamst & Guarino 2006). In this approach, the variables and the items that are held to represent them are defined at the beginning of the procedure, rather than emerging from the analysis. The statistical procedure is then performed to test how well the hypothesised theoretical structure fits the empirical data (Meyers, Gamst & Guarino 2006). This was the main objective of the analysis of the data, in which it was observed how well the observed data supported the structure of the framework proposed in Chapter 4. This was also used to answer the five questions associated with the framework.

Confirmatory factor analysis is a specialised component of structural equation modelling. The statistical procedure allows researchers to hypothesise a model that they believe to be underlying the items measured in the study (Bryant et al. 1996; Meyers, Gamst & Guarino

2006). Confirmatory factor analysis then estimates the value of the parameters that tie the variables together. In addition, the model is described in terms of indexes that assess the quality of the fit between the model and the data (Bentler 1992; Brace, Kemp & Snelgar 2006). This research developed a structural equation model (SEM) to represent the framework proposed in Chapter 4. This included variables and the association between them, as shown in the framework. In addition, it attached the items associated to the variables, as described in Table 14. Thus, confirmatory factor analysis was used to indicate how well the data fit with the SEM, and what effects the strategic business requirements had on the completeness of the system requirements.

6.6.1 Exploratory Factor Analysis

As described above, exploratory factor analysis was conducted to evaluate the appropriateness of the 12 items associated with the four variables: strategic business requirements, functional requirements, non-functional requirements and completeness of the system requirements. The principal axis factoring method and a direct oblimin of 12 items was performed on a random sample (n: 1,096) by using IBM SPSS 19. The 1,096 refers to the number of data samples for each of the 12 items. The direct oblimin was used because, theoretically, the 12 items were associated or correlated with each other in a factor solution. The factor extraction limit was not enforced to encourage a normal statistical procedure. A normal criterion for suppression of 0.32 was used, which meant that anything below 0.32 would be eliminated from the data when the 12 items were loaded onto the four variables.

Prior to conducting the principal axis factor analysis, the data were screened by examining the descriptive statistics of each item, the inter-item correlation and any possible univariate and multivariate assumption violations. The Kaiser-Myere-Olkin measure of sampling adequacy was 0.768, indicating that the data were suitable for principal axis factoring (principle axis factoring was used because the variables were associated with each other). Similarly, Bartlett's test of sphericity was significant ($p < 0.001$), indicating that the correlation or association between items was sufficient, thereby allowing the analysis to

proceed. The inter-item correlation matrix, which showed a strong correlation between the items, is presented in Appendix K. In addition, communalities for the 12 items were reasonably high, with a range of 0.343 to 0.606, except one item whose communality was 0.154. This value can be problematic for smaller samples; however, since this research produced a large dataset, 0.154 was not a candidate for removal.

The results of the principal axis factor, as shown in Table 16, showed that the 12 items loaded on four meaningful factors, explaining 70% of the common item variance. This meant that 70% of the data supported the four-factor solution. However, this test did not indicate whether the four factors were strategic business requirements, functional requirements, non-functional requirements or completeness of system requirements.

Factor one (eigenvalue = 3.2) accounted for 27% of the variance, factor two (eigenvalue = 2.7) accounted for 22% of the variance, factor three (eigenvalue = 1.4) accounted for 12% of the variance and factor four (eigenvalue = 1%) accounted for 9% of the variance. According to Table 16, the total eigenvalue for the four factors was higher than one, and 70% of the variance in data was dedicated to the four factors, which meant there was strong support for the four factors. However, the principal axis factoring did not indicate the name of those four factors.

Table 16: Total Variance Explained

Factor	Initial eigenvalues			Extraction sums of squared loadings			Rotation sums of squared loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
1	3.281	27.344	27.344	2.872	23.935	23.935	2.117	17.645	17.645
2	2.679	22.328	49.672	2.279	18.990	42.925	1.876	15.636	33.280
3	1.432	11.932	61.604	1.037	8.640	51.565	1.563	13.028	46.309
4	1.073	8.943	70.547	.560	4.663	56.228	1.190	9.919	56.228
5	.690	5.751	76.298						
6	.527	4.390	80.688						
7	.488	4.066	84.754						
8	.467	3.893	88.648						
9	.421	3.511	92.159						
10	.358	2.981	95.140						
11	.320	2.670	97.810						
12	.263	2.190	100.000						
Extraction method: principal axis factoring									

To find the names of the four factors, factor analysis for a pattern matrix was conducted. The results of the pattern matrix of principal axis factor analysis, as shown in Table 17, demonstrated clear extraction of the four factors and that all 12 items were cleanly loaded on the hypothesised variables (strategic business requirements, functional requirements, non-functional requirements and completeness of system requirements). The pattern of item loading was similar to the pattern of association described in Chapter 3. Each of the 12 items had a loading above 0.50 onto the variables, except one item—constraints—that had a loading of 0.453. This was below the recommended value of 0.50, which did not affect the results of the analysis (Kearns & Sabherwal 2006-7). There was only one secondary loading with a minor value of 0.338, which was considered ignorable (Meyers, Gamst & Guarino 2006).

Table 17: Pattern Matrix of 12 Items

	Factor			
	1	2	3	4
taskperform	0.897			
whatsystem	0.776			
features	0.640			
longdir		0.870		
marketlead		0.742		
mgmetgoals		0.720		
appropriate			0.838	
precise			0.720	
effective			0.507	
qualities				0.696
howsystem	0.338			0.553
constraints				0.453
Extraction method: principal axis factoring Rotation method: oblimin with Kaiser normalisation				
a. Rotation converged in six iterations				

The results of the exploratory factor analysis of the survey data indicated that the 12 items were measuring the variables they were proposed to represent. The results provided the base on which the relationships between the variables, as shown in the framework, could be evaluated effectively. Thus, confirmatory factor analysis was conducted. To do so, structural equation modelling was adopted—this is a typical approach used to develop and test models (Bryant et al. 1996; Meyers, Gamst & Guarino 2006). Various software tools help develop and test models, such as LISREL, EQS, Mplus and AMOS. This research adopted AMOS 19 because it was easily accessible from the university technical support department for this research.

6.6.2 Confirmatory Factor Analysis

As highlighted above, the purpose of the confirmatory factor analysis was to assess whether the relationships between the variables shown in the framework resembled the relationships between the variables in the observed dataset. In other words, it examined how well the data explained the model that represented the structure of the framework. There were five specific questions related to the structure of the framework, which were provided at the beginning of this chapter.

In the confirmatory factor analysis, three types of hypothesised models were developed by using AMOS 19 to determine the effects of the strategic business requirements on the functional, non-functional and completeness of system requirements. This included the correlation, indirect and direct effect models. The correlation model was developed to determine whether the strategic business requirements were associated with the functional requirements, non-functional requirements and completeness of system requirements. The correlation between the variables is generally considered an important first step towards assessing the effects of the latent variables on the observed variable (Meyers, Gamst & Guarino 2006).

The indirect effect model represented the framework proposed in Chapter 3. This was an obvious target in this research to test the influence of the strategic business requirements on the completeness of system requirements via the functional and non-functional requirements of the system. The direct effect model was developed to measure the effect on the completeness of system requirements when the strategic business requirements were not considered. This was another way of measure the effect of the strategic business requirements on the completeness of system requirements.

The following section describes how the empirical data of 12 items (1,096) was used in the models. The statistical analysis began by testing the models against the combined data to determine how well the data provided by all the 274 subjects explained the models. This was followed by an explanation of the models against the data of the various groups—such as the experts and novices and the more experienced and less experienced subjects—as described in Table 12. This helped understand the views of the various groups for the various types of relationships shown in the models. The statistical results of these models helped address the five research questions provided at the beginning of this chapter.

6.6.2.1 Correlation Model of the Four Variables

The correlation model, as shown in Figure 8, was developed to measure the level of association of the strategic business requirements with the functional, non-functional and

completeness of system requirements. However, for the validity of the statistical results, it was also important to measure the fitness level of the model with the empirical data. In this regard, the following research question was asked:

> Do the strategic business requirements associate with the functional, non-functional and completeness of system requirements?

The hypothesised model (Figure 8) was assessed by using AMOS 19 maximum likelihood factor analysis. The model was evaluated for five fit measures that are commonly used in confirmatory studies (Chan, Sabherwal & Thatcher 2006; Kearns & Sabherwal 2007; Ravichandran & Lertwongsatien 2005; Tallon 2008):

1. Chi-square;
2. Normal fit index (NFI);
3. Comparative fit index (CFI);
4. Goodness of fit index (GFI); and
5. Root mean square error of approximation (RMSEA).

The results of the statistical procedure indicated that the chi-square had a value of 335.138, the degree of freedom was 48 and $P = 0.000$ for the sample of 1,096. This was significant, with the chi-square value indicating there was a weak match between the proposed model and the observed data. It is importance to note that the chi-square value is sensitive to the sample size—as the sample size increases, the chi-square value increases (Meyers, Gamst & Guarino 2006). Since a large amount of data was used to test the fitness of the model, the chi-square value was expected to be high. In this situation, the chi-square is suggested to be supplemented with other fit measures, such as NFI, CFI, GFI and RMSEA (Bentler 1992). For the three indexes of CFI, NFI and GFI, values between 0.90 and 1.0 are considered an acceptable fit between the model and data (Kearns & Sabherwal 2006-7; Medsker, Williams & Holahan 1994). In this study, these measures were as follows: CFI = 0.923 and NFI = 0.912. This indicated an acceptable fit between the model and data. The GFI = 0.941, which also indicated an acceptable fit between the model and data.

The RMSEA and standardised root mean square residual (SRMR) have recently been recognised as two of the most informative criteria in covariance structure modelling (Meyers, Gamst & Guarino 2006). Loehlin (Loehlin 2004) proposed the following criteria to evaluate the RMSEA index: less than 0.08 indicates a good fit; 0.08 to 0.1 indicates a moderate fit; and greater than 0.1 indicates a poor fit. However, SRMR below 0.10 is a good fit of the model with the data. In this study, RMSEA = 0.082, which indicated a moderate fit between the data and the model. SRMR = 0.0634, which was below 0.10, thus indicating that the model fit well to the data. Therefore, the model explained the data reasonably well and presented a strong case for further analysis. The next step was to evaluate the estimates related to the correlation between the four variables.

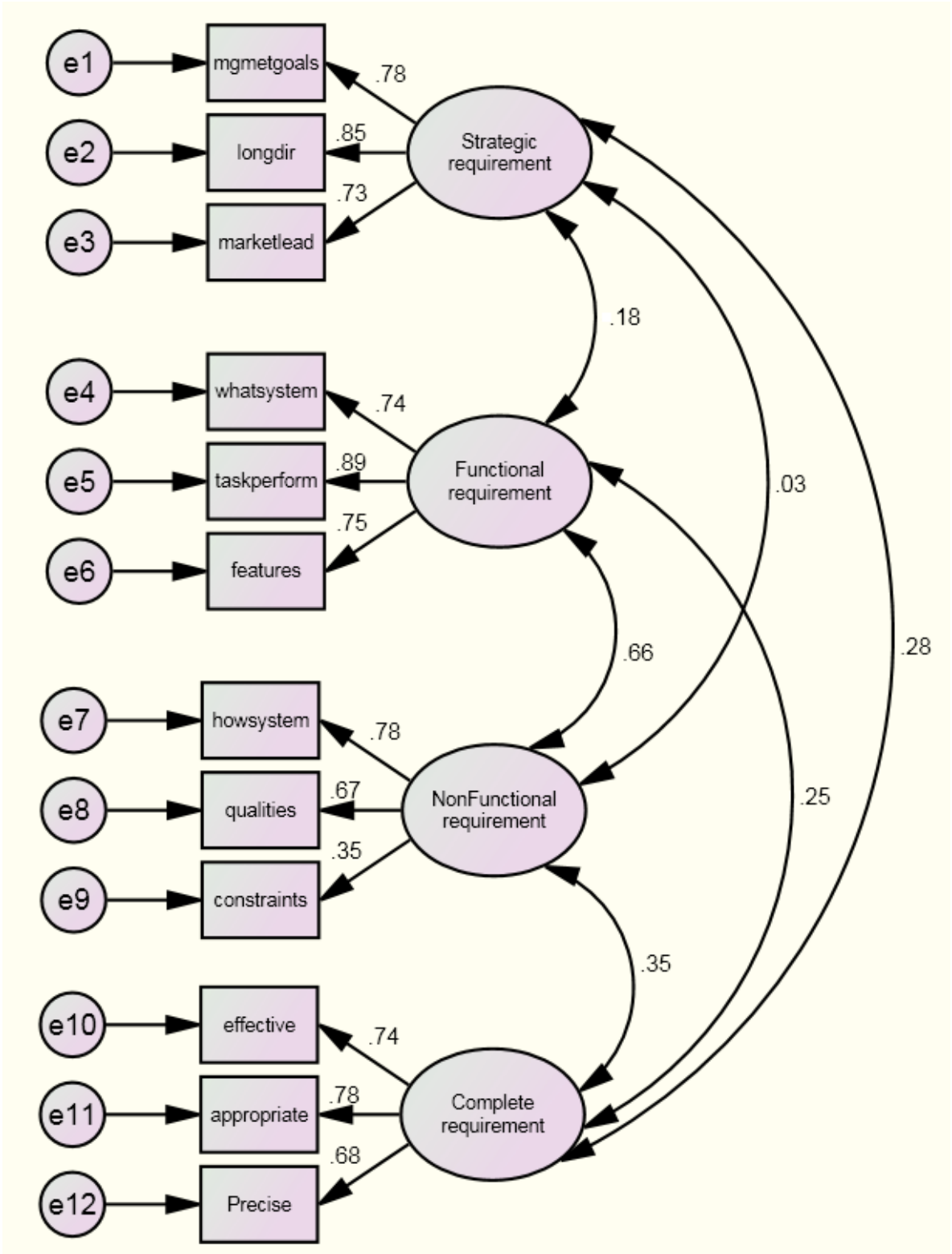


Figure 8: The Correlation Model of the Four Variables

6.6.2.2 Level of Association Between the Variables

Before the association between the four variables is described, an introduction to the principles of correlation is provided. Correlation is a statistical technique that can show whether and how strongly pairs of variables are related to each other (Kenny 1979; Meyers, Gamst & Guarino 2006). The possible correlation range is from +1 to -1. If a correlation value is close to +1, this means that, as one variable becomes larger, the other also becomes larger. If a correlation value is close to -1, this means that, as one variable becomes smaller, the other becomes also smaller. A zero correlation means there is no association between the variables. The results can be shown in standardised and un-standardised formats. For consistency reasons and to avoid any confusion, the results are reported in this thesis in the standardised format.

6.6.2.2.1 Association Between Strategic Requirements and Functional Requirements

This sought to answer the question: do the strategic business requirements associate with the functional, non-functional and completeness of system requirements? The results of the correlation model in Figure 8 indicated that the strategic business requirements had a moderate level of association (0.18) with the functional requirements. This meant that the functional requirements increased as the strategic business requirements of the system increased. This was a positive test with respect to the research question provided in Section 6.6.2.1 that assessed whether strategic requirements were associated with the functional requirements of the system.

6.6.2.2.2 Association Between Strategic Requirements and Completeness of System Requirements

The standardised results shown in Figure 8 demonstrated a moderate association (0.28) between the strategic business requirements and completeness of system requirements. This indicated that the completeness of system requirements was enhanced as the strategic business requirements of the system increased. This was a positive indication with respect

to the research question that examined whether strategic business requirements were associated with the completeness of requirements.

6.6.2.2.3 Association Between Strategic Requirements and Non-functional Requirements

In contrast to the above, Figure 8 shows a weak correlation (0.03) between the strategic requirements and non-functional requirements of the system, thus indicating that, as the strategic requirements increased, the non-functional requirements could also increase. Due to this weak correlation, it can be argued that the strategic business requirements and non-functional requirements do not associate with each other at all, which means that, if the strategic business requirements increase, the non-functional requirements may not increase. Therefore, the answer in relation to the question proposed above is that the strategic business requirements do not correlate with the non-functional requirements of the system.

6.6.2.2.4 Association Between Functional Requirements and Non-functional Requirements

The model addressed the research question by demonstrating a strong association (0.66) between the functional requirements and non-functional requirements of the system. This meant that, if there was an increase in the non-functional requirements, there would be an increase in the functional requirements of the system. The result also satisfied the existing requirements engineering phenomenon, in which there is general consensus that functional and non-functional requirements are associated with each other.

6.6.2.2.5 Association Between Functional and Non-functional Requirements with Completeness of System Requirements

The results of the correlation model indicated that the functional and non-functional requirements had a moderate level of association (0.25 and 0.35, respectively) with the completeness of the system requirements. These results addressed the research question positively by indicating that the functional and non-functional requirements were associated with the completeness of system requirements.

In addition to the level of association between the four variables, it is important to point out that the regression weights of the four variables were significant with a minor standard error. This meant that the items were strongly related to their respective variables. This confirmed the results of the exploratory factor analysis, in which the items measured the variables they were proposed to represent (see Table 17). However, it was still necessary to test how correct these results were, and whether the data of the novices and experts would separately provide similar results for the correlation model. In this regard, the correlation model was tested against the two major sets of data—experts and novices—to observe how different the results were for the correlation model.

6.6.2.3 Correlation Models of Novices and Experts' Data

Estimates of the correlation model based on the experts' data indicated a strong correlation between the strategic business requirements with the functional requirements and the completeness of system requirements (0.10 and 0.20, respectively). This indicated that, if the strategic requirements increased, the functional requirements and completeness of system requirements would also increase. The numeric values shown in Figure 9 indicated that the association of the strategic business requirements with the functional requirements and completeness of system requirements was strong, with minor variation. However, there was a considerable difference in the level of association of the strategic business requirements with the non-functional requirements. The correlation model of the novices' data indicated that the strategic business requirements were not associated with the non-functional requirements, whereas the correlation model of the experts' data highlighted that the strategic business requirements were moderately associated with the non-functional requirements. This raised the question of the reason behind this variation in the correlation models of the two datasets for the novices and experts.

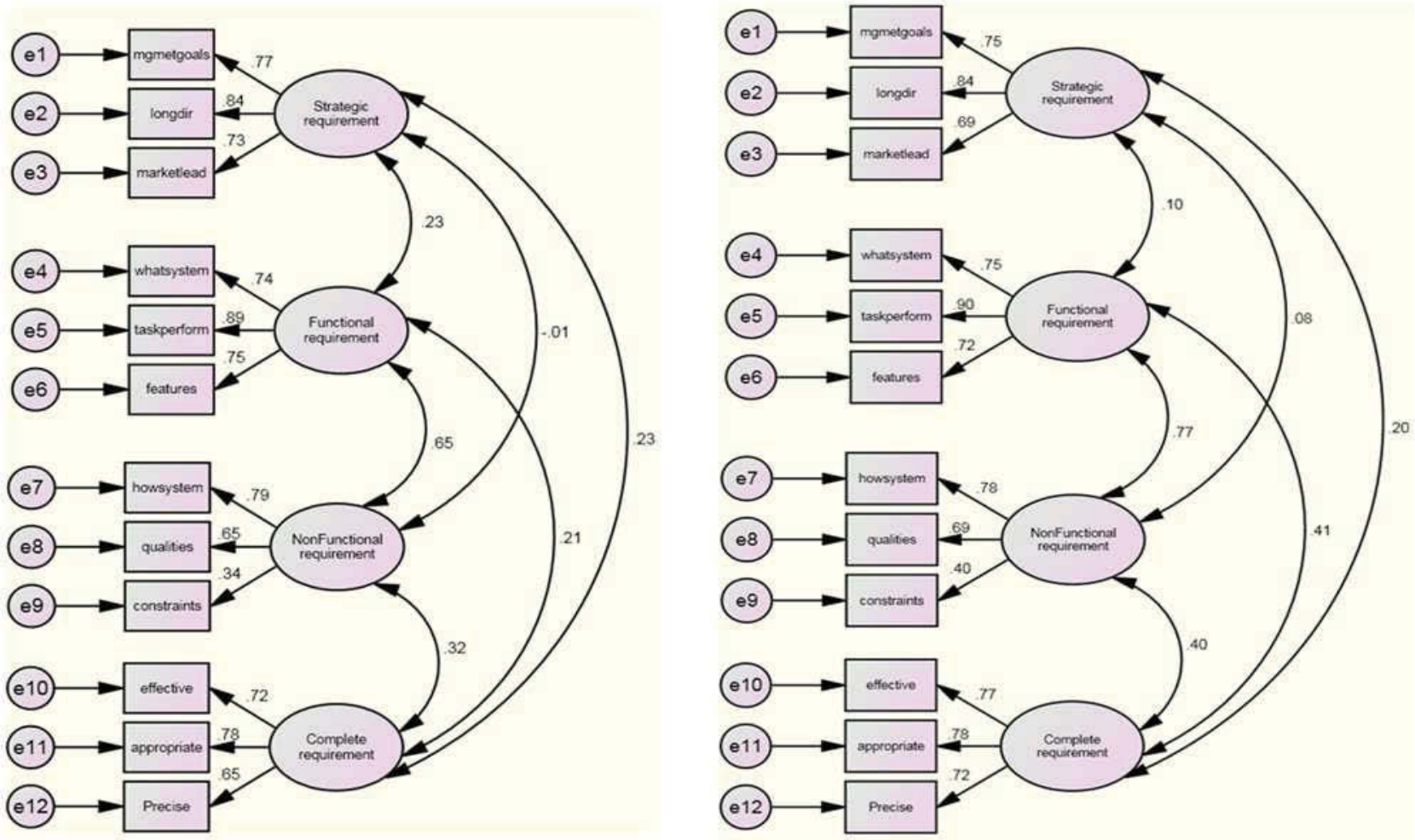


Figure 9: Novices' Correlation Model (Left) and Experts' Correlation Model (Right)

To further investigate the relationships between the strategic business requirements and the non-functional requirements of the system, the data of the four groups of subjects (as shown in Table 12) were used to test the correlation model. In this way, four correlation models for the four sets of data were achieved, as shown in Figure 10. The results indicated a gradual increase in the level of association between the strategic business requirements and non-functional requirements of the system, as the experience of the subjects increased. This is depicted in Figure 10.

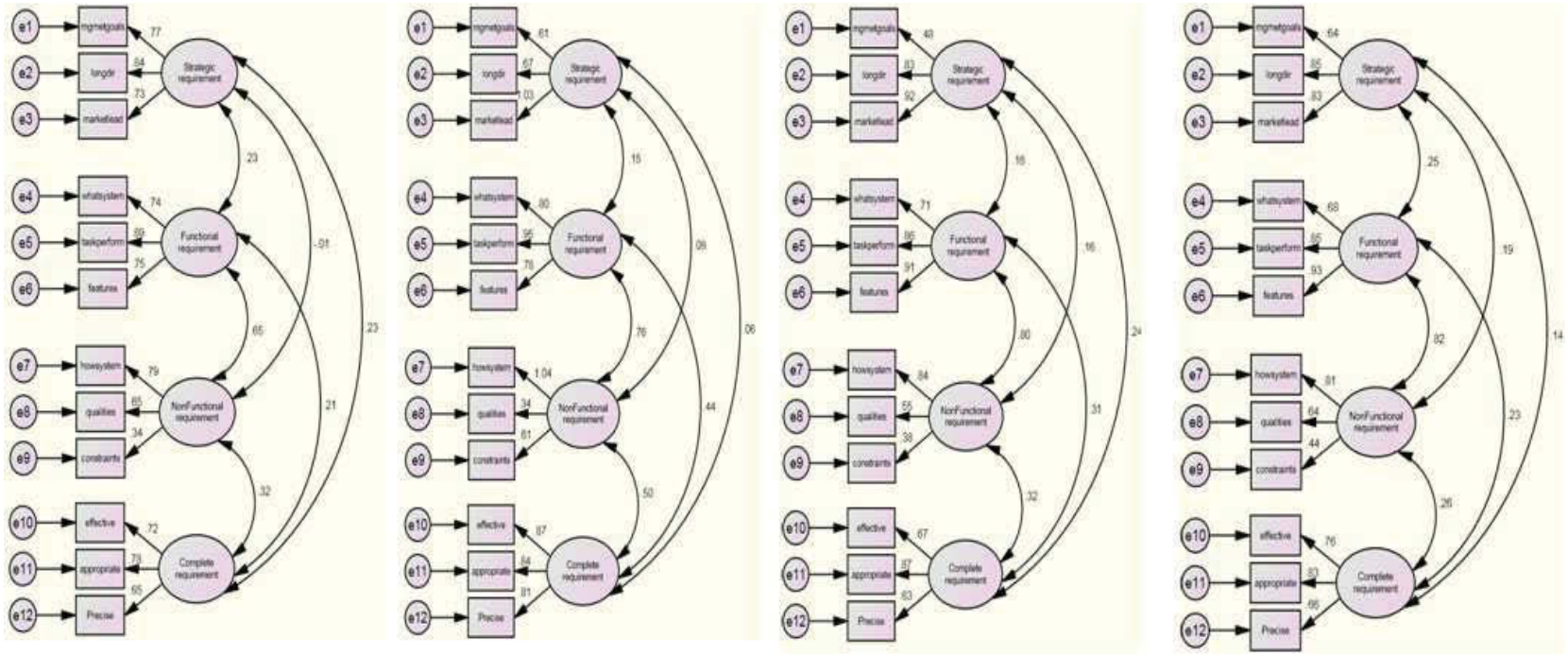
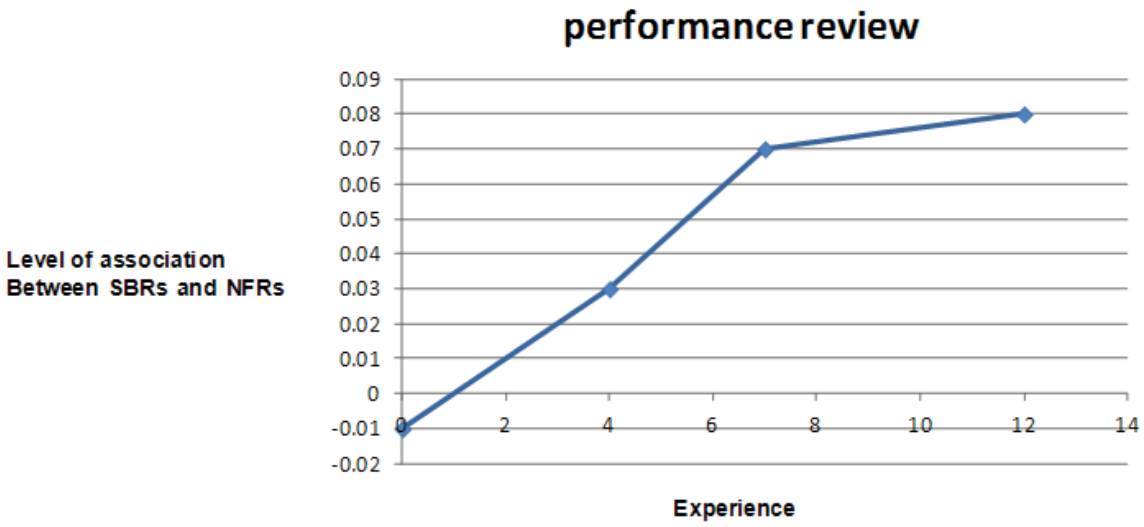


Figure 10: Correlation Models (from Left to Right) of Novices, Junior, Middle and Senior Business Analysts' Data

This test was performed to investigate why there was considerable variation in the level of association between the strategic business requirements and non-functional requirements of the system, as highlighted in Figure 11. There were four groups of subjects with different levels of experience, and the graph indicates that, as the experience of the subjects increased, the level of association between the strategic business requirements and non-functional requirements of the system also increased.



Note: SBR = strategic business requirements; NFR = non-functional requirements

Figure 11: Relating Experience to the Level of Association Between Strategic Business Requirements and Non-functional Requirements

Overall, the statistical results of these tests addressed the research question: do the strategic business requirements associate with the functional, non-functional and completeness of system requirements? They addressed this by indicating that the functional, non-functional and completeness of system requirements increased with the increase in strategic business requirements. However, the increase in level of association depended on the experience of the subjects. The statistical results suggested that, as the experience of the subjects increased, the level of association of the strategic business requirements with the functional, non-functional and completeness of system requirements also increased. These results provide a strong base for the other tests, in which the effects of the strategic business

requirements on the functional, non-functional and completeness of system requirements could be measured.

6.6.3 Re-specification of the Correlation Model

To test the framework, the correlation model was re-specified in AMOS 19, in which the direct and indirect effects of the strategic business requirements on the completeness of system requirements were modelled to represent the structure of the ESRE framework. This is a general approach, in which the correlation data, presenting rich information, can be applied in a variety of ways, such as via the direct and indirect effects of the variables (Brown 2006).

In the re-specification of the correlation model, the strategic business requirements, functional requirements and non-functional requirements were the latent variables, while the completeness of system requirements was a dependent variable—or an observed variable. As shown in the framework, the strategic business requirements were directly and indirectly related to the completeness of system requirements, as shown with the arrowhead lines. The model was re-specified in the SEM, as shown in Figure 12, to represent the structure of the ESRE framework. According to multivariate analysis techniques, during the re-specification, the model must be identified (Bentler 1992; Bollen 1989; Meyers, Gamst & Guarino 2006). The model identification has to do with the difference between the number of variables in the analysis and the number of parameters that need to be estimated by the model. The parameters are what the SEM is designed to generate, and these parameters are unknown at the beginning of the analysis. The rules in this regard are as follows:

1. If there are more unknown parameters than known parameters, the value for the degree of freedom is negative. The model is ‘under identified’ and cannot perform meaningful analysis;
2. If the known and unknown parameters are equal, the model is considered ‘just identified’. This means that there is an artificial fit between the model and the data, and no meaningful results can be obtained by running the analysis further; and

3. If there are more known and less unknown parameters, the model is considered 'over identified' with a positive degree of freedom, which means that the model is ready to be processed further.

The degree of freedom of the correlation model (known parameters) was 48; however, the degree of freedom of the re-specified model (the SEM) was 49. Therefore, the model was over identified (49 *dof* – 48 *dof* = 1 *dof*). This indicated that the model was ready to be processed for further analysis.

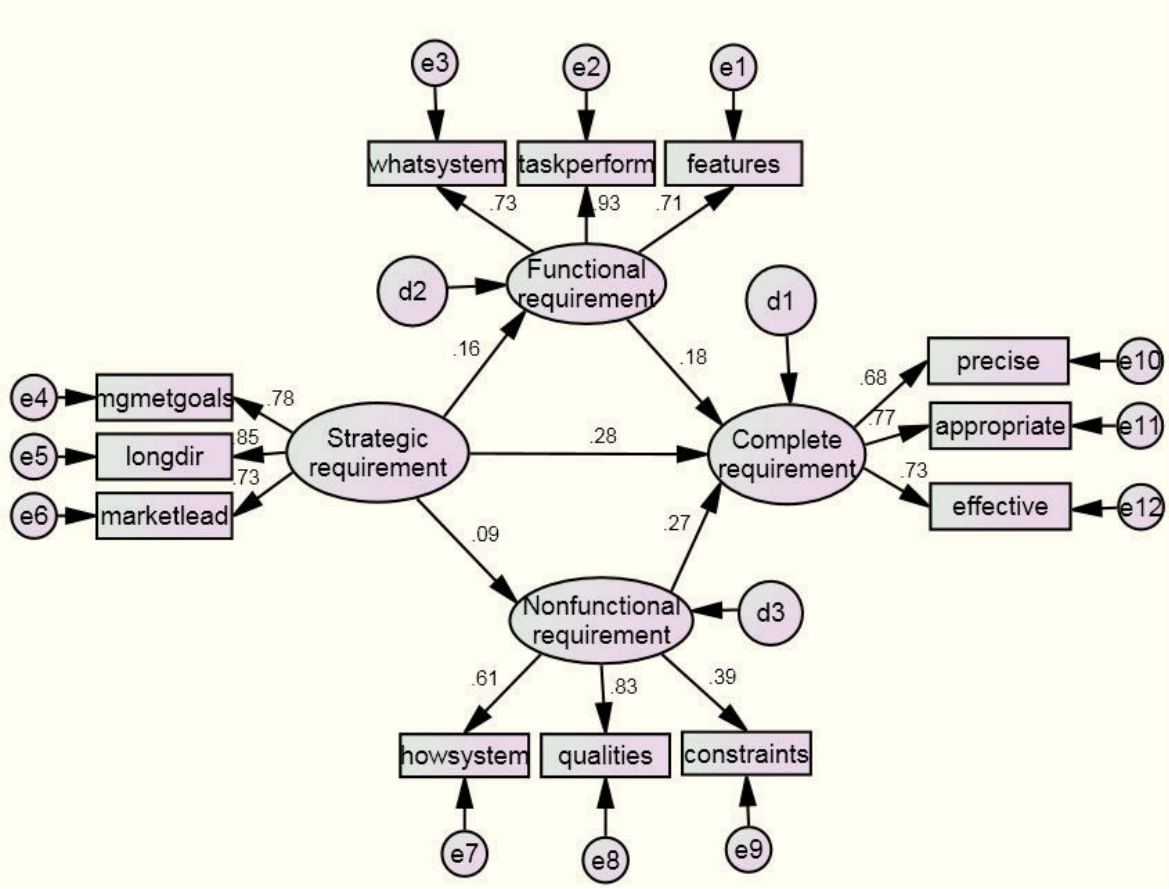


Figure 12: Results of Testing the Framework with the Combined Set of Data

The variable of project success was not considered in the SEM shown in Figure 12 because the measure of project success was beyond the scope of this research. Thus, the variable of project success was excluded from the SEM to avoid any bias in the statistical results. The results shown in Figure 12 indicated that the strategic business requirements directly and

indirectly influenced the completeness of system requirements. Five research questions related to the testing of the framework: Q 4, Q 5, Q 6, Q 7 and Q 8. In relation to Q 4 (Do the strategic business requirements affect the completeness of system requirements?), the coefficient value 0.28 indicated that the strategic business requirements had a strong positive effect on the completeness of system requirements. The coefficient value 0.28 meant that, if the strategic business requirements increased by one, the completeness of system requirements would increase by 0.28. It is important to point out here that generally in multivariate analysis, a path coefficient above 0.10 refers to a strong effect, while below 0.05 refers to a weak effect (Brown 2006; Bryant et al. 1996).

In relation to Q 5 (Do the strategic business requirements affect the functional requirements?) and Q 6 (Do the strategic business requirements affect the non-functional requirements?), the path coefficients 0.16 and 0.09 indicated that the effect of the strategic business requirements on the functional requirements was much stronger than on the non-functional requirements of the system. This meant that the functional requirements increased more than the non-functional requirements due to the effect of the strategic business requirements. Q 7 (Do the functional requirements affect the completeness of system requirements?) and Q 8 (Do the non-functional requirements affect the completeness of the system requirements?) were related to the consequent effect of the functional and non-functional requirements on the completeness of the system requirements, as shown in Figure 10. The coefficient values 0.18 and 0.27 indicated that the functional requirements had less positive effect than the non-functional requirements on the completeness of system requirements, though both were in the category of strong effects.

In summary, the results of the survey conducted with combined data indicated that the strategic business requirements correlated with the functional, non-functional and completeness of requirements at various levels. In addition, the strategic business requirements both directly and indirectly affected the completeness of system requirements. A few questions arose as a result of these findings, including:

- Did the experts and novices individually have similar views about the requirements lists?

- Would the statistical results be different if their data were assessed separately?

As discussed in the methodology chapter, novices and experts were the two main populations of interest in this research. Therefore, the empirical data collected in this study were divided into these two categories to observe the differences in the statistical results.

6.6.4 Comparing the SEMs of Novices' and Experts' Data

This comparison began with testing the fitness of the SEM representing the framework, with the novices' and experts' data. This test was conducted to identify how well the model explained both sets of empirical data collected in this study. The fitness results, as shown in Table 18, indicated that the SEM fit better with the experts' data than the novices' data. However, the sample size of this survey was smaller than the previous survey, and often a smaller sample leads to inconsistent results (Meyers, Gamst & Guarino 2006). Rules related to the tests shown in Table 18 were discussed in Section 6.6.2.1.

Table 18: Comparing the Fitness Results

	Chi-square	Degree of freedom	Probability	CFI	GFI	RMSEA	SRMR
Experts' data	64.144	49	0.052	0.980	0.949	0.042	0.052
Novices' sample	335.22	49	0.000	0.924	0.941	0.081	0.063

Note: The chi-square should be insignificant for better fit. 0.052 was not significant, which meant that the model fit better to the experts' data. CFI and GFI > 0.08 and RMSEA and SRMR < 0.1, which indicated a better fit of the model with the data (Kearns & Sabherwal 2006-7).

The SEM of the experts' data, as shown in Figure 13, indicated that all 12 items loaded onto the four variables effectively. The standardised regression weights on the four variables indicated that there was a strong association between the items and the variables they were proposed to represent. Both models indicated strong loadings of the 12 items to the proposed variables.

Overall, the results of the SEMs of the novices' and experts' data indicated that the strategic business requirements affected the completeness of system requirements both directly and indirectly via the functional and non-functional requirements of the system. As

indicated in Figure 13, the influence of the strategic business requirements on the functional and non-functional requirements was reasonably consistent with the SEMs of the experts' data and novices' data. Both models indicated that the strategic business requirements had a greater influence on the functional requirements than the non-functional requirements of the system. These results addressed two of the five research questions proposed in the beginning of this chapter, which were:

- Do the strategic business requirements affect the functional requirements of the system?
- Do the strategic business requirements affect the non-functional requirements of the system?

The results of the SEMs also addressed the question: do the strategic business requirements affect the completeness of system requirements? They addressed this by indicating that the strategic business requirements do positively affect the completeness of the system requirements, which was also consistent across both SEMs. In addition to this, the results also addressed another two research questions:

- Do the functional requirements affect the completeness of system requirements?
- Do the non-functional requirements affect the completeness of system requirements?

The models showed that the functional and non-functional requirements positively influenced the completeness of system requirements. However, there was a considerable difference between the results across the two SEMs, as depicted in Figure 13. The effect of the functional requirements on the completeness of system requirements was much stronger than the effect of the non-functional requirements for the SEM of the practitioners' data. In contrast, the results of the SEM for novices indicated that the effect of the non-functional requirements on the completeness of requirements was much stronger than the effect of the functional requirements on the completeness of system requirements. Thus, it was necessary to investigate the cause of this difference, and to determine whether this might have been created by the experience of the subjects in relation to the level of contribution of functional and non-functional requirements to the completeness of system requirements.

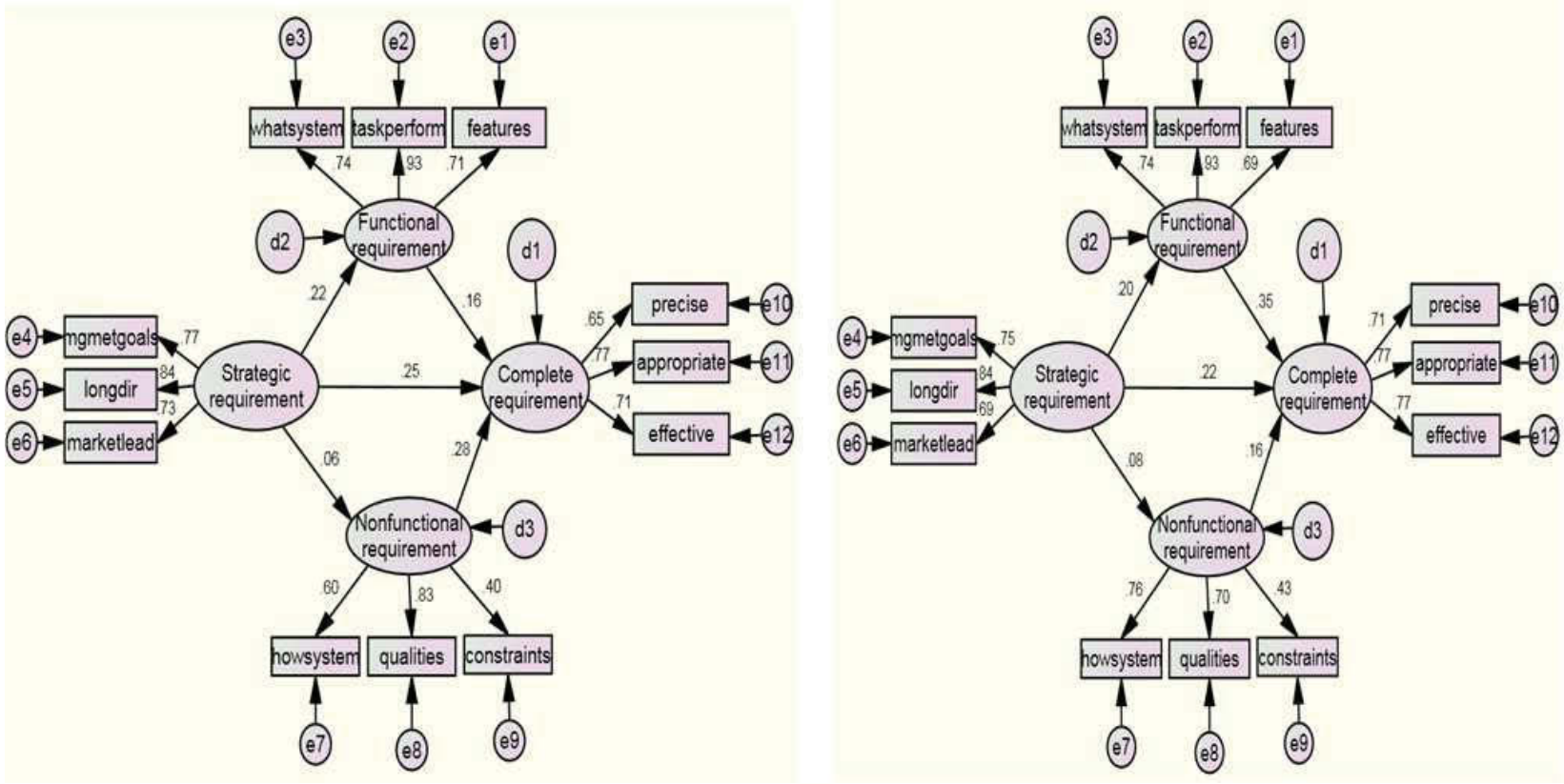


Figure 13: SEM for Novices' Data (Left) and SEM for Experts' Data (Right)

To investigate these questions, a new model was specified, as shown in Figure 14. In this model, the functional, non-functional and strategic business requirements were directly related to the completeness of system requirements. The direct effects of these variables on the completeness of system requirements were based on the correlational relationships between these variables, which was considered a plausible approach for measuring the direct effects (Brown 2006; Meyers, Gamst & Guarino 2006). In accordance with the correlation model in Section 6.6.2.3, this model was tested against the data of four groups of subjects with different levels of experience to determine whether the level of effect changed with the level of experience. This included three groups of experts with different levels of experience (as highlighted in Table 12) and one group of novices with no industry experience. Testing the model in Figure 14 against the data of these four groups helped demonstrate whether industry experience was the reason behind the varied level of influence from the functional and non-functional requirements of the system on the completeness of system requirements.

Although both SEMs in Figure 14 indicated consistency in the influence of the strategic business requirements on the completeness of the system requirements, this variable was still considered for the direct effect model to test its influence on the completeness of system requirements with the data related to varied experience. The results in Figure 14 indicated that the functional and non-functional requirements still affected the completeness of system requirements; however, their influence varied for the four sets of data. The influence of the strategic business requirements was also consistent for the four sets of data.

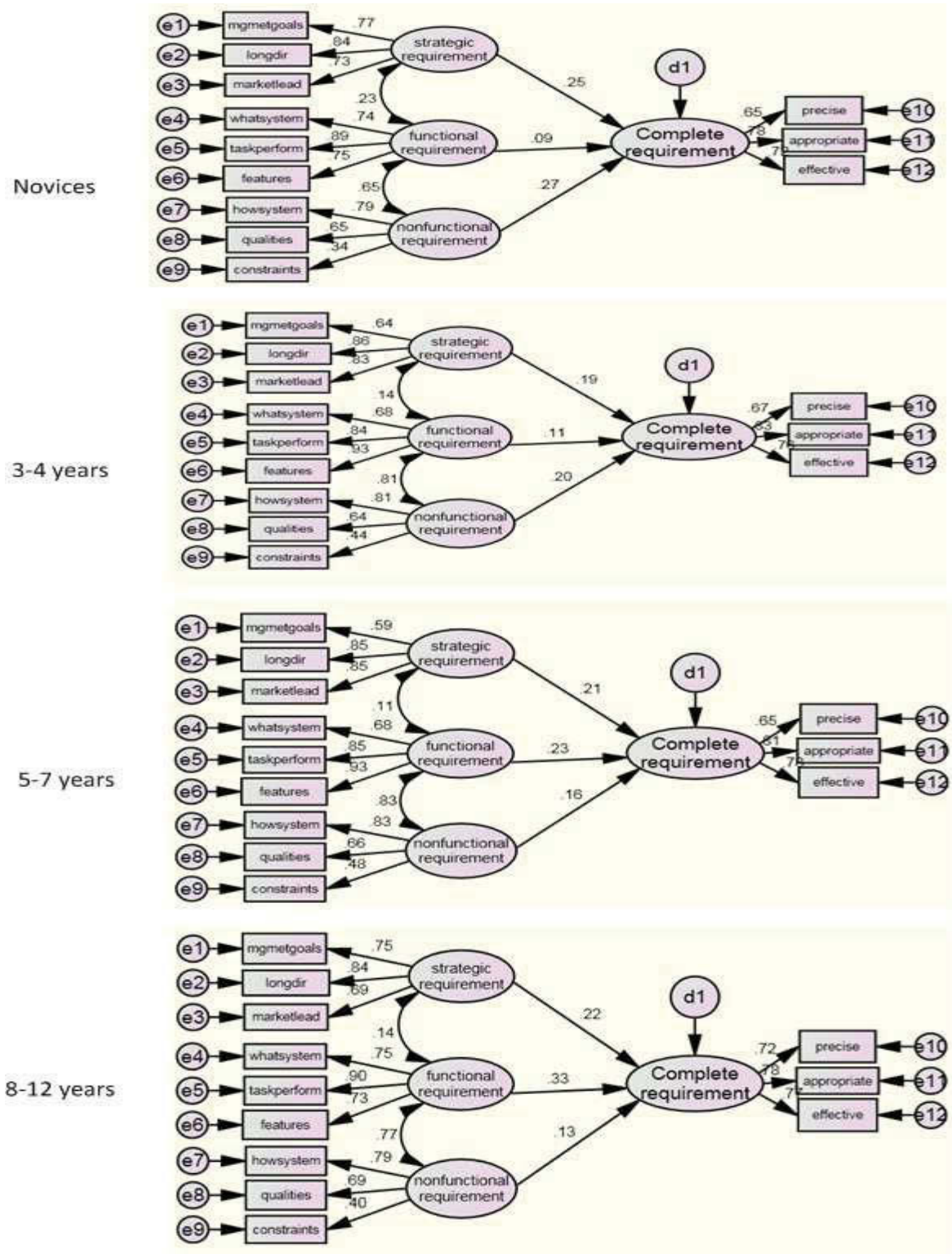
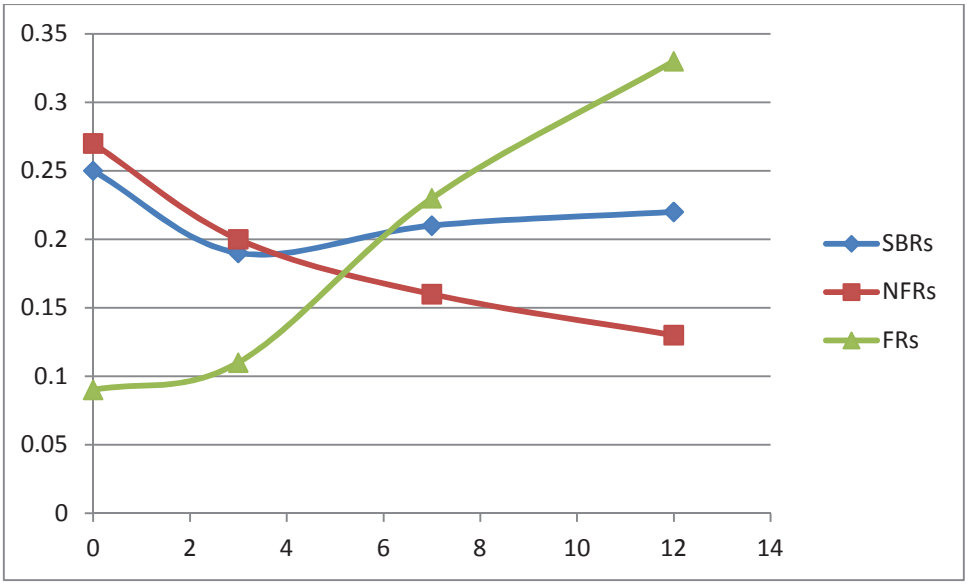


Figure 14: Subjects' Experience and Level of Effect of the Three Types of Requirements on the Completeness of System Requirements

The results of the four SEMs, as shown in Figure 14, indicated that the level of influence of the functional requirements and non-functional requirements on the completeness of system requirements depended on the experience of the subjects. The graph in Figure 15 indicates that the level of influence of the functional requirements increased as the experience of the subjects increased; however, the level of influence of the non-functional requirements decreased as the experience of the subjects increased. Thus, their levels of influence were in opposition in terms of the experience of the subjects. However, the influence of the strategic business requirements on the completeness of system requirements was nearly consistent across four groups of subjects with varied experience.



Note: SBRs = strategic business requirements; NFRs = non-functional requirements; FRs = functional requirements

Figure 15: Level of Influence Against the Experience of the Subjects

In summary, the results addressed the five research questions related to the framework by indicating that the strategic business requirements both directly and indirectly (via the functional and non-functional requirements) influenced the completeness of system requirements. These results were consistent for the various groups of subjects with different levels of experience, except for the results for a couple of relationships that showed inconsistency across the two samples.

6.6.5 Multi-group Analysis to Test the Framework

Until this point, the two main sets of data—novices and experts—were analysed separately to test the framework. The statistical results of the one sample were compared with the other sample to assess consistency. Another way of checking consistency between the two samples is to assess the data collectively. In this regard, multi-group invariance was a useful technique to test how consistent the structure of the framework was across both samples. Again, the data were divided into two main sets—novices and experts—for this multi-group analysis. This was done for two reasons:

1. These were the two mainstream populations of interest in the results; and
2. To produce meaningful statistical results.

Further breakdown of the data into smaller group may not be suitable for multi-group analysis. The multi-group analysis, undertaken with AMOS 19, was a three-step procedure with the following requirements:

- Equal form invariance: the number of factors and patterns of indicators should have identical factor loading across both samples. This referred to the 12 items of the four variables;
- Construct level metric invariance: the factors for the experts' sample should be measured in the same way as for the novices' sample; and
- Equality of the structural coefficient: the effects of the strategic business requirements, functional requirements and non-functional requirements should be invariant (equivalent) across the two samples.

Typically, multi-group analysis means that the framework is operating in exactly the same way and that the underlying constructs being measured have the same theoretical structure for each group under study (Byrne 2004). Multi-group analysis was performed on the re-specified model (SEM, as shown in Figure 12), which was the ultimate model representing the framework proposed in Chapter 3. This analysis tested whether the model structure retained in the first survey was invariant or equivalent to the second survey. In other words,

it examined whether the specified SEM structure of measure was identical across the two groups of data.

6.6.5.1 General Procedure

Specification of the multi-group model using AMOS 19 graphics was guided by the default rule of equality constraints, which states that all groups in the analysis have an identical path diagram structure (Byrne 2004). As such, in the multi-group invariance test, a model structure needs only to be developed from the first sample because all the other groups will have the same structure by default (Byrne 2004). The SEM of this test was drawn from the first sample (novices), and the second sample (experts) had that structure by default in the invariance analysis. This meant that both samples had the same model, which represented the framework proposed in Chapter 3. The default rule of equality constraints does not pose any inconsistency.

Before discussing the model being tested for the three hypotheses, it is important to point out that the invariance or equality test in multi-group analysis is about equivalence of model structure—whether the specified factorial structure of measure is identical across groups (Byrne 2004). This does not mean that the estimates have to be identical because the estimates are likely to be based on different co-variances and standard errors derived from the two different samples. In testing for equivalence across the two groups—novices and experts—sets of parameters were put to the test in a logically ordered and increasingly stringent fashion. The stepwise model test used for the three hypotheses is described below.

6.6.5.1.1 Step 1: Equal Form Invariance

This step measured whether the model structure in terms of the 12 items measured the four variables in an appropriate manner. As shown in the SEMs and correlation models, the items loaded to the variables they were proposed to represent. This structural aspect was analysed in the confirmatory factor analysis. There were two important reasons for performing confirmatory factor analysis again here. First, the former tests were conducted

for the two groups separately; however, the tests for the validity of factorial structure were conducted across the two groups simultaneously. Second, in testing for invariance by using the AMOS program, the fit of this simultaneously estimated model could provide a baseline value against which all the subsequent models could be compared (Byrne 2004).

Model assessment. The fit statistics related to this test are reported in Table 19. The chi-square value of 401.340 with a degree of freedom of 98 provided the base line value against which subsequent tests for invariance could be compared. The CFI and RMSEA values of 0.934 and 0.053, respectively, indicated that the framework structure had a reasonably strong fit across the two samples. Thus, it was found that the hypothesised model fit the two independent samples. The equal form invariance was tenable and retained, and thus this research proceeded to test the construct level metric invariance.

Table 19: Multi-group Testing for Framework Structure

Hypothesis	χ^2	*df*	$\Delta\chi^2$	Δdf	*CFI*	ΔCFI
Unconstrained Equal form	401.340	98	---	---	0.934	---
Model 1 Metric invariance	404.359	106	3.01	8	0.935	0.001
Model 2 Structural coefficient invariance	407.637	109	3.2	3	0.935	0.000

Note: χ^2 represents the chi-square and Δ represents the difference. $\Delta\chi^2$ = difference between the chi-square values between models. Δdf = difference in degrees of freedom between the models

6.6.5.1.2 Step 2: Construct Level Metric Invariance

The second step was about testing whether the fully constrained model was invariant across the two samples. In this test, all the factor loadings were constrained equally across the two samples. This was the primary test in which it was observed whether the experts and novices were equivalently agreed regarding the pattern of factor loadings in the model.

Model assessment. The fit statistics related to the constrained two-group model are described in the second row of Table 19. In testing for the invariance of the constrained model, the chi-square value of 404.359 (degree of freedom: 106) of this constrained model

was compared with the initial model, in which no equality constraints were imposed. Like single group analysis, when models are nested, their difference in chi-square value is distributed as chi-square value, and their degree of freedom is equal to the difference in degrees of freedom (Byrne 2004). Given that this constrained model was nested with the initial model, a comparative procedure was used here. This comparison yielded a chi-square difference ($\Delta\chi^2$) of 3.01 with a degree of freedom difference of eight, which was well below the critical value of 0.05 (Meyers, Gamst & Guarino 2006). Thus, this indicated that the model had excellent fit in terms of its factor loadings across both groups. The ΔCFI was well below the critical value of 0.01, thus also indicating that the model fit reasonably well on the factor loading constraints across the groups. Therefore, the model was tested positively and was considered ready to proceed to the third step.

6.6.5.1.3 Step 3: Equality of the Structural Coefficient

This third step was about testing whether the constrained model was invariant across both samples. The equality of structural coefficient was critical for this research because measuring the effect of the three types of requirements on the completeness of system requirements was the main topic of this research. Three latent factors (strategic, functional and non-functional requirements) affected the observed variable (completeness of system requirements). This step sought to determine whether both groups—novices and experts—supported these effects simultaneously.

Model assessment. The fit results related to this constrained two-group model are described in the third row of Table 19. This test of invariance for the constrained model was guided by the rules described in Step 2. The chi-square of 407.637 (degree of freedom: 109) was compared with that of the first model, in which the equality constraints (metric invariance) were imposed. This comparison yielded a chi-square difference ($\Delta\chi^2$) of 3.2 with a degree of freedom difference of 3.0, which was again well below the critical value of 0.05 (Meyers, Gamst & Guarino 2006). Thus, this indicated that the model fit excellently in terms of its structural coefficient across both groups: experts and novices. The ΔCFI was

also well below the critical value of 0.01, thus also indicating that the model fit excellently on the structural coefficient for both groups.

In summary, the statistical results of this multi-group analysis indicated that the structure of the framework held strong when tested against both sets of data collectively. The framework was strong in terms of the relationships between the four variables (strategic business requirements, functional requirements, non-functional requirements and completeness of system requirements) and the items loading on them.

6.7 Testing the Framework Without Strategic Business Requirements

The above tests were performed on the individual and collective groups of data to assess whether the SEM, representing the framework, explained the data well. Overall, the results indicated that the strategic business requirements were strongly related to the functional, non-functional and completeness of requirements and, therefore, the strategic business requirements provided positive direct and indirect effects on the completeness of system requirements. However, the results did not show whether there was any negative effect on the completeness of the system requirements if the strategic business requirements did not exist. Thus, a test needed to be conducted in which the influence of the strategic business requirements was restricted in order to observe the negative effects of excluding the strategic business requirements. The research question was defined as:

> Does the completeness of system requirements reduce in the absence of the strategic business requirements?

This test was conducted to strengthen the claim that strategic requirements provide direct and indirect effects on the completeness of system requirements. In this regard, the R^2 method was applied, in which the effects of the strategic requirements on the completeness of requirements were constrained to '0' on the SEM in AMOS 19. The R^2 value represented the contribution of the independent variables to the observed variable in terms of variance. In this method, the statistical estimates of the constrained effects were compared with the non-constrained estimates of the effects of the strategic business requirements at the

individual sample level. The results are discussed below based on the two individual samples.

6.7.1 Novices' Sample

The results of the novices' data indicated that the three unconstrained independent variables (strategic business requirements, functional requirements and non-functional requirements) together explained 16.6% of the variance in the completeness of the requirement variable, as shown in Table 20. However, when the variable of strategic business requirements was constrained to '0', the remaining two variables (functional requirements and non-functional requirements) explained 12.7% of the variance in the complete requirements variable. The difference between the two variances was 3.9% (16.6 – 12.7 = 3.9%), indicating that the absence of strategic business requirements reduced the completeness of the system requirements to 3.9%.

To test whether this reduction was significant, the chi-square value and degree of freedom of the variance achieved with the strategic business requirements were taken away from the chi-square value and degree of freedom of the variance achieved without the strategic business requirements. The results provided in Table 20 indicated that the chi-square difference was 32.042 and the difference in degree of freedom was one. The critical chi-square value with one degree of freedom was 3.841 (Meyers, Gamst & Guarino 2006) and because 32.042 is well above 3.841, this indicated that, without strategic business requirements, the reduction in the completeness of system requirements was significant.

6.7.2 Experts' Sample

A similar pattern of results was observed for the experts' data. As shown in Table 20, the contribution of the independent variables (without strategic business requirements) to the completeness of the system requirements decreased by 3.7%, similar to the decrease for the novices' sample. The chi-square value was increased by 6.607, with one extra degree of

freedom, meaning that the reduction in the completeness of the system requirements was significant when the strategic business requirements were absent.

Therefore, the estimates of both samples indicated that the exclusion of the strategic business requirements had a significant negative effect on the completeness of the system requirements. This was another way of providing evidence that the strategic business requirements positively influenced the completeness of the system requirements.

Table 20: Model Statistics without Strategic Requirements

	R^2	R^2 (without SR)	ΔR^2	χ^2	χ^2 (without SR)	$\Delta\chi^2$	df	df (without SR)	Δdf
Student sample	0.166 (16.6%)	0.127 (12.7%)	3.9%	335.223	367.265	32.042	49	50	1
Expert sample	0.222 (22.2%)	0.185 (18.5%)	3.7%	66.144	72.751	6.607	49	50	1

Note: *SR* = strategic requirements

6.8 Summary of Study 2

This study effectively addressed the five research questions related to the framework, as shown in Table 21.

Table 21: Study 2 Questions and Answers

Question	Answer
RQ 4: Do the strategic business requirements affect the completeness of system requirements?	Yes
RQ 5: Do the strategic business requirements affect the functional requirements of the system?	Yes
RQ 6: Do the strategic business requirements affect the non-functional requirements of the system?	Yes
RQ 7: Do the functional requirements affect the completeness of the system requirements?	Yes
RQ 8: Do the non-functional requirements affect the completeness of the system requirements?	Yes

For the five research questions provided at the beginning of this survey, the results indicated that the strategic business requirements positively affected the functional, non-functional and completeness of system requirements. In order to address the five research

questions, various types of models were developed by using AMOS 19. These were then tested against the data of various groups of subjects with varying levels of experience.

First, a correlation model was developed to test the level of association between the four variables of the framework. This correlation model was tested against the various groups of data to observe variations in the level of association between the variables. The results indicated that the association of the strategic business requirements with the functional requirements and completeness of system requirements was reasonably consistent across the various datasets. However, the level of association of strategic business requirements with the non-functional requirements was reasonably inconsistent across various datasets. Overall, the results addressed the research question: do the strategic business requirements associate with the functional, non-functional and completeness of system requirements?

An SEM that represented the structure of the framework was developed to investigate five research questions related to the framework. The results of this model testing against the empirical data indicated that the strategic business requirements influenced the completeness of the requirements both directly and indirectly via the functional and non-functional requirements of the system. When the data were divided into two major sets—novices and experts—the results indicated that the influence of the strategic business requirements on the functional, non-functional and completeness of system requirements was consistent across both sets of data. However, the influence of the functional and non-functional requirements on the completeness of system requirements varied across both samples. Overall, the results effectively addressed the five research questions related to the framework.

In addition, two more tests were performed. The first evaluated the structure of the framework in terms of the strength of the structure of the framework against the two sets of data. The second evaluated the effect on the completeness of system requirements if the strategic business requirements were considered in the requirements specification.

For the first test, a multi-group analysis was performed on the two sets of data for the structure of the framework. The results, provided in Table 19, indicated that the structure of the framework held well for both sets of data. In relation to testing the framework without the strategic business requirements, the statistical results of the R^2 test, provided in Table 2, indicated that the completeness of system requirements deteriorated when the strategic business requirements were not considered. These results were crucial for determining the validity of the framework by demonstrating the role of strategic business requirements in terms of their influence on the functional, non-functional and completeness of system requirements.

Chapter 7: Discussion

This research began by advocating that the completeness of system requirements is an important aspect of requirements engineering because it is strongly related to project success. During the previous two decades, the requirements engineering literature has introduced a number of requirements engineering approaches that have the main purpose of developing requirements models in the context of enterprise business strategy. However, these approaches have neglected to measure the completeness of system requirements, which is crucial to the success of the project.

The basic objective of this research was to develop and test a unique ESRE framework that incorporated the role of the strategic business requirements in terms of their effect on the functional, non-functional and completeness of system requirements. This framework is presented in Figure16.

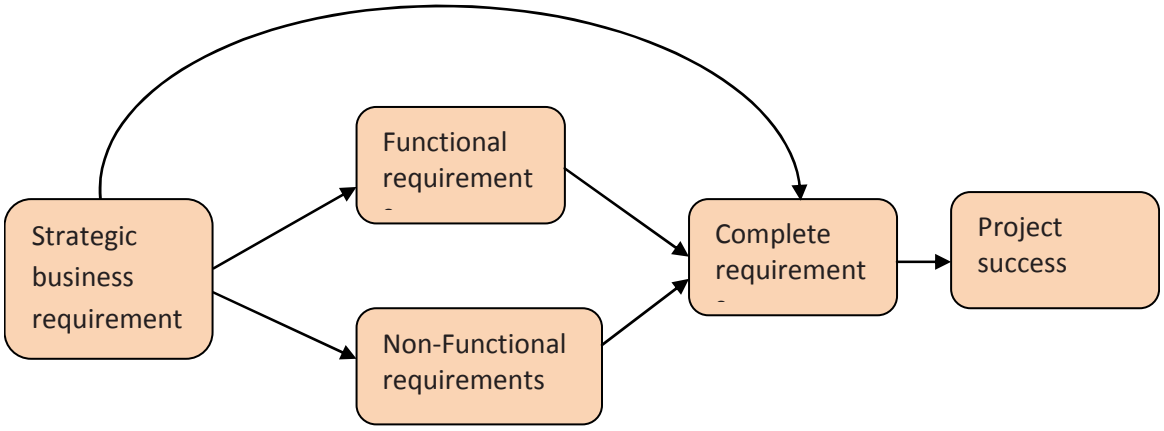


Figure 16: ESRE Framework

All the eight research questions related to testing the framework were addressed in Studies 1 and 2. The lessons learnt from the results of these studies are discussed in the following sections.

7.1 Importance of Strategic Business Requirements

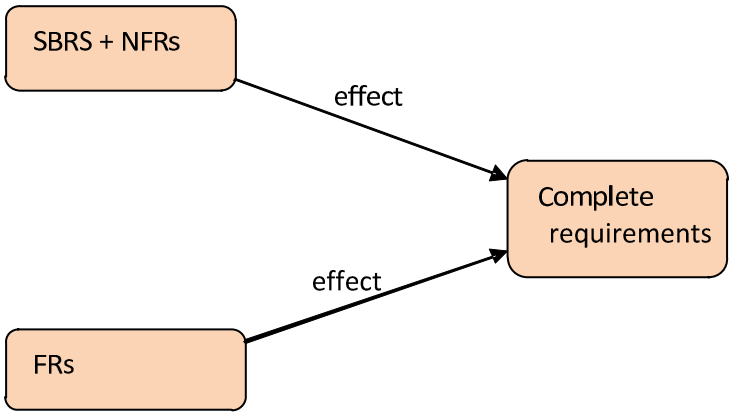
One of the key results of Studies 1 and 2 was that strategic business requirements are important to collect during requirements engineering. This finding is consistent with the argument in the management information system literature that enterprise-wide business goals are important for the development of IT systems. A number of business IT alignment models, proposed in the last three decades (Birnik & Moat 2008; Henderson & Venkatraman 1993; Kaplan & Norton 2004; Luftman 2000) have repeatedly shown the importance of enterprise-wide business goals in relation to IT systems. The resource-based view of the organisation, as discussed in Section 2.2.1, develops the functions and activities that support the business performance targets of the organisation (Schwarz et al. 2010; Tallon 2008; Velcu 2010). Thus, all these frameworks from the management information system discipline recognise the importance of strategic business goals and requirements for system development.

Requirements engineering, which is one of the key phases of the system development lifecycle, embraced this view by arguing that requirements models need to be developed in the context of strategic business requirements so that successful systems can be developed. However, the pre-existing requirements models retain some weaknesses when developed in the context of strategic business requirements, as is discussed in the following two sections.

7.2 Strategic Business Requirements and Their Importance Beyond Non-functional Requirements

The first weakness of the existing requirements engineering approaches (Barone et al. 2010; Bleistein et al. 2006a; Samavi, Yu & Topaloglou 2009; Singh & Woo 2009) is that they consider strategic business requirements within the non-functional requirements of the system. However, the results of this research show that the strategic business requirements are different from the non-functional requirements of the system.

It is evident from the majority of requirements models that high-level strategic goals are considered within the non-functional requirements of the system. This is a common occurrence in requirements engineering approaches, and some researchers argue that their method 'is well-suited to model both organisational strategy (non-functional items) and functional items in the same model' (Thevenet & Salinesi 2007). This clearly highlights that the strategic business requirements are considered within the non-functional requirements of the system. Figure 17 depicts the existing requirements engineering approach from the perspective of the framework to show how the strategic business requirements and non-functional requirements are combined in requirements engineering.



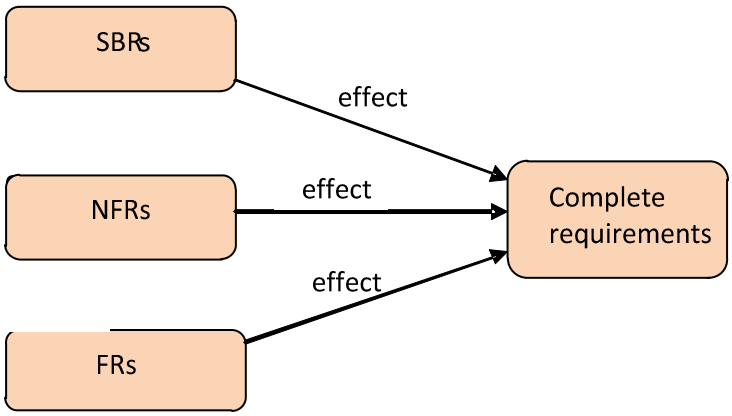
Note: SBRs = strategic business requirements; NFRs = non-functional requirements; FRs = functional requirements

Figure 17: Existing Requirements Engineering View

The empirical results of Studies 1 and 2 show that the strategic business requirements need to be treated separately from the non-functional requirements of the system. The strategic business requirements affect the non-functional requirements, as well as the functional requirements, of the system. The question here is why the strategic business requirements need to be separated from the non-functional requirements of the system. This need was realised in the literature view chapter, in Sections 2.2.1 and 2.2.2.1. According to Section 2.2.1, the strategic business requirements are driven by the vision and mission of the organisation and have often been described as performance targets, longer-term goals and market leadership objectives by the management information system literature (Birnik & Moat 2008; Nevo & Wade 2010; Schwarz et al. 2010; Velcu 2010). However, in Section

2.2.2.1, the non-functional requirements were described as the quality requirements of the system, such as safety, security, privacy and so forth (Lamsweerde 2001). In this regard, Chung and Leite (2009) argue that the non-functional requirements are the quality characteristics of the functionality of a software system, which obviously do not qualify as being the strategic business requirements of the system. In other words, the strategic business requirements cannot be considered within the non-functional requirements of the system.

Since the recent approaches in requirements engineering have embraced business strategy, they should have maintained a difference between strategic business requirements and non-functional requirements for the development of requirements models. However, instead, these approaches actually consider the strategic business requirements within the non-functional requirements of the system, which means they do not incorporate the effects of the strategic business requirements on the requirements models. Separation of strategic business requirements from the non-functional requirements of a system is a crucial contribution of this research to the body of knowledge, and offers a paradigm shift in requirements engineering research.



Note: SBRs = strategic business requirements; NFRs = non-functional requirements; FRs = functional requirements

Figure 18: Direct Effects

Following from this, an important factor to investigate was where the strategic business requirements need to be positioned in the framework. As the strategic business

requirements are separated from the non-functional requirements, there were essentially two options for this research:

1. Relate the strategic business requirements, in parallel with the functional and non-functional requirements, to the completeness of system requirements to measure their direct effects (as shown in Figure 18); or
2. Relate the strategic business requirements to the functional and non-functional requirements to measure their indirect effects.

In the direct effects approach, shown in Figure 14, the strategic business requirements were able to show their effects on the completeness of system requirements, but they were unable to show their effects on the functional and non-functional requirements. This was evident from the results of testing this framework, which were discussed in Section 6.6.4.

The majority of requirements engineering approaches (Barone et al. 2010; Bleistein et al. 2006a; Lamsweerde 2001; Singh & Woo 2009; Thevenet & Salinesi 2007) argue for strategic business requirements to develop the technical considerations of the system, even though they consider the strategic business requirements within the non-functional requirements. This means the position of the strategic business requirements for these frameworks is neither within the non-functional requirements (as depicted in Figure 17), nor outside just affecting directly to the completeness of requirements. Instead, it is actually behind the functional and non-functional requirements of the system, where the strategic business requirements are shown to influence the functional and non-functional requirements of the system (see Figure 19).

This is based on the general understanding of requirements engineering research, in which strategic business requirements are considered to affect the technical considerations of the system (Barone et al. 2010; Bleistein 2006; Samavi, Yu & Topaloglou 2009; Singh & Woo 2009). Therefore, this study proposed an ESRE framework, as depicted in Figure 19, to incorporate the role of strategic business requirements in terms of their influence on the functional, non-functional and the completeness of system requirements.

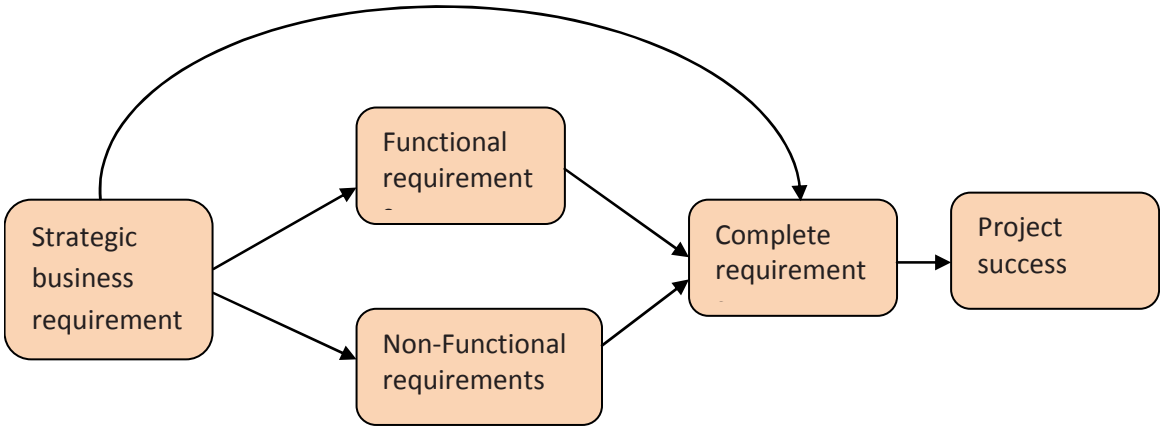


Figure 19: Proposed Framework of this Research

7.3 Strategic Business Requirements and Completeness of System Requirements

The second weakness of the pre-existing requirements engineering research is that it does not show what effect strategic business requirements have on the completeness of system requirements. Project success is associated with the completeness of requirements specification and, according to (Hammer et al. 1998; Kamata & Tamai 2007), the completeness of system requirements affect the outcome of the software project. Since the difference between strategic business requirements and non-functional requirements has been realised in this study's framework, the results of testing the framework show the effect of strategic business requirements on the completeness of system requirements both directly and indirectly via the functional and non-functional requirements of the system.

This realisation in this framework made it possible to measure the effects of the strategic business requirements on the functional and non-functional requirements, as well as the effects of the functional and non-functional requirements on the completeness of system requirements. It is very useful to observe the precise effect of the strategic business requirements on the completeness of system requirements because the completeness of system requirements are crucial to the success of a project (Hammer et al. 1998; Kamata & Tamai 2007). This can be a useful performance indicator to enable researchers to precisely demonstrate the effects of their research artefact. Thus, the introduction of the variable of

completeness of requirements in the framework enables this study to clearly demonstrate the weaknesses in the existing requirements engineering approaches with respect to the completeness of system requirements.

7.4 Behaviour of Business Analysts when Collecting Strategic Business Requirements

The validity of this study's results depended on the performance of the business analysts who collected the requirements in Study 1. This section discusses how these business analysts behaved during the collection of the requirements. The results of Study 1 showed that the junior business analysts did not consider collecting strategic business requirements—rather, the majority of the strategic business requirements were collected by the senior business analysts. These findings reflect the results of previous studies, such as that by (Ellis 2009), in which average business analysts were considered incapable of delivering business goals. Ellis (2009) argues that average business analysts are one of the main reasons for poor requirements gathering, which results in wasting a significant proportion of an organisation's budget dedicated to software development projects. Further details of this were provided in Section 2.1.2.

Junior business analysts generally have little industry experience following their graduation from university. As the results of Studies 1 and 2 show, the junior business analysts did not know what strategic business requirements were, nor who to approach for them. This suggests that these analysts were not well trained during their university study. Since the existing approaches focus on the functional and non-functional requirements of the system, and there is no framework showing the role of strategic business requirements in requirements engineering, graduates of business and IT courses from universities may have little knowledge of enterprise strategy or of their own role in the development of requirements specification. This was reflected in the results of this research.

7.5 Behaviour of the Business Analysts when Approaching Stakeholders

The results of Study 1 showed that the junior business analysts approached fewer stakeholders than did the senior business analysts. This is one of the reasons that the junior business analysts were unable to collect strategic business requirements, as discussed in Section 7.3. Identification of stakeholders requires a rigorous approach through which various classes of stakeholders can be identified (Sharp, Galal & Finkelstein 1999). It is important in requirements collection for a business analyst to determine who the stakeholders of a system are, and what needs to be collected from them. Glinz and Wieringa (2007) state that a business analyst needs to recognise the stakeholders of a system in order to understand their needs and desires. Thus, novices need to be educated about the stakeholders of a system and made aware of how to recognise them from the perspective of a system.

It appears that the training of novices at universities was insufficient in relation to identification of stakeholders for the collection of strategic business requirements. This resulted in these novices having difficulty in recognising the stakeholders of the system. Thus, junior business analysts need to be educated about the stakeholders of the system because this is fundamental to the collection of appropriate and complete system requirements.

7.6 Performance of the Stakeholders

In addition to the above, it is also important to discuss how the stakeholders performed in terms of producing strategic business requirements. The results of Study 1 showed that the top managers of the organisation produced strategic business requirements, whereas the operational level staff were unable to do so. These results correspond with the long-term (three decades) view of business strategy in the management information system literature, which states that strategic business goals, driven by the vision and mission of the organisation, are the business of management. This view also states that senior management

is the source of enterprise-wide business goals (Chan & Huff 1992; Kaplan & Norton 2004).

These results also help understand why the junior business analysts, as discussed in Sections 7.4 and 7.5, were unable to collect strategic business requirements. Since the junior business analysts approached less stakeholders for requirements and did not realise the importance of meeting with the managers of the organisation, they were unable to collect the strategic business requirements. This oversight resulted from their lack of understanding about the importance of strategic business requirements and about the important stakeholders to approach for requirements collection.

7.7 Novices and Experts

The results of Studies 1 and 2 clearly showed that the performance of the novices was different from the experts for the collection and assessment of the requirements lists. This has been a topic of discussion in the software engineering discipline, and there has always been debate regarding the choice of the sample. Many researchers from the system engineering discipline argue that novices are not appropriate subjects to assess research artefacts. However, researchers from software engineering believe that novices, who are the practitioners of tomorrow, are a legitimate population of interest from which a sample can be drawn for a research study (Carver, Jaccheri & Morasca 2003; Host, Regnell & Wohlin 2000; Kitchenham et al. 2002; Sjoberg et al. 2002). The findings of this research support the arguments of those researchers who claim that novices are not as useful as experts for a study. Novices with little industry experience are unable to perform as well as experts, particularly for the collection and assessment of system requirements.

7.8 Summary

The results of this research are consistent with the requirements engineering and management information system literature regarding the importance of strategic business requirements for the development of successful systems. However, in contrast to the

existing requirements engineering approaches, the testing of this study's framework demonstrated that strategic business requirements are different from non-functional requirements, and thus cannot be considered within the non-functional requirements of the system. Unfortunately, the existing requirements engineering approaches have failed to establish this difference and do not demonstrate the effect of strategic business requirements on their requirements models. The completeness of system requirements, which are vital for the success of the project, have been ignored by the majority of the requirements models. This study's proposed framework has clearly shown the role of strategic business requirements in terms of their influence on the completeness of system requirements.

The validity of this study's test results largely depended on the performance of the business analysts involved in collecting and assessing the requirements, as highlighted by various researchers in software engineering. The performance of the business analysts in this research was consistent with the findings of other studies, in which experts are considered more appropriate than novices for collecting system requirements (Carver, Jaccheri & Morasca 2003; Host, Regnell & Wohlin 2000; Kitchenham et al. 2002; Sjoberg et al. 2002). Since this study's novices were not well trained at universities to recognise the importance of strategic business requirements and the source of these requirements, they were unable to identify the appropriate stakeholders from which to collect these requirements. This resulted in them predominately collecting the functional and non-functional requirements of the system. However, the experts were able to identify the appropriate stakeholders for the collection of strategic business requirements.

Chapter 8: Conclusion and Future Work

The requirements engineering literature has introduced a number of approaches to develop requirements models in the context of enterprise business strategy. The main purpose of these approaches is to create alignment between strategic business goals and the technical considerations (functionality) of the intended system. Unfortunately, none of these pre-existing approaches measures the completeness of the requirements with respect to the enterprise-wide business goals. This is despite various empirical studies providing evidence of the importance of the completeness of system requirements for the success of a project. The requirements engineering literature does not offer a framework that incorporates the role of strategic business goals in terms of their influence on the completeness of system requirements.

To address this requirements engineering issue, an ESRE framework was developed in this research project, based on connecting the four themes of strategic business requirements, functional requirements, non-functional requirements and the completeness of the system requirements, as described in Chapter 3. The main purpose of this framework was to incorporate the role of strategic business requirements in terms of their influence on functional and non-functional requirements, and consequently on the completeness of system requirements. The following eight research questions were identified to test the framework:

- RQ 1: Do the business analysts collect strategic business requirements?
- RQ 2: From whom do the business analysts collect the strategic business requirements?
- RQ 3: How do the business analysts behave when approaching stakeholders for the collection of requirements?
- RQ 4: Do the strategic business requirements affect the completeness of system requirements?
- RQ 5: Do the strategic business requirements affect the functional requirements of the system?

- RQ 6: Do the strategic business requirements affect the non-functional requirements of the system?
- RQ 7: Do the functional requirements affect the completeness of the system requirements?
- RQ 8: Do the non-functional requirements affect the completeness of the system requirements?

Two studies were conducted to address these eight questions. Study 1 was conducted to collect requirements and address the first three questions, and Study 2 was conducted to assess the requirements lists and address the remaining five research questions.

The first three questions were related to the performance of the business analysts during the collection of the requirements. In relation to Q 1 (Do the business analysts collect strategic business requirements?), the results of Study 1 highlighted that all the business analysts of varying degrees of experience collected the strategic business requirements. However, the senior business analysts collected more strategic business requirements than did the junior business analysts.

In relation to Q 2 (From whom do the business analysts collect the strategic business requirements?), the results indicated that the strategic business requirements, referring to the vision and mission of the organisation, were collected from all stakeholders—from top managers to the operational level staff. However, the results showed that the top managers revealed more strategic business requirements than did the operational level staff.

In relation to Q 3 (How do the business analysts behave when approaching stakeholders for the collection of requirements?), the results of Study 1 indicated that the senior business analysts tended to approach more stakeholders of the system than did the junior business analysts. Thus, overall, the results of Study 1 addressed the three research questions related to the performance of the business analysts, which was crucial for testing the framework.

The assessment data of the requirements lists collected from Study 2 was analysed through multivariate analysis techniques to address the five research questions related to the

relationships between the variables of the framework (Q 4 to Q 8). In relation to Q 4 (Do the strategic business requirements affect the completeness of system requirements?), the statistical analysis of the assessment data indicated that the strategic business requirements did affect the completeness of system requirements, and that this effect was consistent across various groups of subjects with different levels of experience.

In relation to Q 5 (Do the strategic business requirements affect the functional requirements of the system?) and Q 6 (Do the strategic business requirements affect the non-functional requirements of the system?), the statistical results indicated that the strategic business requirements did affect the functional and non-functional requirements. However, the effect of the strategic business requirements was more related to the functional requirements than the non-functional requirements. This pattern was observed across various groups of subjects with different levels of experience.

In relation to Q 7 (Do the functional requirements affect the completeness of the system requirements?) and Q 8 (Do the non-functional requirements affect the completeness of the system requirements?), the statistical analysis of the data indicated that both the functional and non-functional requirements positively affected the completeness of the system requirements. However, for the experts' data, the results indicated that the functional requirements generated a much stronger effect on the completeness of system requirements than did the non-functional requirements. The results for the novices' data indicated that the functional requirements generated a much weaker effect on the completeness of the system requirements than did the non-functional requirements. This pattern was similar across various groups of subjects. Overall, the results of this study indicated that the framework was valid across various groups of subjects with varying degrees of experience.

The results were discussed further in terms of the value of the framework and the issues surrounding the business analysts involved in the research. The results of this research are consistent with the business strategy and requirements engineering literature regarding the importance of strategic business requirements for the development of a successful system. However, in contrast to the existing requirements engineering approaches, this research

shows that strategic business requirements are different from non-functional requirements, and that they actually affect the non-functional and functional requirements of the system for the completeness of system requirements. The performance of the expert business analysts was better than the performance of the novices during the collection of the strategic business requirements because the novices were not well trained to recognise the important stakeholders for the collection of strategic business requirements.

8.1 Contribution of this Research

The framework and research presented in this thesis make a number of contributions to the requirements engineering research and practice, as outlined in the following sections.

8.1.1 Demonstrates Importance of Strategic Business Requirements

The existing requirements engineering literature highlights the importance of strategic business requirements in the development of requirements models. However, the approaches do not highlight the importance of strategic business requirements in terms of their difference to the functional and non-functional requirements of the system. They also do not consider their influence on the functional, non-functional and completeness of system requirements.

8.1.2 Demonstrates how Strategic Business Requirements Affect Functional and Non-functional Requirements

As discussed in the literature review chapter, the requirements engineering approaches develop requirements models in the context of strategic business goals and demonstrate the relationship between the requirements through traceability links. However, the approaches do not show what effect the strategic business requirements have on the functional and non-functional requirements of the system. This research presents a unique framework that shows precisely what effect the strategic business requirements exert upon the functional and non-functional requirements of the system.

8.1.3 Demonstrates that Strategic Business Requirements Affect Completeness of System Requirements

None of the existing requirements engineering approaches incorporate the effect of strategic business requirements on the completeness of system requirements. The approaches generally have a development model to create alignment between the requirements. The framework proposed in this research guides business analysts to measure the effect of strategic business requirements on the completeness of system requirements both directly and indirectly via the functional and non-functional requirements of the system. This is a significant contribution to the body of knowledge.

8.1.4 Demonstrates that Strategic Business Requirements should be a Separate Set of Requirements

This research demonstrates that strategic business requirements are so important that they should be treated as a separate set of requirements, rather than as just one of the elements of the non-functional requirements. As discussed in the literature review chapter, the majority of requirements engineering approaches include the strategic business requirements within the non-functional requirements of the system (Singh & Woo 2009; Yu, Strohmaier & Deng 2006). In requirements engineering, the non-functional requirements are often described as 'soft' goals. The majority of approaches indicate soft goals as the highest level goals in their requirements models, including some approaches that have clearly described non-functional requirements as the strategic business goals of the system (Rolland & Salinesi 2005; Thevenet & Salinesi 2007).

These approaches do not distinguish between the strategic business requirements and non-functional requirements, which is crucial to the completeness of system requirements. Distinguishing between the strategic business goals and non-functional requirements of the system is the main theme of this study's framework. Therefore, this framework is able to

clearly demonstrate the role of strategic business requirements in relation to the completeness of system requirements.

8.1.5 Introduces Framework as a Guide to Completeness of System Requirements

This study's framework provides clear guidance for business analysts to collect the strategic business requirements, functional requirements and non-functional requirements of the system. The collection of these three types of requirements is a recipe for the completeness of system requirements. The existing approaches do not handle requirements engineering in this manner.

8.1.6 Introduces Elements of Requirements Engineering that must be Taught to Novice Business Analysts

As the results of the Study 1 indicated, novice business analysts tended to approach the operational level staff of an organisation to acquire the requirements. They avoided meeting the top managers of the organisations, which led them to collect less strategic business requirements. It appears that they did not realise the importance of collecting strategic business requirements, nor did they realise from whom these requirements should be collected. Therefore, novices need to be trained about these three types of requirements so that they can understand what they are, how important they are and from whom they can be collected.

8.1.7 Introduces Theoretical Underpinning to Support Existing Requirements Engineering Approaches

Identification of these three types of requirements provides a base upon which these can be used to develop a requirements model. Development of a requirements model in the context of these three types of requirements will help improve the alignment between the requirements and will also improve the completeness of system requirements.

8.1.8 Provides Empirical Evidence on the Evaluation of the Framework

The existing requirements engineering literature generally adopts qualitative methods to test research artefacts. The research artefacts are often validated through qualitative feedbacks in terms of comments made by a group of subjects. Rather than adopting this subjective approach, this research adopted an objective approach to test the ESRE framework in order to provide empirical evidence on the usefulness of the framework. A powerful statistical analysis tool, IBM SPSS 19 (Argyrous 2005), was used to provide precise empirical evidence regarding the role of strategic business requirements in terms of their influence on the functional, non-functional and completeness of system requirements. Thus, this empirical evidence highlights the practicality of the framework.

8.1.9 Introduces Framework as Important Foundation to BABOK and Education for Collection of Requirements

As no framework exists in requirements engineering research that highlights the role of strategic business requirements in terms of their influence on the functional and non-functional requirements for the completeness of system requirements, novice business analysts are not well trained to recognise the difference between these requirements. Therefore, this study's framework provides a foundation upon which novices can be trained to understand strategic business requirements and their importance in relation to the completeness of system requirements.

8.1.10 Validates Approach for the Framework

The existing requirements engineering literature shows that approaches are validated by the development of models. In some cases, models are validated with feedback from experts of the domain. This is a general approach for validating research artefacts in requirements engineering research. However, rather than adopting this traditional validation approach, this research adopted a rigorous approach to validate the framework.

8.2 Research Limitations

There were some limitations to the research presented in this thesis, which are discussed below.

8.2.1 Application of the Framework to Organisation of One Size

In research, organisations are generally divided into three categories: small, medium and large. However, this framework was only applied to one medium sized organisation—Five Star—that had approximately 500 staff. The framework was not tested on small or large organisations to collect the requirements or measure the association between the various types of requirements.

8.2.2 Framework's Applicability to Different Industries

This framework was tested in a retail industy. It would be interesting to test the framework in other industries, such as finance and software, to see how the system would be developed to support other organisations' longer-term goals.

8.2.3 Focus on Particular Organisational Roles for Requirements

This research focused on 10 particular roles for the collection of requirements in Study 1: sales manager, marketing manager, store manager, direct users, suppliers, CIO, EA, accountant, business executive and business director. This research did not include other roles, such as a CEO, to determine the strategic direction of the organisation. There was the possiblity of including other roles for the collection of requirements; however, for containment reasons, only 10 roles were considered as stakeholders of the system in study 1.

8.2.4 Measuring the Effect of Completeness of System Requirements on Project Success

This research did not measure the effect of the completeness of system requirements on the project's success, despite the relationship between completeness of requirements and the success of projects. However, because various other studies have provided empirical evidence on this relationship, this research did not do so.

8.3 Future Research

The empirical research presented in this thesis is the first step towards the more extensive research needed in the requirements engineering domain. This research provides initial results regarding the usefulness of this framework, via the two studies. Further real-life projects are necessary to test the applicability of this framework in the industry. This will lead to further improvement of this framework. Research questions are described below to guide areas for future research. Answering these research questions will also help address the limitations of this research, as outlined in Section 8.2.

8.3.1 Is the Framework Applicable to Various Organisation Sizes?

Usually organisations are grouped into three sizes: large, medium and small. This research applied the framework to a medium organisation, named Five Star. This framework now also needs to be applied to small and large organisations. This will help observe whether the framework can be equivalently applied to various organisation sizes to produce similar results. It will also demonstrate whether the collection of strategic business requirements is useful across various organisation sizes. This will lead to improvement of the framework, if any weaknesses are identified.

8.3.2 Can the Framework be Mapped to the Requirements Models?

Requirements engineering approaches have developed a large number of requirements models and claimed that these have been developed in the context of enterprise strategy. An interesting topic would be to investigate whether these models map well the strategic business requirements, functional requirements and non-functional requirements of a system. It is also important to examine how complete the requirements models are with respect to the strategic business goals of the organisation.

8.3.3 Can a Software Tool be Developed to Assess the Completeness of System Requirements and Project Success?

The future work of this research could involve the development of a software tool to test the completeness of system requirements and success of the project. In alignment with the framework, this tool could accept the requirements and explain whether the framework has encompassed all three types of requirements (strategic business requirements, functional requirements and non-functional requirements). In addition, based on the data, it could calculate the completeness of the system requirements.

8.3.4 Is the Framework Suitable for Use in a Real-life Requirements Engineering Project?

The majority of requirements engineering approaches have been developed and tested in an academic setting, where approaches are developed and tested by researchers. The requirements models developed by researchers are validated by qualitative feedback from a limited number of practitioners. The current study involved practitioners and academics in the development and testing of the framework, and provided empirical evidence. The next step of this research is the application of the ESRE framework in an industry setting, where real-life stakeholders of the systems can be used for the collection of the requirements. This is a limitation of this research that could be addressed by using the framework in a real-life project.

8.3.5 Does the System Developed with the ESRE Framework Satisfy the Organisation?

The main research idea of this study was that strategic business requirements are important for the completeness of system requirements, leading to the development of a system that supports the business strategy of the organisation. Thus, it is important to know how satisfied an organisation is with the developed system. This can be a longer-term goal associated with this research, in which the system is first developed by using this framework, then the usefulness of the system is measured in terms of the satisfaction of the organisation.

8.3.6 Does this Framework Demonstrate Quantifiable Return on Investment? Is the Level of Return on Investment Compelling to Industry Stakeholders?

The existing requirements engineering approaches do not consider the completeness of system requirements and their relationship with project success. This framework expands the scope of the existing requirements engineering phenomenon and relates the collection of requirements to the completeness of system requirements, and consequently to the success of the project. This requirements engineering approach can be time consuming and costly. Whether the development of this system provides significant returns on investment is a critical question in relation to future research.

8.3.7 Do the existing requirements engineering approaches need a taxonomy of strategic business requirements.

The existing approaches address strategic business requirements in a perfunctory manner or they do not address business strategy and strategic goals at all (Bleistein 2006). Therefore, a taxonomy of strategic business requirements needs to developed to ensure that the analysts collect strategic business requirements.

References

Achour, C., Rolland, C. & Souveyet, C. 1998, 'A Proposal for Improving the Quality of the Organisation of Scenario Collections', *REFSQ'98*, Pisa, Italy.

Anderson, J., Narus, J. & Rossum, W. 2006, 'Customer Value Propositions in Business Markets', *Business Harvard Review*, vol. 84, no. 3, pp. 90-99.

Anthony, R. 1985, *Planning and Control Systems: A Framework for Analysis*, Division of Research, Graduate School of Business, Harvard University, Boston, Mass.

Anton, A. 1996, 'Goal-Based Requirements Analysis', *2nd IEEE International Conference on Requirements Engineering*, Colorado Spring, pp. 136-144.

Anton, A. & Potts, C. 1998, 'The Use of Goals to Surface Requirements for Evolving Systems ', *Proceedings of the 20th international conference on software engineering* Washington, DC, USA, pp. 157-166.

Argyrous, G. 2005, *Statistics or Research: With a Guide to SPSS*, SAGE, London.

Aspelmeier, J., Aspelmeier, J.E. & Pierce, T.W. 2009, *SPSS: A User-Friendly Approach*, W H Freeman & Co.

Avison, D., Jones, J., Powell, P. & Wilson, D. 2004, 'Using and Validating the Strategic Alignment Model', *Journal of Strategic Information Systems*, vol. 13, no. 2004, pp. 223-246.

Barone, D., Yu, E., Won, J., Jiang, L. & Mylopoulos, J. 2010, 'Enterprise Modeling for Business Intelligence', *3rd IFIP WG8.1 Working Conference on the Practice of Enterprise Modelling (PoEM2010)*, Delft, The Netherlands, pp. pp. 31-45.

Bentler, P.M. 1992, 'On the Fit of Models to Covariences and Methodology to the Bulletin', *Psychological Bulletin*, no. 112, pp. 400-404.

Bhat, J.M., Gupta, M. & Murthy, S.N. 2006, 'Overcoming Requirements Engineering Challenges: Lessons from Offshore Outsourcing', *IEEE Software*, pp. 38-43.

Birnik, A. & Moat, R. 2008, 'Developing Actionable Strategy', *Business Strategy Review*, vol. 19, no. 1, pp. 28-33.

Bishop, M. 2009, *2009 Standish Group CHAOS Report: Worst Project Failure Rate in a Decade*, 19-07-2011 <http://www.irise.com/blog/index.php/2009/06/08/2009-standish-group-chaos-report-worst-project-failure-rate-in-a-decade/>.

Bleistein, S. 2006, 'B-SCP: An Integrated Approach for Validating Alignment of Organisational IT Requirements with Competitive Business Strategy', Univeristy of New South Wales, Sydney.

Bleistein, S., Cox, K., Verner, J. & Phalp, K. 2006a, 'B-SCP: A Requirements Analysis Framework for Validating Strategic Alignment of Organizational IT Based on Strategy, Context, and Process', *Information and Software Technology*, vol. 49, no. 9, pp. 846-868.

Bleistein, S.J., Cox, K., Verner, J. & Phalp, K.T. 2006b, 'Requirements engineering for e-business advantage', *Requirements Engineering*, vol. 11, no. 1, pp. 4-16.

Bollen, K.A. 1989, *Structural Equations with Latent Variables*, New york: Wiley

Bontis, N., Crossan, M.M. & Hullanij, J. 2002, 'Managing an Organisational Learning System by Aligning Stocks and Flows', *Journal of Management Studies*, vol. 39, no. 4, pp. 437-469.

Brace, N., Kemp, R. & Snelgar, R. 2006, *SPSS for Psychologists: A Guide to Data Analysis using SPSS for Windows* 3rd edn, Palgrave Macmillan.
Bresciani, P., Perini, A., Giorgini, P., Giunchiglia, F. & Mylopoulos, J. 2004, 'Tropos: An Agent-Oriented Software Engineering Methodology', *Journal of Autonomous Agents and Multi-Agent Systems*, vol. 8, no. 3, pp. 203-236.
Briand, L.C. & Basili, V.R. 2008, 'In this Issue', *Empirical Software Engineering*, vol. 13, no. 4, pp. 339-342.
Brown, T. 2006, *Confirmatory Factor Analysis for Applied Research*, New York, Guilford.
Bryant, Fred, B., Yarnold & Paul, R. 1996, *Principal Components Analysis and Exploratory and Confirmatory Factor Analysis, In: Grimm and Yarnold, Reading and understanding multivariate analysis*, Washington, DC: American Psychological Association.
Bubenko, J.A., Roland, C., LOUCOPOULOS, P. & DEANTONELLIS 1994, 'Faciliating "Fuzzy to Formal" Requirements Modelling', *First International Conference on Requirements Engineering*, Colorado Springs, CO, USA, pp. 154-157.
Burton, L.J. & Mazerolle, S.M. 2011, 'Survey Instrument Validity Part 1: Principles of Survey Instrument Development and Validation in Athletic Training Education Research', *Athletic Training Education Journal*, vol. 6, no. 1, pp. 28-35.
Byrne, B.M. 2004, 'Testing for Multigroup Invariance using AMOS Graphics: A Road Less Traveled ', *Structural Equation Modeling: A Multidiciplinary Journal*, vol. 11, no. 2, pp. 272-300.
Carver, J., Jaccheri, L. & Morasca, S. 2003, 'Issues in Using Students in Empirical Studies in Software Engineering Education', *Proceedings of the Ninth International Software Metrics Symposium (METRICS'03)*, Sydney, Australia.
Cerpa, N. & Verner, J. 2009, 'Why Did Your Project Fail?', *Communication of ACM*, vol. 52, no. 12, pp. 130-134.
Champion, R.E.M. & Moore, T.T. 1996, 'Exploiting an Enterprise Model during Systems' Requirements Capture and Analysis', *International Conference on Requirements Engineering (ICRE'96)*, Colorado Springs, CO, pp. 208-215.
Chan, Y. & Huff, S. 1992, 'Strategy: An Information Systems Research Perspective', *Journal of Strategic Information Systems*, vol. 1, no. 4, pp. 191-204.
Chan, Y., Sabherwal, R. & Thatcher, J. 2006, 'Antecedents and Outcomes of Strategic IS Alignment: An Empirical Investigation ', *IEEE Transaction on Engineering Management* vol. 53, no. 1, pp. 27-47.
Charette, R.N. 2005, 'Why Software Fails', *IEEE Spectrum*, vol. 42, no. 9, pp. 42-49.
Chung, L. & Leite, J.C.S.d.P. 2009, 'On Non-Functional Requirements in Software Engineering', *Lecture Notes in Computer Science*, vol. Volume 5600/2009.
Chung, L. & Nixon, B.A. 2000, *Non-Functional Requirements in Software Engineering* Kluwer Academic Publisher.
Cook, J.D., Hepworth, S.J., Wall, T.D. & Warr, P.B. 1981, *The Experience of Work*, San Diego: Academic Press.
Cox, K. & Phalp, K. 2000, 'Replicating the CREWS Use Case Authoring Guidelines Experiment', *Empirical Software Engineering*, vol. 5, no. November 2000, pp. 245-267.
Creswell, J.W. 2003, *Research design: Qualitative, Quantitative, and Mixed Methods Approaches*, 2nd edn, Thousand Oaks, CA: Sage.

Damas, C., Lambeau, B., Dupont, P. & Lamsweerde, A. 2005, 'Generating Annotated Behaviour Models from End-User Scenario', *IEEE Transaction on Software Engineering*, vol. 31, no. 12, pp. 1056-1072.

Dardenne, A. & Lamsweerde, A. 1996, 'Formal Refinement Patterns for Goal-Driven Requirements Elaboration ', *Fourth ACM SIGSOFT'96*, San Francisco.

Dardenne, A., Lamsweerde, A. & Fickas, S. 1993, 'Goal-Oriented Requirements Acquisition', *Science of Computer Programming*, vol. 20, no. 1-2, pp. 3-50.

Dawes, J. 2007, 'Do Data Characteristics Change According to the Number of Scale Points Used?', *International Journal of Market Research*, vol. 50, no. 1, pp. 61-77.

Easterbrook, S., Singer, J., Storey, M.-A. & Damian, D. 2008, *Selecting Empirical Methods for Software Engineering Research*, Springer 2008.

Easterbrook, S., Yu, E., Aranda, J. & Fan, Y. 2005, 'Do Viewpoints lead to better conceptual model: An exploratory study', *13th IEEE International Conference on Requirements Engineering*.

Ellis, K. 2009, *Business Analysis Benchmark: The Impact of Business Requirements on the Success of Technology Projects*, IAG Consulting, <http://www.iag.biz/images/resources/iag%20business%20analysis%20benchmark%20-%20full%20report.pdf>.

Eriksson, H.E. & Penker, M. 2000, *Business Modeling with UML: Business Patterns at Work*, New York, John Wiley & Sons.

Espana, S., Condori-Fernandez, N., Gonzalez, A. & Pastor, O. 2009, 'Evaluating the Completeness and Granularity of Functional Requirements Specification: A Controlled Experiment', *17th IEEE International Requirements Engineering Conference*, pp. 161-170.

Espana, S., Gonzalez, A. & Pastor, O. 2009, 'Communication Analysis: A Requirements Elicitation Approach for Information System', *21st International Conference on Advanced Information Systems*, LNCS, The Netherlands.

Finkelsetin, A., Kramer, K., Nuseibeh, B., Finkelstein, L. & Goedicke, M. 1992, 'Viewpoints: A framework for integrating multiple perspectives in system development', *International Journal of Software Engineering and Knowledge Engineering*, vol. 2, no. 1, pp. 31-57.

Finkelstein, A. & Sommerville, I. 1996, 'The Viewpoints FAQ', *BCS/IEE Software Engineering Journal*, vol. 11, no. 1.

Finkelstein, C. 1992, *Information Engineering: Strategic Systems Development*, Sydney;Reading, Mass, Addison-Wesley.

Fornell, C. & Larcker, D.F. 1981, 'Evaluating Structured Equation Models with Unobservable Variables and Measurement Error', *Journal of Marketing Research*, vol. 18, pp. 39-50.

France, R. & Rumpe, B. 2007, 'Model-driven Development of Complex Software: A Research Roadmap', *Proceeding FOSE '07 2007 Future of Software Engineering* pp. 37-54.

Freeman, R.E. 1984, *Strategic Management A Stakeholder Approach*, Pitman, Boston.

Galorath, D. 2008, *Software Project Failure Costs Billions.. Better Estimation & Planning Can Help*, viewed 19-07-2011 <http://www.galorath.com/wp/software-project-failure-costs-billions-better-estimation-planning-can-help.php>.

Glass, R.L. 2006, 'The Standish Report: Does It Really Describe a Software Crisis', *Communications of the ACM*, vol. 49, no. 8, pp. 15-16.

Glinz, M. & Wieringa, R.J. 2007, 'Stakeholders in Requirements Engineering, Guest Editor's Introduction', *IEEE Software*, vol. 24, no. 2, pp. 18-20.
Godet, P.M. 2001, *Creating Futures: Scenario Planning as a Strategic Management Tool*, Economica, London.
Gordijn, J. & Akkermans, H. 2003a, 'Value Based Requirements Engineering: Exploring Innovative e-Commerce Ideas', *Requirements Engineering*, vol. 8, no. 2, pp. 114-135.
Gordijn, J. & Akkermans, J. 2003b, 'Value-Based Requirements Engineering: Exploring Innovative Ecommerce Ideas', *Requirements Engineering Journal*, vol. 8, no. 2, pp. 114-134.
Gough, P.A., Fodemski, F.T., Higgins, S.A. & Ray, S.J. 1995, 'Scenarios - An Industrial Case Study and Hypermedia Enhancement', paper presented to the *Requirements Engineering, 1995., Proceedings of the Second IEEE International Symposium on*, 27-29 March
Guba, E.G. & Lincoln, Y.S. 1994, *Competing the Paradigms in Qualitative Research: A Handbook of Qualitative Research*, Sage Publication, London.
Hammer, T.F., Huffman, L.L., Rosenberg, L.H. & Leonore, L. 1998, 'Doing Requirements Right the First Time', *Crosstalk Journal of Defence Software Engineering*, pp. 20-25.
Henderson, J.C. & Venkatraman, N. 1993, 'Strategic Alignment: Leveraging Information Technology for Transforming Organisations', *IBM Sys Journal* vol. 38, no. 2, pp. 472-484.
Hinkin, T.R. 1995, 'A Review of Scale Development Practices in the Study of Organisations ', *Journal of Management*, vol. 21, no. 5, pp. 967-988.
Hinkin, T.R. & Schriesheim, C.A. 1989, 'Development and Application of New Scales to Measure the French and Raven (1959) Bases of Social Power.', *Journal of Applied Psychology*, vol. 74, no. 4, pp. 561-567.
Horkoff, J. 2006, 'Using i* Models for Evaluation', Master's thesis, University of Toronto, Computer Science Department, Toronto.
Host, M., Regnell, B. & Wohlin, C. 2000, 'Using students as Subjects: A Comparative Study of Students and Professionals in Lead-Time Impact Assessment', *Empirical Software Engineering*, vol. 5, no. 3, pp. 201-214.
Humphrey, W.S. 2000, *A Discipline for Software Engineering*, 9 edn, Addison-Wesley, NY.
Ivari, J. 1986, 'Dimensons of Information Systems Design: A Framework for a Long Range Research Program', *Information Systems Journal*, vol. June.
Jackson, M. 2001, *Problem Frames: analysing and Structuring Software Development Problem*, Addison-Wesley, MA.
Jackson, M. & Zave, P. 1995, 'Deriving Specifications from Requirements: An Example', *ICSE '95*, Seattle, Washington USA.
Jacobson, I. 1992, *Object-Oriented Software Engineering: A Use Case Driven Approach*, ACM press.
Jarke, M., Bui, X.T. & Carroll, J.M. 1998, 'Scenario Management: An Interdisciplinary Approach', *Requirements Engineering*, vol. 3, no. 3-4, pp. 155-173.
Jorgensen, M. & Molokken-Ostvold, K. 1997, 'How Large are Software Cost Overrun? A Review of the 1994 CHAOS Report', *Information and Software Technology*, vol. 48, no. 4, pp. 297-301.

Jr., H.B. & Goodstein, L.D. 1996, 'Measuring Customer Value: Gaining the Strategic Advantage', *Organisational Dynamics*, vol. 24, no. Winter, pp. 63-77.
Kamata, M.I. & Tamai, T. 2007, 'How Does Requirements Quality Relate to Project Success or Failure?', *15th IEEE International Requirements Engineering Conference*, pp. 69-78.
Kaplan, R.S. & Norton, D.P. 2004, *Strategy Maps: Converting Intangible Assets into Tangible Outcomes*, 2004 edn, Harvard Business School Publishing Corporation.
Kavakli, E. & Loucopoulos, P. 1996, 'Goal-Driven Business Process Analysis Application in Electricity Deregulation', *Information systems*, vol. 24, no. 3, pp. 187-207.
Kavakli, E. & Loucopoulos, P. 2003, 'Goal Driven Requirements Engineering: Evaluation of Current Methods', *Proceedings of 8th CAiSE/IFIP*, Nicosia, Cyprus, pp. 1339 - 1343
Kearns, G. & Sabherwal, R. 2007, 'Antecedents and Consequences of Information Systems Planning Integration', *IEEE Transactions on Engineering Management*, vol. 54, no. 4, pp. 628-643.
Kearns, G.S. & Sabherwal, R. 2006-7, 'Strategic Alignment Between Business and Information Technology: A Knowledge-Based View of Behaviors, Outcome, and Consequences', *Journal of Management Information Systems / Winter 2006–7*, vol. 23, p. 3.
Kenny, D.A. 1979, *Correlation and Causality*, New York: Wiley.
Kitchenham, B.A. & Pfleeger, S.L. 2002a, 'Principles of Survey Research Part 4: Questionnaire Evaluation', *Software Engineering Notes*, vol. 27, no. 3, pp. 20-23.
Kitchenham, B.A. & Pfleeger, S.L. 2002b, 'Principles of Survey Research Part: 3 Constructing a Survey Instrument', *Software Engineering Notes*, vol. 27, no. 2, pp. 20-24.
Kitchenham, B.A., Pfleeger, S.L., Pickard, L.M., Jones, P.W., Hoaglin, D.C., Emam, K.E. & Rosenberg, J. 2002, 'Preliminary Guidelines for Empirical Research in Software Engineering', *IEEE Trans. Software Engineering*, vol. 28, no. 8, pp. 721-733.
Krigsman, M. 2009, *Worldwide cost of IT failure: $6.2 trillion*, viewed 19-07-2011 <http://www.zdnet.com/blog/projectfailures/critique-62-trillion-global-it-failure-stats/7695?tag=mantle_skin;content>.
Lamsweerde, A. 2000, 'Requirements Engineering in the Year 00: A Research Perspective ', *ICSE 2000*, Limerick, Ireland, pp. 5-19.
Lamsweerde, A. 2004, 'Goal-Oriented Requirements Engineering: A Roundtrip from Research to Practice', *12th IEEE International Requirements Engineering Conference (RE'04)*, Kyoto, Japan, pp. 4-7.
Lamsweerde, A. 2009, 'Goal Models as Architectural Knowledge', *Proceedings of the 3rd International Workshop on Sharing and Reusing Architectural Knowledge*, Leipzig, Germany, pp. 1-2.
Lamsweerde, A. & Letier, E. 2000, 'Handling Obstacles in Goal-Oriented Requirements Engineering', *20th International Conference on Software Engineering*, Kyoto, Japan, pp. 1-29.
Lamsweerde, A.v. 2001, 'Goal-Oriented Requirements Engineering: A Guided Tour', *In: Proceedings of the 5th IEEE international Symposium on Requirements Engineering*, Washington, p. 249.

Lei, D. & John W. Slocum, J. 2005, 'Strategic and Organisational Requirements for Competitive Advantage', *Academy of Management Executives*, vol. 19, no. 1, pp. 31-45.
Libin, R. 2009, 'It's More Than Just Selling', *Ward's Dealer Business*, vol. 43, no. 9, pp. 34-34.
Little, R.J.A. 1988, 'A Test of Missing Completely at Random for Multivariate Data with Missing Values', *Journal of American Statistical Association*, vol. 83, no. 404, pp. 1198-1202.
Loehlin, J.C. 2004, *Latent Variable Models: An Introductuon to FActor, Path, and Structured Analysis*, 4th edn, Mahwah, NJ, Erlbaum.
Loucopoulos, P. 2003, 'The S3 (Strategy-Service-Support) Framework for Business Process Modelling. IN EDER, J., MITTERMEIR, R. & PERNICI, B. (Eds.)', *Workshop on Requirements Engineering for Business Process Support (REBPS'03)*, Klagenfurt/Velden, Austria, pp. 378-372.
Luftman, J. 2000, 'Assessing Business-IT alignment Maturity', *Communications of the Association for Information Systems* vol. 4, no. 14, pp. 1-50.
Luftman, J. & Brier, T. 1999, 'Achieving and Sustaining Business-IT Alignment', *California Management review*, vol. 42, no. 1, pp. 109 - 122.
Marx, M. 2008, 'Project Failure', *iSixSigma Magazine*, vol. 4, no. 6, pp. 1-6.
Medsker, G.J., Williams, L.J. & Holahan, P.J. 1994, 'A Review of Current Practices for Evaluating Causal Models in Organisaitonal Behaviour and Human Resources Management Research', *Journal of Management*, vol. 20, no. 2, pp. 43-464.
Menzel, I., Mueller, M., Gross, A. & Doerr, J. 2010, 'An Experimental Comparison Regarding the Completeness of Functional Requirements Specification ', paper presented to the *18th IEEE International Requirements Engineering Conference*.
Mertens, D.M. 1998, *Research Methods in Education and Psychology: Integrating Diversity with Quantitative & Qualitative Approaches*, Thousand Oaks, Calif: Sage.
Meyers, L.S., Gamst, G. & Guarino, A.J. 2006, *Applied Multivariate Research: Design and Interpretation*, SAGE Publication, London.
Moody, D.L., Sindre, G., Brasethvik, T. & Solvberg, A. 2003, 'Evaluating the Quality of Information Models: Empirical Testing of a Conceptual Model Quality Framework', *25th International Conference on Software Engineering (ICSE 2003)*, pp. 295-305.
Mylopolous, J., Chung, J. & Nixon, B. 1992, 'Representing and Using Non-Functional Requirements: A Process-Oriented Approach', *IEEE Transaction on Software Engineering* vol. 18, no. 6, pp. 483-497.
Mylopoulos, J., Chung, L., Liao, S., Wang, H. & Yu, E. 2001, 'Exploring Alternatives during Requirements Analysis', *IEEE Software*, vol. 18, no. 1, pp. 92-96.
Myrtveit, I., Stensrud, E. & Olsson, U.H. 2001, 'Analysing Data Sets with Missing Data: An Empirical Evaluation of Imputation Methods and Likelihood-Based Methods ', *IEEE Trans. Software Engineering*, vol. 27, no. 11, pp. 999-1013.
Nevo, S. & Wade, M.R. 2010, 'The Formation and Value of IT-Enabled Resources: Antecedents and Cosequences of Synergistic Relationships', *MIS Quarterly*, vol. 34, no. 1, pp. 163-183.
Nunnally, J.C. 1976, *Psychometric Theory*, 2nd edn, New York: McGraw-Hill.
Nurcan, S., Etien, A., Kaabi, R., Zoukar, I. & Rolland, C. 2005, 'A Strategy Driven Business Process Modelling Approach', *Business Process Management* vol. 11, no. 6, pp. 628-649.

Nustini, Y. 2006, 'Determinants of a Sustainable Competitive Advantage due to an IT-enabled Strategy', *Jurnal Siasat Bisnis*, vol. 11, no. 1, pp. 21-36.
Ould, M.A. 1995, *Business Processes: Modelling and Analysis for Re-engineering and Improvement*, Wiley, Chichester, New York.
Pallant, J. 2011, *SPSS Survival Manual: A Step by Step Guide to Data Analysis Using the SPSS* Buckingham: Open University Press.
Parasuraman, A. 1997, 'Reflections on Gaining Competitive Advantage Through Customer Value', *Journal of the Academy of Marketing Science*, vol. 25, no. 2, pp. 154-161.
Pfleeger, S.L. & Kitchenham, B.A. 2002, 'Principles of Survey Research Part 1: Turning Lemons into Lemonade', *Software Engineering*, vol. 26, no. 6, pp. 16-18.
Porter, M. & Millar, V. 1985, 'How Information Gives you Competiitve Advantage', *Harverd Business Review*, vol. 63, no. 4, pp. 149 -160.
Postmaa, T.J.B.M. & Lieblb, F. 2005, 'How to Improve Scenario Analysis as a Strategic Management Tool?', *Technological Forecasting & Social Change*, vol. 72, no. 2005, pp. 161-173.
Potts, C., Takahashi, K. & Anton, A. 1994, *Inquiry-Based Scenario Analysis of System Requirements*.
Ravichandran, T. & Lertwongsatien, C. 2005, 'Effect of Information Resources and Capabilities on Firm Performance: A Resource Based Perspective', *Journal of Management Information Systems*, vol. 21, no. 4, pp. 237-276.
Ray, G., Barney, J.B. & Muhanna, W.A. 2004, 'Capabilities, Business Processes and Competitive Advantage: Choosing the Dependent Variable in Empirical Tests of the Resource-Based View', *Strategic Management Journal*, vol. 25, no. 1, pp. 23-37.
Rescher, N. 1977, *Methdological Pragmatism: Systems-Theoretic Approach to the Theory of Knowledge*, Oxford: Basil Blackwell.
Roland, C., Souveyet, C. & Achour, C.B. 1998, 'Guiding Goal Modelling Using Scenarios ', *IEEE Transaction on Software Engineering*, vol. 24, no. 12, pp. 1055-1071.
Rolland, C. & Grosz, G. 1999, 'Experience with Goal-Scenario Coupling in Requirements Engineering', *IEEE 4th International Symposium on Requirements Engineering*, Limerick, Ireland.
Rolland, C. & Salinesi, C. 2005, 'Modeling Goals and Reasoning with Them', in, *Engineering and Managing Software Requirements* Springer Berlin Heidelberg, pp. 189-217.
Rolland, C. & Salinesi, C. 2009, *Supporting Requirements Elicitation through Goal/Scenario Coupling*, Springer Berlin / Heidelberg.
Ross, D.T. & Schoman, K.E. 1977, 'Structured Analysis for Requirements Definition', *IEEE Trans. Software Engineering*, vol. 3, no. 1, pp. 6-15.
Rosson, M.B. & Carroll, J.M. 2002, *Scenario-Based Design*, Lawrence Erlbaum Associates.
Samavi, R., Yu, E. & Topaloglou, T. 2009, 'Strategic Reasoning about Business Models: A Conceptual Modeling Approach', *Info System E-business Management* vol. 7, no. 2, pp. 171-198.
Schmitt, N.W. & Stults, D.M. 1985, 'Factors Defined by Negatively Keyed items: The Results of Careless Respondents?', *Applied Psychological Measurement*, vol. 9, pp. 367-373.

Schriesheim, C.A. & Eisenbach, R.J. 1991, 'Item Wording Effects on Exploratory Factor-Analytic Results: An Experimental Investigation', *Pp. 396-398 in Proceedings of the 1990 Southern Management Association annual meetings.*

Schwarz, A., Kilika, M., Kefi, H. & Schwarz, C. 2010, 'A Dynamic Capabilities Approach to Understanding the Impact of IT-Enabled Businesses Processes and IT-Business Alignment on the Strategic and Operational Performance of the Firm', *Communication of AIS*, vol. 26, no. 4, pp. 57-84.

Selic, B. 2003, 'The Pragmatics of Model-Driven Development', *IEEE Software*, vol. 20, no. 5, pp. 19-25.

Shaffer, P.A., Vogel, D.L. & Wei, M. 2006, 'The Mediating Roles of Anticipated Risks, Anticipated Benefits and Attitudes on the Decision to Seek Professional Help: An Attachement Perspective', *Journal of Counseling Psychology*, vol. 53, no. 4, pp. 442-453.

Sharp, H., Galal, G.H. & Finkelstein, A. 1999, 'Stakeholder Identification in the Requirements Engineering Process', *Proc. 10th Int'l Workshop Database and Expert System Applications, IEEE CS Press*, pp. 387-391.

Sim˜ao, R.e.P.S. & Belchior, A.D. 2003, 'Quality Characteristics for Software Components: Hierarchy and Quality Guides', *Component-Based Software Quality, LNCS 2693*, pp. 184–206.

Singh, S.N. & Woo, C. 2009, 'Investigating Business IT alignment Through Multi-disciplinary Goal Concepts', *Requirements Engineering Journal*, vol. 14, no. 3, pp. 177-207.

Sjoberg, D.I.K., Anda, B., Arisholm, E., T. Dyba, T., Jorgensen, M., Karahasanovic, A., Koren, E.F. & Vokac, M. 2002, 'Conducting Realistic Experiments in Software Engineering', *Empirical Software Engineering, 2002. Proceedings. 2002 International Symposium*.

Sjoberg, D.I.K., Hannay, J.E., Hansen, O., Kampenes, V.B., Karahasanovic, A., Liborg, N.-K. & Rekdal, A.C. 2005, 'A Survey of Controlled Experiments in Software Engineering', *IEEE Trans. Software Engineering*, vol. 31, no. 9, pp. 733-752.

Sommerville, I. & Ransom, J. 2005, 'An Empirical Study of Industrial Requirements Engineering Process Assessment and Improvement', *ACM Transactions on Software Engineering Methodology* vol. 14, no. 1, pp. 85-117.

Sommerville, I. & Sawyer, P. 1997, 'Viewpoints: principles, problems, and a practical appraoch to requirements engineering', *Annals of Software Engineering*, vol. 3, no. 1997, pp. 101-130.

Stafford, J. 2009, *Why Software Projects Fail and More will Fail in 2009*, viewed 29-07-2011 <http://itknowledgeexchange.techtarget.com/software-quality/why-software-projects-fail-and-more-will-fail-in-2009/>.

Straub, D.W. 1989, 'Validating Instruments in MIS Research', *MIS Quarterly*, vol. 13, no. 2, pp. 147-169.

Sutcliffs, A. 2003, 'Scenario-Based Requirements Engineering ', *11th IEEE International Requirements Engineering Conference* Monterey California, pp. 320-329.

Tajfel, H. 1982, *Social Identity and Intergroup Relations*, Cambridge University Press.

Tallon, P.P. 2008, 'A Process-Oriented Perspective on the Alignment of Information Technology and Business Strategy', *Journal of Management Information Systems*, vol. 24, no. 3, pp. 227-268.

Thevenet, L.-H. & Salinesi, C. 2007, 'Aligning IS to Organisation's Strategy: The InStAl Method', *CAiSE* pp. 203-217.
Velcu, O. 2010, 'Strategic Alignment of ERP Implementation Stages: An Empirical Investigation', *Information & Management*, vol. 47, no. 2010, pp. 158-166.
Verner, J., Cox, K. & Bleisten, S. 2005, 'Requirements Engineering and Software Project Success: An Industrial Survey in Australia and US.', *AJIS*, vol. 13, no. 1, pp. 225-238.
Walsham, G. 1993, *Interpreting Information Systems in Organisations*, Wiley, Chichester.
Wieringa, R.J. & Heerkens, J.M.G. 2004, 'Evaluating the Structure of Research Papers: A Case study ', *Second International Workshop in Comparative Evaluation of Requirements Engineering*, IEEE Press, Kyoto, Japan, pp. 41-50.
Wieringa, R.j. & Heerkens, J.M.G. 2006, 'The Methodological Soundness of Requirements Engineering Papers: A Conceptual Framework and Two Case Studies', *Requirements Engineering Journal*, vol. 11, no. 4, pp. 295-307.
Wohlin, C., Runeson, P., Höst, M., Ohlsson, M., Regnell, B. & Wesslén, A. 2000, *Experimentation in Software Engineering: An Introduction*, Springer.
Wohlin, C. & Wesslen, A. 1998, 'Understanding software defect detection in the Personal Software Process ', *Software Reliability Engineering, 1998. Proceedings. The Ninth International Symposium on*, Paderborn , Germany pp. 49-58.
Woodruff, R.B. 1997, 'Customer Value: The Next Source for Competitive Advantage', *Journal of the Academy of Marketing Science* vol. 25, no. 2, pp. 139-154.
Yu, E. 1993, 'Modelling Organisations for Information Systems Requirements Engineering', *IEEE International Symposium on Requirements Engineering*, San Diego, CA, USA, pp. 34 - 41.
Yu, E. 1995, 'Modelling Strategic Relationships for Process Engineering', PhD thesis, University of Toronto, Computer Science Department, Toronto.
Yu, E. 1997, 'Towards Modelling and Reasoning Support for Early-Phase Requirements Engineering', *Proceedings of the 3rd IEEE International Symposium on Requirements Engineering*, Annapolis, USA, pp. 226-235.
Yu, E. 2009, 'Social Modeling and i*', in, *LNCS*, vol. 5600/2009, Springer Berlin / Heidelberg, pp. 99-121.
Yu, E. & Mylopoulos, J. 1997, 'Modelling Organizational Issues for Enterprise Integration', *Proceedings of International Conference on Enterprise Integration and Modelling Technology*, Turin, Italy, pp. 28-30.
Yu, E., Strohmaier, M. & Deng, X. 2006, 'Exploring Intentional Modeling and Analysis for Enterprise Architecture', paper presented to the *10th IEEE International Enterprise Distributed Object Computing Conference Workshops (EDOCW'06)*, Hong Kong, China, pp. 32.
Yue, K. 1987, 'What Does it Mean to Say that a Specification is Complete? ', *Proc. of IWSSD-4*, Monterey.
Zave, P. 1997, 'Classification of Research Efforts in Requirements Engineering', *ACM Computing Surveys*, vol. 29, no. 4, pp. 315-321.

Appendix A: Five Star business scenario

A "Five Star" multinational company is using IT to dramatically change many aspects of the way retailing is done. Five Stars focuses on four aspects: pricing and merchandising, reducing operating cost, using information technology and strategic site selection. Through this strategy Five Star is keen to achieve double digit profitability target and shareholder value. After 17 years of sustained growth in sales and profit, Five Star shows no intention of slowing its expansion. Since its creation the company has achieved one of the highest returns on equity in the industry. Since 2007 sales for Five Star have been exceeding those of its parent company and wants rapid increase in sale.

Business performance target of Five Star is to achieve total sales in Australia in excess of the sales of all Australian retail stores which aligned with Five stars' mission. For that Five stars wants to pursue top quality control beyond conventional standards through which Five stars would be responding to customers' diverse needs by supplying items worthy of customer expectations. Five Stars is keen to dominant the market through distribution and logistics efficiency, operation and information systems effectiveness, franchise support efficiency and corporate image. For effective customer service and better inventory control *Five Star* wants from their suppliers to deliver the products that were in demand on a just-in-time basis, thereby eliminating dead and slow selling items and replacing them by the faster selling one. It also includes high quality products and service to the customers with competitive price.

Cost reduction strategy is to find the best way for each store to control inventory. In particular, attention has been given to avoid non-availability – that is losing a sale because something is out of stock. The company needs to not simply identify what particular products customers like but more importantly the company should accurately determine when, where and in which quantities and at which price these products are needed. Product ordering is the most constructive part of retail business. To address the rapid changes in the compositions of customer demands and long queues *Five Star* wants an efficient ordering system which can also help to solve excess inventory problems. In a retail shop the items kept in stock and on the shelf are precisely selected for the targeted customers and the

products quality is kept high. Stores hold that right amount of stock for those selling items. To provide value-added services Five Star started a home delivery parcel service as well in cooperation with large transportation company.

Appendix B: 10 viewpoints from the business scenario

1. Sales Manager viewpoint

In retail business, pricing and merchandising strategies include efforts to sell more imported and private-label products because both types of products have been accounted for major portion to the firm's sales. It also includes high quality products and service to the customers with competitive price.

Cost reduction strategy is to find the best way for each store to control inventory. In particular, attention has been given to avoid non-availability – that is losing a sale because something is out of stock. A missed opportunity to sell an item because it is sold out is believed to represent up to three times the value of the actually realized profit. The company needs to not simply identify what particular products customers like but more importantly the company should accurately determine when, where and in which quantities and at which price these products are needed.

Product ordering is the most constructive part of retail business. To address the rapid changes in the compositions of customer demands and long queues *Five Star* wants an efficient ordering system which can also help to solve excess inventory problems.

2. Marketing Manager viewpoint

Since the customer demands for more variety, are changing rapidly in retail industry, for quick and effective response *Five Star* needs to constantly monitor customer needs and desires. In this regard the company collects customer profile data – age group and gender on continuous basis at the counter of their stores. The company needs to not simply identify what particular products customers like but more importantly we should accurately determine when, where and in which quantities and at which price these products are needed. Therefore, company believes that reviewing the data on continuous basis can help

to deliver the products and services on-time as well as to forecast customers demand weeks ahead in a larger context through analysis and estimation. Five Star targets all the individuals living or working in the vicinity of the store. A new store will open only if there is enough population density within the area and no direct competition. The primary segmentation is therefore by geography. Then the customers can be classified into according to three shopping habits:

1. *Immediate consumption.* These are mainly young people often single who want to buy typical items for instant consumption.
2. *Daily and distress.* There are customers who make distress purchase or buy daily supplies.
3. *One stop shopping.* These are the customers who typically like to all their shopping in their neighborhood store.

3. Direct user viewpoint

In a retail shop the items kept in stock and on the shelf are precisely selected for the targeted customers and the product quality is kept high. Five Star discovered that customer loyalty was driven more by specific items than by item categories. The implication was that the Five Star needed to plan demands and deliver on an item-by-item basis. Stores hold that right amount of stock for those selling items. Since the product turnover is high the goods to be always new and fresh. To address the rapid changes in the compositions of customer demands and long queues *Five Star* wants an efficient ordering system which can also help to solve excess inventory problems. To provide value-added services Five Star started a home delivery parcel service as well in cooperation with large transportation company.

4. Supplier viewpoint

Customers of the retail giant are ready to pay a premium for freshness, quality of products and convenience. Simplest way of achieving such targets is to keep to large inventories of a wide range of products. Unfortunately this solution could not be applied in retail stores where shelf and storage space are limited. Five Stars pursued a strategy of supplying products that were in demand on a just-in-time basis. In this regard Five Star expects from

the suppliers to develop a combined delivery centre whereby the same kind of products coming from different suppliers can be centralized in a combined delivery centre. The benefit is that it involves fewer deliveries from the producers to the wholesalers. Five stars started home delivery service in cooperation with their suppliers to meet their customer service level.

5. Store manager viewpoint

Serving as safe and secure community base Five Star work to prevent underage sale of liquor and cigarettes by clearly labeling sales areas and checking customer's age at the counter. It is Five Star duty as a member of local community to care for the environment and contribute to a sound upbringing of young customers. In addition, to providing products and services Five Star stores are open 24 hours a day, 365 days a year making them ideal as bases able to serve the general public in case of emergency by supporting such service as responding to children calls.

6. Chief Information Officer (CIO) viewpoint

A "Five Star" multinational company is using IT to dramatically change many aspects of the way retailing is done. In surveys customers have typically complaint about: (1) the products they were looking for being sold, (2) the long waiting lines at the cashiers, the store being closed when they needed the service and product freshness. In new strategy, Five Star focuses on four aspects: pricing and merchandising, reducing operating cost, using information technology and strategic site selection. Through this strategy Five Star is keen to achieve double digit profitability target and shareholder value.

7. Accountant viewpoint

Five Star is concerned with providing financial and other information to the management to enable them to carry out their planning. A look at average store sales at Five Star and its direct competitors show average daily sale $20,000 to $9800 of the industry average. After 17 years of sustained growth in sales and profit, Five Star shows no intention of slowing its expansion. Since its creation the company has achieved one of the highest returns on equity

in the industry. Since 2007 sales for Five Star have been exceeding those of its parent company. The same year Five Star net income became the largest in the retail industry and is still number one. The market is rapidly saturating as competition intensifies. Since 2000 the number of retail stores has multiplied 20-fold with one store for approximately 2000 people. Can Five Star sustain its advantage? Is it time for aggressive international expansion? Management needs to do cost benefit analysis.

8. Enterprise Architect viewpoint

Five Star intends to use IT for its unique competitive situation, retail industry and corporate objectives for which the company want to link software systems with the overall management goals. Business performance target of Five Star is to achieve total sales in Australia in excess of the sales of all Australian retail stores which aligned with Five star's mission. For that Five star wants to pursue top quality control beyond conventional standards through which Five star would be responding to customers' diverse needs by supplying items worthy of customer expectations. Five Star is keen to dominant the market through distribution and logistic efficiency, operation and information systems effectiveness, franchise support efficiency and corporate image. For effective customer service and better inventory control *Five Star* wants from their suppliers to deliver the products that were in demand on a just-in-time basis, thereby eliminating dead and slow selling items and replacing them by the faster selling one. In this regard Five Star wants to have superior distribution and logistics efficiency through a combined delivery system. This would represent revolution for the suppliers whose products were traditionally delivered separately through exclusive channels however in this way there would be fewer deliveries from the producers and wholesale dealers.

9. Business executive viewpoint

In the last decade the Five Star has shown sustained growth in sales and profits and the retail giant has no intention of slowing its expansion. Since its creation the company has achieved one of the highest returns on equity in the industry testifying to its performance of its outsourcing principles. Five Star net income has become the largest in the retail industry and They have a target of net sale more than the total sale of all other stores. In new

strategy some of aspects which have been given the attention are pricing and merchandising, reducing operating cost and strategic site selection.

10. Business director viewpoint

A "Five Star" multinational company is using IT to dramatically change many aspects of the way retailing is done. Five Stars focuses on four aspects: pricing and merchandising, reducing operating cost, using information technology and strategic site selection. Through this strategy the organization is keen to achieve double digit profitability target and massive shareholder value. After many years of sustained growth in sales and profit, the firm shows no intention of slowing its expansion. Since its creation the company has achieved one of the highest returns on equity in the industry. Since 2007 sales for Five Star have been exceeding those of its parent company and wants rapid increase in sale.

Appendix C: Requirements lists collected from group-A stakeholders

Requirements list 1
- Improve shareholder value. - Top quality control. - Provide efficient information related to logistics and distribution. - Provide accurate information related to delivery. - Double the growth
Requirements list 2
- Optimize operational cost. - Keep and share up-to-date inventory information with supplier. - Just-in-time deliveries. - A combined delivery system, in which products are delivered from single warehouse. - Open up new stores.
Requirements list 3
- Increase shares of the company. - Target new markets. - Review alliances and partnerships. - Create new alliances. - Review merging options.
Requirements list 4
- Ecommerce strategy. - Online business strategy. - Reduce operational cost. - Improve service quality.

- Improve customer satisfaction.
Requirements list 5
- Improve relationships with partners. - Improve understanding of the future of the business market. - Use IT to support firm's global strategy. - Enhance communication with the customers.
Requirements list 6
- Double digit growth increase - Increase dividend. - Improve business performance locally and globally. - Cost conscious purchasing and resourcing. - Analyse customer buying pattern.
Requirements list 7
- Need to understand changing government policies. - Create economic evaluation bodies. - Reduce cost of the operations. - Develop knowledge management system. - Develop resource centre. - Forecast customers buying pattern. - Achieve profitability target. - Customer satisfaction index. - Increase in sale targets.
Requirements list 8
- Enhance leadership qualities - Increase organizational capabilities. - Capture the ideas of customers who are continuously interacted with the markets. - Develop innovative business ideas
Requirements list 9
- IT should show leadership qualities.

- Increase global business performance. - Increase market shares. - Increase productivity. - Five Star wants to expand the business.
Requirements list 10
- Develop strong customer relationships. - Enhance customer value proposition. - Exceed customer expectations. - Increase revenue growth. - Inventory control.
Requirements list 11
- Improve operational capabilities such as data, infrastructure and networks. - Develop strong vendor management. - Enhance global service quality - Develop high performance organization. - Enhance customer relationship
Requirements list 12
- Develop market leadership. - Innovate to grow. - Fresh perspective to improve core business. - Build strong capabilities on strong foundation. - Explore possibilities to derive business forward. - Expand globally. - Infrastructure support
Requirements list 13
- Deliver superior value through high standard operations. - Adopt best in class practices. - Enhance customer experience. - Improve operational performance to fund growth. - New customer base.

Requirements list 14
- Develop 5-10 years growth plan. - Predict changes and trends in the business world. - Identify the threats to the business. - Understand market trends. - Deliver new products and services.
Requirements list 15
- Identify competitors of this business. - Manage inventory system. - Just-in-time delivery system. - Develop combined delivery system. - Acquisition approach.
Requirements list 16
- Reduce IT cost. - Improve infrastructure outsourcing. - Enhanced sourcing model, sourcing commodity services from off shore. - Increased use of virtual technologies. - Partnership with other companies
Requirements list 17
- A business-focused IT infrastructure. - Develop flexible business environment. - Increase speed to market. - New products and services.
Requirements list 18
- Develop a risk control system. - Enhance production rate. - Around the clock services. - Online services.
Requirements list 19
- Increase stores in the market.

- Enhance IT infra structure. - New product line. - Operational efficiency
Requirements list 20
- Provide customer service on their demand. - Integration of new products and acquisitions. - Control inventory store in real time. - Develop a system track customers' buying pattern. - Enhance operational excellence.
Requirements list 21
- Deliver products and services on time. - Identify cost effective outsourcing opportunities. - Provide stock ordering decision support system.
Requirements list 22
- Provide efficient services to the customers. - Reduced maintenance costs and environmental impact. - Develop business knowledge centre. - Use business intelligence. - Increase market shares.
Requirements list 23
- Provide competitive products and services to the customers. - Identify business opportunities from the changes in the market. - Increase sale. - Economical purchasing decisions. - Increase customer satisfaction. - New user friendly system.
Requirements list 24
- Improve cost structure. - Better control over finances of the firm. - Online strategy.

- Increase revenue growth - Develop the culture of using analytics. - Enhance customer relationships.

Appendix D: Requirements lists from group-B stakeholders

Requirements list 1
- Scan products. - Enter customer profile data. - Excellent delivery system. - Take orders from customers. - Prepare orders for delivery.
Requirements list 2
- Develop customer feedback system. - Identify appropriate communication channels. - Develop IT skills necessary for the new systems. - High level of data integrity. - Maintain security of the data.
Requirements list 3
- Better customer inventory management system. - Deliver value added services to the customers. - Support professional education. - More efficient communication system.
Requirements list 4
- Enhance communication among the staff. - Define short term goals. - Coordinate supply chain with EDI system. - Forecast consumer demand.
Requirements list 5

- Reduce lost opportunity at the store. - Minimize unsold perishables. - Introduce promotions in the stores. - Communicate promotion with the customers. - Continuously develop predictive model.
Requirements list 6
- Enhance procurement system. - Enhance delivery system. - Manage inventory system. - Maximize the use of the floor space. - Just-in-time delivery.
Requirements list 7
- Product administration enhancements - Enhanced front-ends and product administration - Improve order processing. - Process automation. - Improve image of the company. - Increase market shares.
Requirements list 8
- Collect customer profile. - Enhance security of the profile data. - Secure network data transmission. - Create customer accounts. - Around the clock accessibility. - Manage customer inquiries.
Requirements list 9
- Share knowledge. - Develop knowledge centre. - Easy accessibility to the data. - Develop customer feedback system.

- Reduce employee training cost.
Requirements list 10
- Connect target registry system to hub. - Separate processes and front-end from core systems. - Multiple user interfaces - Move duplicate functionality into reusable services. - Customer retention.
Requirements list 11
- Provide central access to the information. - Separate core registry systems from business users. - Provide identifiers to the customers. - Share knowledge across the departments. - Build common customer identifier across products.
Requirements list 12
- Consolidate duplicate functions. - Reduce reliance on legacy system. - Consolidate front-ends to improve staff productivity. - Enhance scalability of the systems. - Improve accessibility to the system. - 24/7 accessibility to the ordering system
Requirements list 13
- Provide online ordering system. - Use various channels for marketing. - Follow customers' buying pattern. - Enhance communication with customers. - One stop shopping for the customers.
Requirements list 14
- Special event based sale opportunities. - Define sales targets - Conduct risk analysis.

- Offer promotions to the customers. - Use various means to access customers. - The customers need to be informed.
Requirements list 15
- Process payment rapidly. - Keep the systems available 24/7. - Order the items out of stock. - Provide efficient services to the customers. - Delivery quick services
Requirements list 16
- Manage online order taking system. - Handle the cash with safety. - Generate stock order recommendation. - Privacy of the customer data. - Conduct risk analysis.
Requirements list 17
- Collect customer data. - Collect customer purchase data. - Transmit data to the back-end system. - Use scanners to remit the data. - Manage customer data. - Analyse data. - Forecast customer demands.
Requirements list 18
- Offer products to the customers online. - Get customer attention. - Increase growth value. - Customer decides on the offer. - Salesperson contacts the customer. - Deliver the product.

- Expand the organization.
Requirements list 19
- Understand customer needs and desires. - Collect customer age and gender based information. - Review customer data continuous basis. - Ensure timely product and service delivery. - Identify need for opening up new store. - Increase productivity. - Open up new stores. - Expand the organization with new stores.
Requirements list 20
- One stop shopping place. - Make purchase easy for customers. - Evaluate competitors in the market. - Provide variety of products and services - Increase sale by double. - New customer market.
Requirements list 21
- Keep the shelves busy. - High quality products. - High quality services. - Develop customer loyalty program. - 24/7 service
Requirements list 22
- An efficient ordering system. - Better inventory control system. - Provide value added services. - Home delivery service. - Online services. - Enhance customer satisfaction index.

Requirements list 23
- Safe and secure buying environment for the customers. - Customer age checking system for tobacco purchase. - Environment friendly business operations. - Helps in healthy upbringing of the young customers. - Accessibility to the store 24/7.
Requirements list 24
- Provide emergency support to the distressed calls from the customers. - The store does not sell liquor and tobaccos. - Security of the customer data. - Safety and security of the customers at the store. - 24/7 accessibility to the stores.
Requirements list 25
- Quality products delivery by the suppliers at the store. - On-time supplies as the stores have limited space. - Ensure supplies to the centralized combined store. - Supplies on demand by the stores.
Requirements list 26
- Review customer data on daily basis. - Share data across stores. - Predict customer buying pattern. - Determine accurate store needs on daily basis. - Determine accurate customer needs from the store on daily basis.
Requirements list 27
- Reduce cost by controlling inventory. - High quality products and services. - Analyse customer data. - E-commerce strategy.
Requirements list 28
- Keep the shelves at the store busy.

- High quality products at the store. - Better inventory control system. - Ensure supplies to the centralized combined store. - Increase sale by 100%. - Prompt delivery of the goods and services.
Requirements list 29
- Monitor customer needs and desires. - Gather customer data. - Analyse customer data. - Analyse customer buying pattern. - Satisfy the customer needs. - Measure customer satisfaction.
Requirements list 30
- Order tracking system. - Reduce long queues of customer. - Plan demand and delivery on item-by-item basis. - Use efficient means to approach customers. - Use app technology for ordering.
Requirements list 31
- Keep the products fresh at the store. - Conduct market research. - Enhance privacy of the customer data. - Provide platform for new products. - Just in time delivery. - Enhanced customer services.
Requirements list 32
- Scan products - Enter customer profile data. - Five Star policies towards suppliers. - Take orders from customers.

- Prepare orders for delivery. - Process payment rapidly. - Keep the systems available 24/7. - Order the items out of stock.
Requirements list 33
- Provide efficient services to the customers. - Keep the products fresh. - Manage online order taking system. - Handle the cash with safety. - Generate stock order recommendation.
Requirements list 34
- Exceed customer expectations by understanding and responding to their needs and desires. - Conduct market research to know consumer requirements. - Use multi channels for marketing. - Inform customers about new deals. - Understand customers buying pattern. - Enhance communication with customer and collaboration with partners. - Get access to reliable data. - Target new customer markets. - Conduct statistical analysis of consumer data

Appendix E: The assessment template for the requirements lists

Participant's Name:_____

Participant's position:_____

Participant's industry experience:_____

Business scenario

A "Five Star" multinational company is using IT to dramatically change many aspects of the way retailing is done. Five Stars focuses on four aspects: pricing and merchandising, reducing operating cost, using information technology and strategic site selection. Through this strategy Five Star is keen to achieve double digit profitability target and shareholder value. After 17 years of sustained growth in sales and profit, Five Star shows no intention of slowing its expansion. Since its creation the company has achieved one of the highest returns on equity in the industry. Since 2007 sales for Five Star have been exceeding those of its parent company and wants rapid increase in sale.

Business performance target of Five Star is to achieve total sales in Australia in excess of the sales of all Australian retail stores which aligned with Five stars' mission. For that Five stars wants to pursue top quality control beyond conventional standards through which Five stars would be responding to customers' diverse needs by supplying items worthy of customer expectations. Five Stars is keen to dominant the market through distribution and logistics efficiency, operation and information systems effectiveness, franchise support efficiency and corporate image. For effective customer service and better inventory control *Five Star* wants from their suppliers to deliver the products that were in demand on a just-in-time basis, thereby eliminating dead and slow selling items and replacing them by the faster selling one. It also includes high quality products and service to the customers with competitive price.

Cost reduction strategy is to find the best way for each store to control inventory. In particular, attention has been given to avoid non-availability – that is losing a sale because something is out of stock. The company needs to not simply identify what particular products customers like but more importantly the company should accurately determine when, where and in which quantities and at which price these products are needed. Product

ordering is the most constructive part of retail business. To address the rapid changes in the compositions of customer demands and long queues *Five Star* wants an efficient ordering system which can also help to solve excess inventory problems.

In a retail shop the items kept in stock and on the shelf are precisely selected for the targeted customers and the products quality is kept high. Stores hold that right amount of stock for those selling items. To provide value-added services Five Star started a home delivery parcel service as well in cooperation with large transportation company.

Requirements List 1

…….

…….

…….

Review the above list of requirements against the scenario and assess how well this business analyst has achieved the following:

1. Management goals

   1 2 3 4 5 6 7 8 9 10

2. What the system must do

   1 2 3 4 5 6 7 8 9 10

3. How the system should function

   1 2 3 4 5 6 7 8 9 10

4. Tasks to be performed by the system

   1 2 3 4 5 6 7 8 9 10

5. Goals that drive to market leadership

   1 2 3 4 5 6 7 8 9 10

6. Features of the desired system

   1 2 3 4 5 6 7 8 9 10

7. Qualities of the system

   1 2 3 4 5 6 7 8 9 10

8. Organization's longer term directions

   1 2 3 4 5 6 7 8 9 10

9. Preciseness of requirements

1 2 3 4 5 6 7 8 9 10

10. Constraints on the system

1 2 3 4 5 6 7 8 9 10

11. Appropriateness of requirements

1 2 3 4 5 6 7 8 9 10

12. Effectiveness of requirements

1 2 3 4 5 6 7 8 9 10

Requirements List 2

…….

…….

…….

Review the above list of requirements against the scenario and assess how well this business analyst has achieved the following:

1. Management goals

   1 2 3 4 5 6 7 8 9 10

2. What the system must do

   1 2 3 4 5 6 7 8 9 10

3. How the system should function

   1 2 3 4 5 6 7 8 9 10

4. Tasks to be performed by the system

   1 2 3 4 5 6 7 8 9 10

5. Goals that drive to market leadership

   1 2 3 4 5 6 7 8 9 10

6. Features of the desired system

   1 2 3 4 5 6 7 8 9 10

7. Qualities of the system

   1 2 3 4 5 6 7 8 9 10

8. Organization's longer term directions

   1 2 3 4 5 6 7 8 9 10

9. Preciseness of requirements

   1 2 3 4 5 6 7 8 9 10

10. Constraints on the system

    1 2 3 4 5 6 7 8 9 10

11. Appropriateness of requirements

    1 2 3 4 5 6 7 8 9 10

12. Effectiveness of requirements

    1 2 3 4 5 6 7 8 9 10

Requirements list 3

…….

…….

…….

Review the above list of requirements against the viewpoint and assess how well the business analyst has achieved the following:

1. Management goals

   1 2 3 4 5 6 7 8 9 10

2. What the system must do

   1 2 3 4 5 6 7 8 9 10

3. How the system should function

   1 2 3 4 5 6 7 8 9 10

4. Tasks to be performed by the system

   1 2 3 4 5 6 7 8 9 10

5. Goals that drive to market leadership

   1 2 3 4 5 6 7 8 9 10

6. Features of the desired system

   1 2 3 4 5 6 7 8 9 10

7. Qualities of the system

   1 2 3 4 5 6 7 8 9 10

8. Organization's longer term directions

1 2 3 4 5 6 7 8 9 10

9. Preciseness of requirements

   1 2 3 4 5 6 7 8 9 10

10. Constraints on the system

    1 2 3 4 5 6 7 8 9 10

11. Appropriateness of requirements

    1 2 3 4 5 6 7 8 9 10

12. Effectiveness of requirements

    1 2 3 4 5 6 7 8 9 10

Requirements list 4

…….

…….

…….

Review the above list of requirements against the viewpoint and assess how well the business analyst has achieved the following:

1. Management goals

   1 2 3 4 5 6 7 8 9 10

2. What the system must do

   1 2 3 4 5 6 7 8 9 10

3. How the system should function

   1 2 3 4 5 6 7 8 9 10

4. Tasks to be performed by the system

   1 2 3 4 5 6 7 8 9 10

5. Goals that drive to market leadership

   1 2 3 4 5 6 7 8 9 10

6. Features of the desired system

   1 2 3 4 5 6 7 8 9 10

7. Qualities of the system

   1 2 3 4 5 6 7 8 9 10

8. Organization’s longer term directions

   1 2 3 4 5 6 7 8 9 10

9. Preciseness of requirements

   1 2 3 4 5 6 7 8 9 10

10. Constraints on the system

    1 2 3 4 5 6 7 8 9 10

11. Appropriateness of requirements

    1 2 3 4 5 6 7 8 9 10

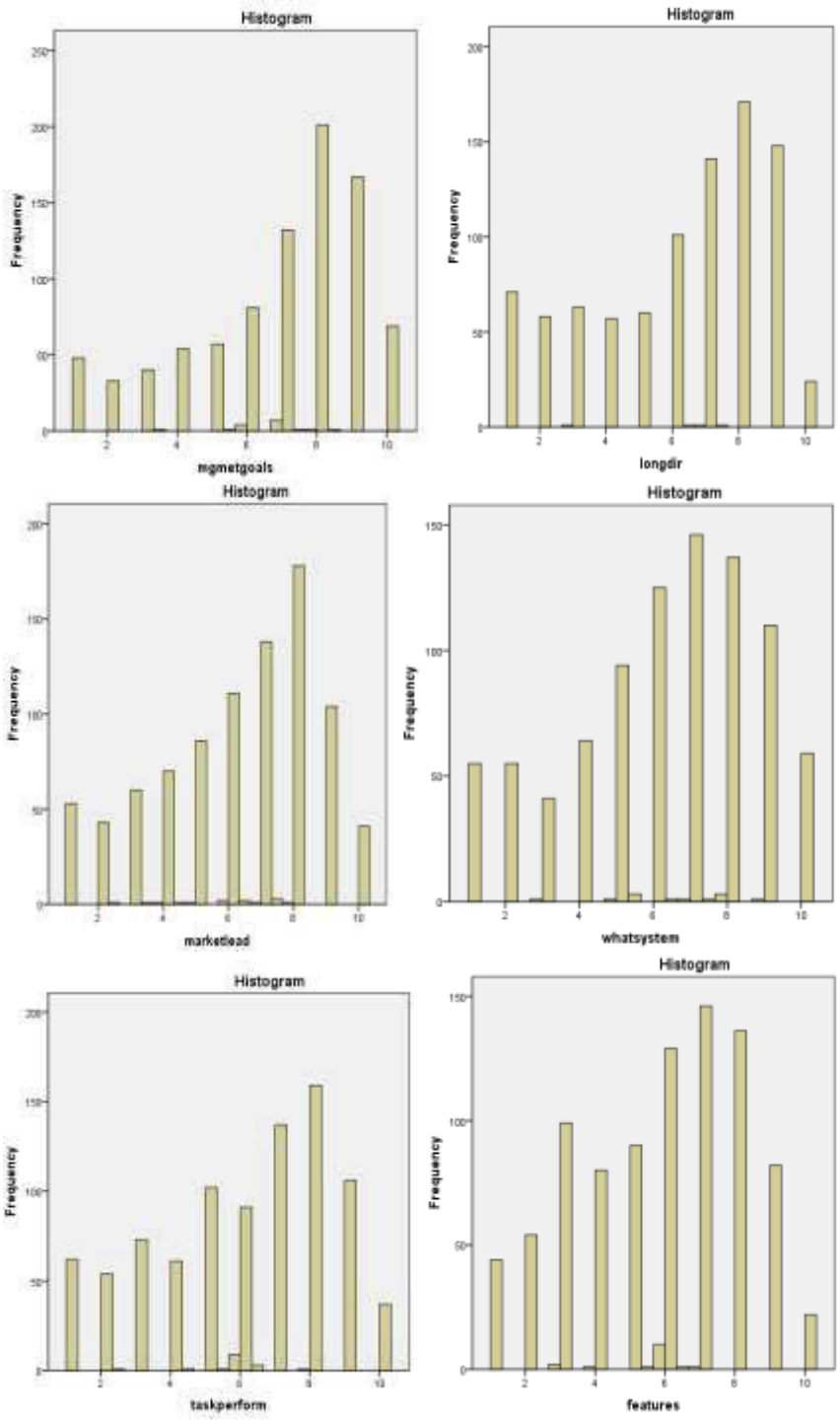
12. Effectiveness of requirements

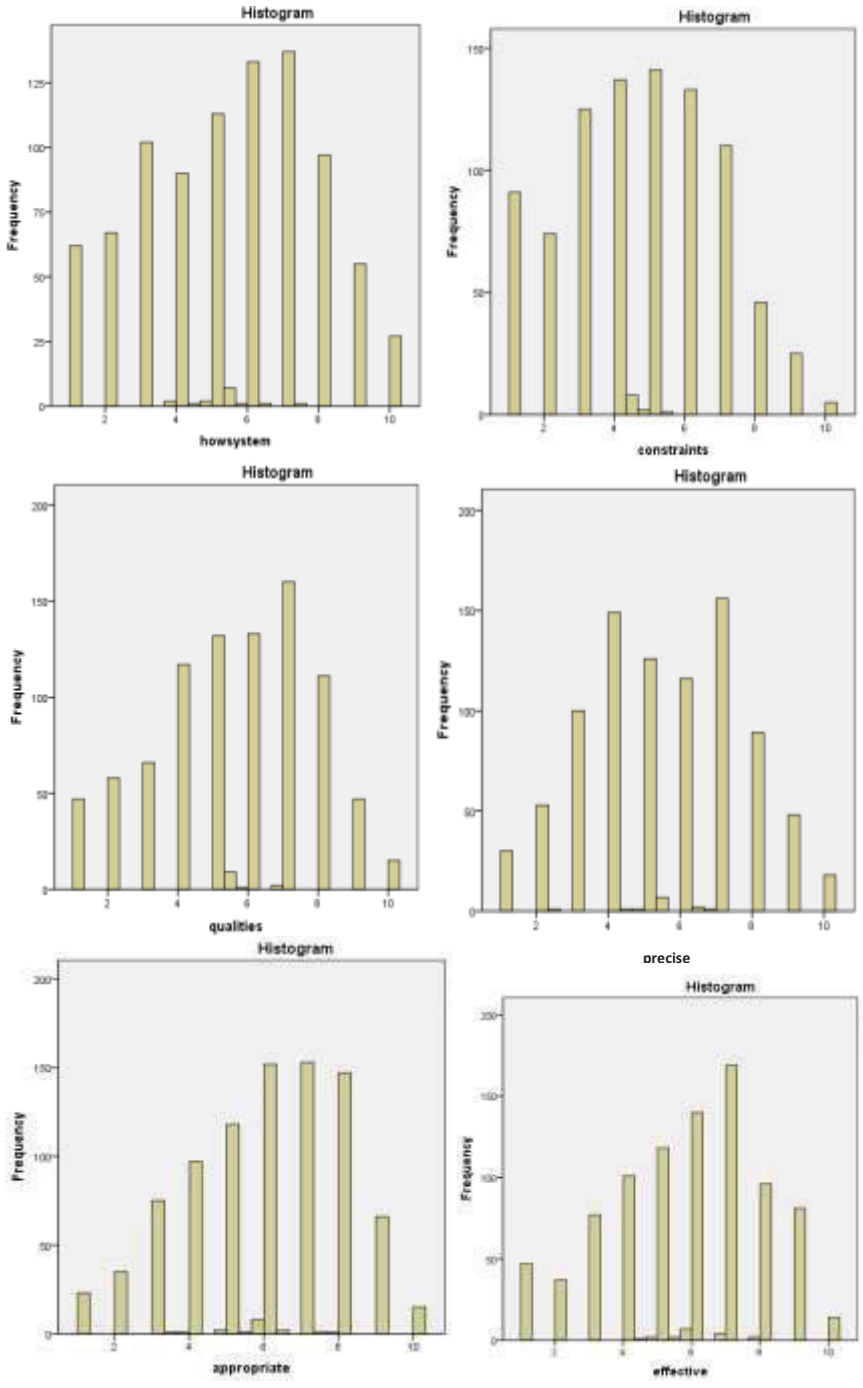
    1 2 3 4 5 6 7 8 9 10

Appendix F: Kolmogorov-Smirnov and Shapiro-Wilk test

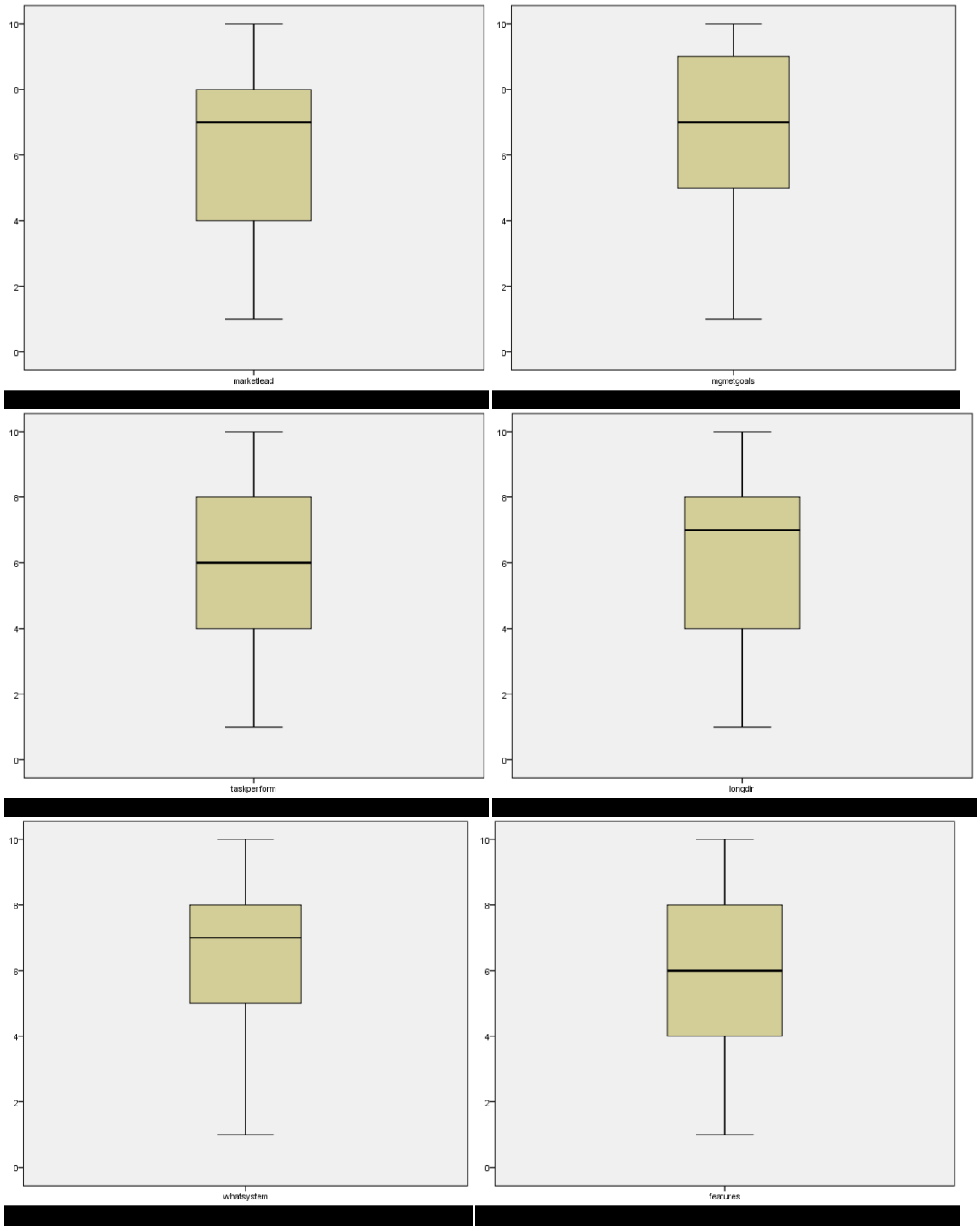
Appendix 5-2						
	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
mgmetgoals	.184	898	.000	.898	898	.000
longdir	.178	898	.000	.907	898	.000
marketlead	.155	898	.000	.936	898	.000
whatsystem	.139	898	.000	.940	898	.000
taskperform	.152	898	.000	.937	898	.000
features	.134	898	.000	.952	898	.000
howsystem	.109	898	.000	.962	898	.000
qualities	.123	898	.000	.963	898	.000
constraints	.098	898	.000	.963	898	.000
precise	.119	898	.000	.970	898	.000
appropriate	.128	898	.000	.961	898	.000
effective	.125	898	.000	.960	898	.000
a. Lilliefors Significance Correction						

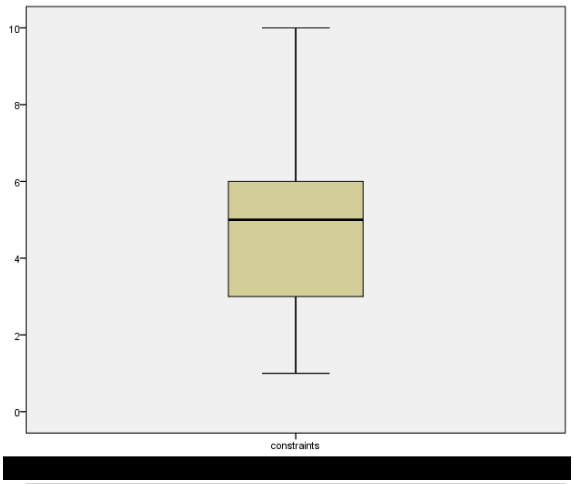
Appendix G: Histograms of 12 items

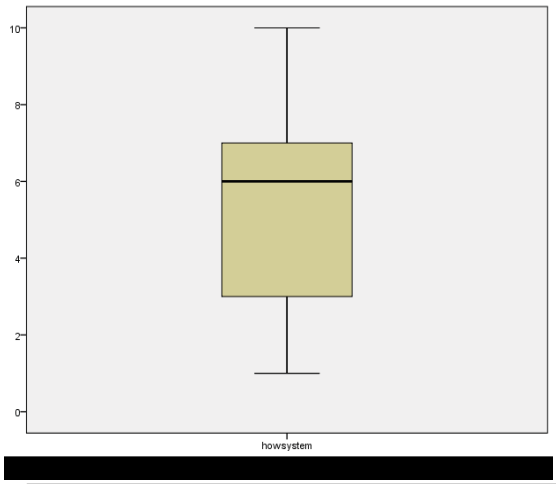


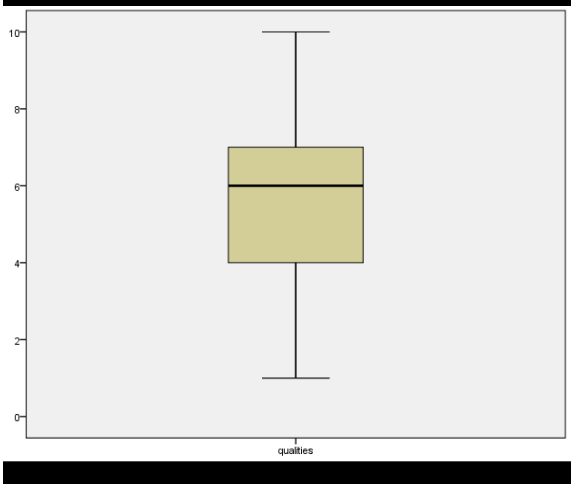

Histogram
Frequency
howsystem
Histogram
Frequency
constraints
Histogram
Frequency
qualities
Histogram
Frequency
precise
Histogram
Frequency
appropriate
Histogram
Frequency
effective

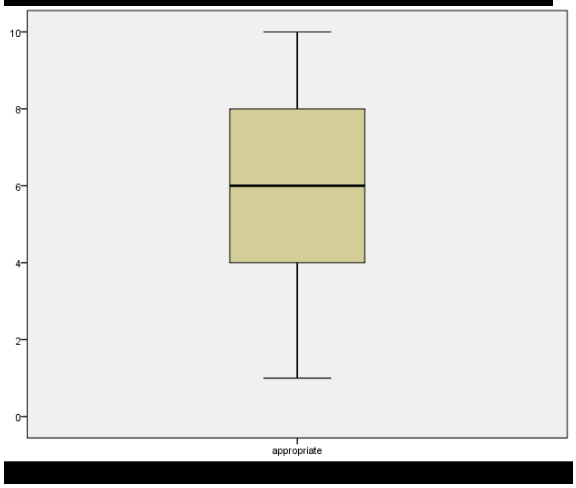
Appendix H: Box plots of 12 items

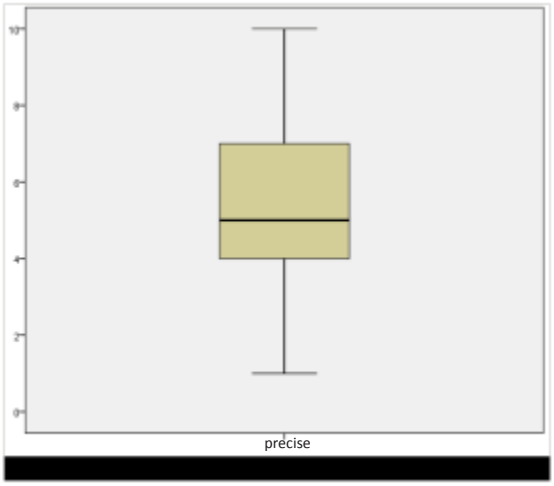


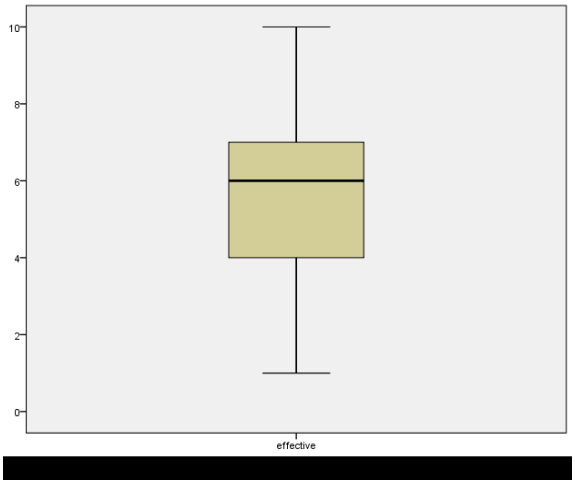

10
8
6
4
2
0
constraints


10
8
6
4
2
0
howsystem

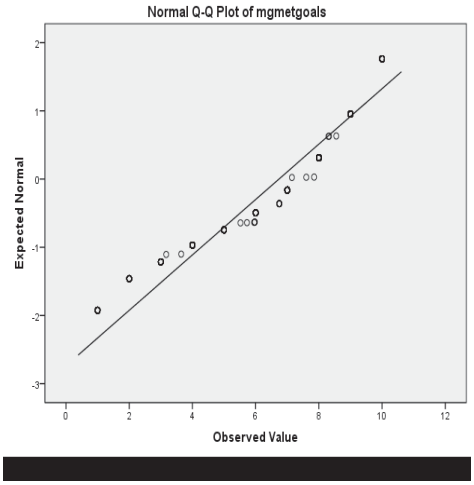

10
8
6
4
2
0
qualities

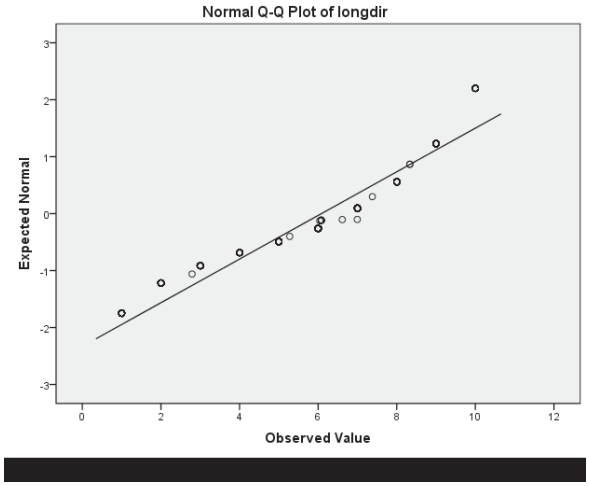

10
8
6
4
2
0
appropriate

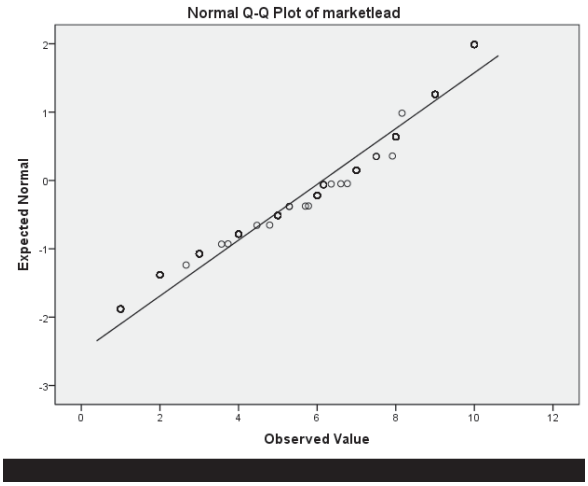

precise

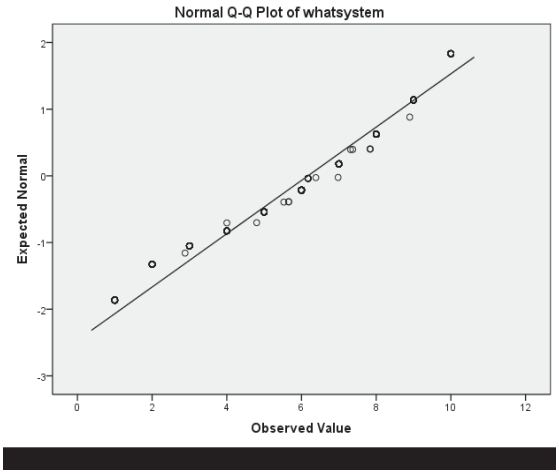

10
8
6
4
2
0
effective

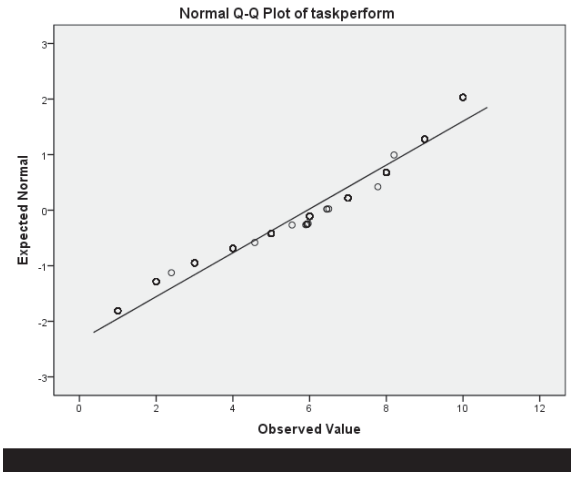
Appendix I: Q-Q plots of 12 items

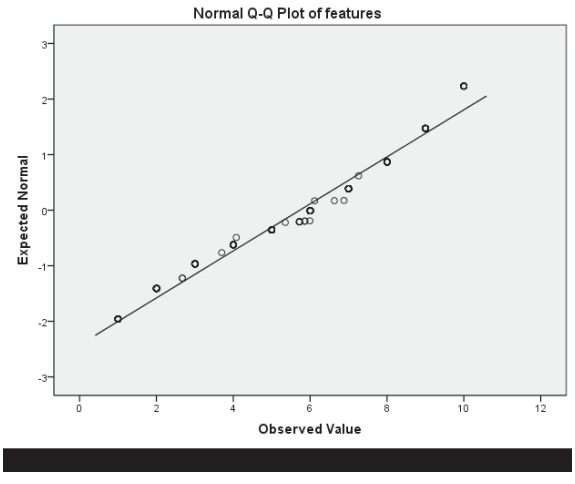


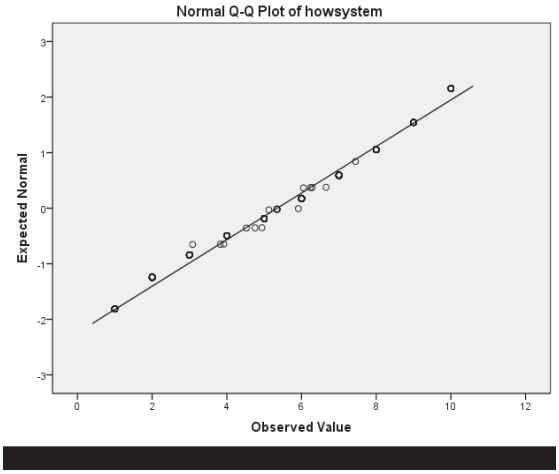


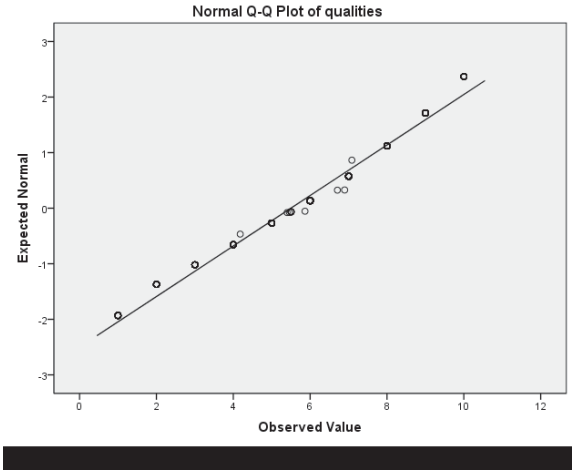


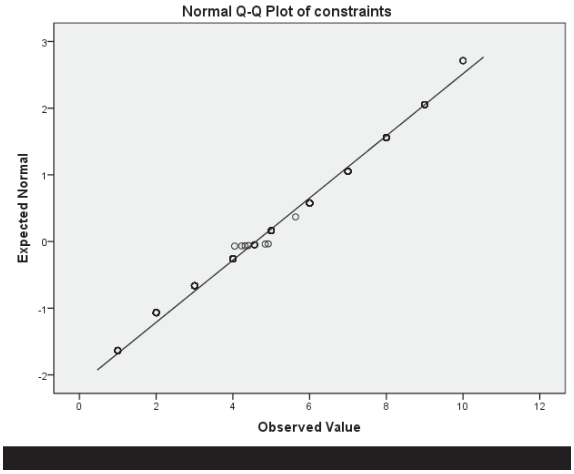


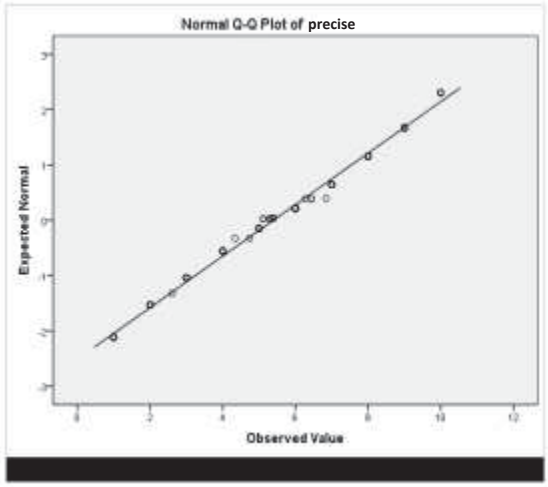


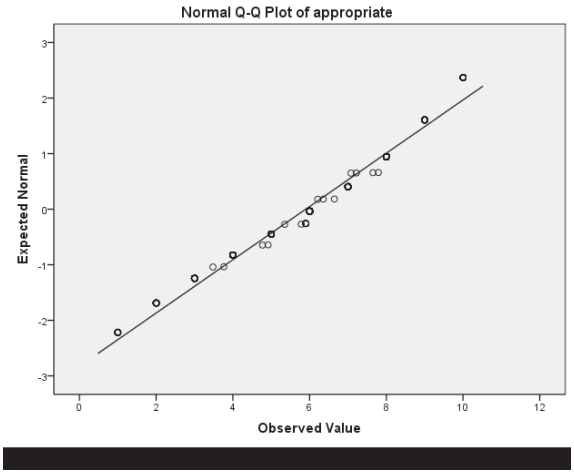


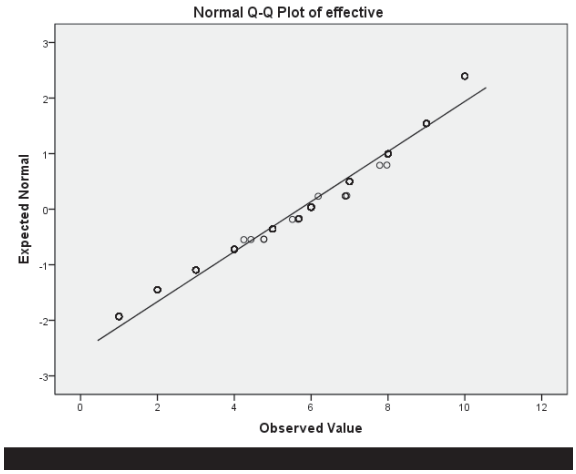

Normal Q-Q Plot of howsystem
Expected Normal
Observed Value


Normal Q-Q Plot of qualities
Expected Normal
Observed Value


Normal Q-Q Plot of constraints
Expected Normal
Observed Value


Normal Q-Q Plot of precise
Expected Normal
Observed Value


Normal Q-Q Plot of appropriate
Expected Normal
Observed Value


Normal Q-Q Plot of effective
Expected Normal
Observed Value