Strategic Management of ERP Project Lifecycle

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for the degree of Doctor of Philosophy (PhD)

University of Western Sydney

2011
I would like to dedicate this thesis to several invaluable persons in my life.

My dedication goes to my loving wife, Kalees and my two boys, Kaartheik and Krithikk. Their love and support throughout my doctoral study journey has been limitless.

I dedicate this doctoral thesis to a dearly missed friend, mentor and teacher -- the late Dr. A.S. Santhapparaj. His sudden demise has brought unbearable ache, but knowing that he is now in a better place, brings serenity.

I would also like to dedicate this thesis to two other important persons – Professor Mahendhiran Nair and Professor Bala Shanmugam. These two pillars have molded me to what I am today.
I would like to express sincere gratitude to few people who have helped me throughout my doctoral study journey.

For a start, I thank my parents who believed in me and my academic dreams, despite the many academic downfalls that I have gone through in the past.

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Finally, I thank God the Almighty for providing me an opportunity to exist, survive and move forward.
Statement of Authentication

The work presented in this thesis is, to the best of my knowledge and belief, original except as acknowledged in the text. I hereby declare that I have not submitted this material, in either full or in part, for a degree at this or any other institution.

________________

MUDIARASAN KUPPUSAMY

2011
Table of Contents

Dedication
Acknowledgements
Statement of Authentication

Table of Contents i
List of Tables vi
List of Figures viii
Abbreviations xiv
Scholarly outputs x
Abstract xi

CHAPTER 1: INTRODUCTION

1.1 Background 1
1.2 Research problems 3
1.3 Research questions and hypotheses 5
1.4 Justification for the research 6
1.5 Contributions of the research 7
1.6 Research design and methodology 9
1.7 Thesis structure 10
## CHAPTER 2: LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1 Introduction 12

2.2 ERP adoption 14

2.2.1 An overview of ERP history and current state of play 17
2.2.2 ERP adoption failure 21
2.2.3 ERP adoption success 22
2.2.3.1 Success across ERP project’s lifecycle 24
2.2.4 ERP adoption critical success factors 25
2.2.4.1 Summary of CSFs across ERP project’s lifecycle 32
2.2.5 Summary of ERP adoption 34

2.3 The process theory 34

2.3.1 The process theory and ERP adoption 35
2.3.1.1 Process theory-ERP lifecycle based empirical studies 38
2.3.2 Summary of the process theory 39

2.4 The theory of complementarity 39

2.4.1 The theory of complementarity and ERP adoption 41
2.4.2 Summary of the theory of complementarity 42

2.5 Summary of parent theories review 42

2.6 Hypotheses development 43

2.6.1 Organisational assets 47
2.6.2 Research hypotheses formation 49
2.6.2.1 Governance asset 50
2.6.2.2 Knowledge 51
2.6.2.3 Relationship 52
2.6.2.4 Complementary relationships 55
CHAPTER 3: RESEARCH METHODOLOGY & DATA ANALYSIS

TECHNIQUES

3.1 Introduction 67

3.2 Ontological and epistemological views 67

3.3 Research design 68

3.3.1 Experimental research 68

3.3.2 Ex post factor research 69

3.4 Pilot study 71

3.4.1 Pilot study’s unit of analysis and sampling 74

3.4.2 Pilot study’s survey instrument (quantitative phase) 74

3.4.3 Pilot study’s interviews (qualitative phase) 76

3.5 Large-scale study 76

3.5.1 Large-scale study’s unit of analysis and sampling 77

3.5.2 Large-scale study’s survey instrument (quantitative phase) 78

3.5.3 Large-scale study’s interviews (qualitative phase) 83

3.6 Data analysis 84

3.6.1 Quantitative data analysis 84

3.6.2 Structural equation modeling (SEM) with PLS 87
CHAPTER 4: RESEARCH FINDINGS FROM PILOT STUDY

4.1 Introduction

4.2 The pilot study’s empirical findings
   4.2.2 Findings from quantitative research
   4.2.3 Findings from qualitative research

4.3 Summary of findings from the pilot study

4.4 Chapter summary

CHAPTER 5: RESEARCH FINDINGS FROM LARGE-SCALE STUDY

5.1 Introduction

5.2 The large-scale study’s empirical findings
   5.2.1 Findings from quantitative research
   5.2.2 Findings from qualitative research

5.3 Summary of large-scale study’s findings

5.4 Chapter summary
CHAPTER 6: DISCUSSIONS AND CONCLUSION

6.1 Introduction 145

6.2 Results discussion 148
   6.2.1 Addressing the first research question 148
   6.2.2 Addressing the second research question 150
   6.2.3 Answering the third research question 161

6.3 Research and practical implications 163
   6.3.1 Research implications 163
   6.3.2 Practical implications 165

6.4 Limitations and future research 166

6.5 Conclusion 168

REFERENCES 172

APPENDICES 199
## List of Tables

Table 2.1: ERP vendors’ sales revenue, 2005 – 2006 19
Table 2.2: ERP market outlook 2006 – 2011 20
Table 2.3: Enterprise management systems evolution 20
Table 2.4: Unified critical success factors model 27
Table 2.5: Esteves and Pastor’s (2003) critical success factors across SAP ASAP model 28
Table 2.6: Summary of Nah et al.’s (2001) critical success across ERP project’s four stages 30
Table 2.7: Somers and Nelson’s (2001) critical success factors across ERP project’s six stages 31
Table 2.8: Summary of critical success factors across ERP project’s lifecycle 33
Table 2.9: Key process theory models on technological innovation adoption 35
Table 2.10: Markus and Tanis’s (2000a) ERP systems experience cycle 38
Table 2.11: Key organisational assets used in this research 62
Table 3.1: Quantitative and qualitative research approach differences 73
Table 3.2: Pilot study’s survey instrument questions and its reference source 77
Table 3.3: Pilot study interview questions 78
Table 3.4: Measurement scale operationalisation 82
Table 3.5: Large-scale study’s interview questions 84
Table 3.6: Summary of characteristics and decision rules to determine reflective or formative construct 97
Table 3.7: Determination of reflective and formative constructs in this study 98
Table 3.8: Issues in participant information sheet 104
Table 4.1: Pilot study respondents’ profiles 110
Table 4.2: Statistical results of outer model evaluation 111
Table 4.3: Multicolinearity statistics - individual direct effect model’s formative construct 113
Table 4.4: Statistical results of complementarity effect model 114
Table 4.5: Multicolinearity statistics for complementarity effect model 115
Table 4.6: Structural inner model evaluation for individual direct & complementarity effect models 116
Table 5.1: Large-scale study respondents’ profile 125
Table 5.2: Non-response bias test results 126
Table 5.3: Exploratory factor analysis output 127
Table 5.4: Statistical results of outer model evaluation for large 129
Table 5.5: Multicolinearity statistics for large 131
Table 5.6: Structural model estimation statistics for large

Table 5.7: Summary of findings from large-scale study

Table 6.1: Summary of findings from pilots study

Table 6.2: The conditions for flanking complementarity to emerge in all the three ERP stages

Table 6.3: Summary of research findings for second research question
# List of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>Thesis development process</td>
<td>11</td>
</tr>
<tr>
<td>2.1</td>
<td>Venn diagram of the research direction</td>
<td>12</td>
</tr>
<tr>
<td>2.2</td>
<td>Literature review flow</td>
<td>13</td>
</tr>
<tr>
<td>2.3</td>
<td>ERP system’s functionality</td>
<td>15</td>
</tr>
<tr>
<td>2.4</td>
<td>ERP architecture evolution, SAP case example</td>
<td>16</td>
</tr>
<tr>
<td>2.5</td>
<td>Complementary relationships between organisational assets and achievement of pre-implementation stage’s success</td>
<td>46</td>
</tr>
<tr>
<td>2.6</td>
<td>Complementary relationships between organisational assets and achievement of implementation stage’s success</td>
<td>46</td>
</tr>
<tr>
<td>2.7</td>
<td>Complementary relationships between organisational assets and achievement of post-implementation stage’s success</td>
<td>47</td>
</tr>
<tr>
<td>2.8</td>
<td>Individual direct effect model</td>
<td>57</td>
</tr>
<tr>
<td>2.9</td>
<td>Complementarity effect model</td>
<td>58</td>
</tr>
<tr>
<td>2.10</td>
<td>Large-scale research model</td>
<td>67</td>
</tr>
<tr>
<td>3.1</td>
<td>Individual direct effect model</td>
<td>74</td>
</tr>
<tr>
<td>3.2</td>
<td>Complementarity effect model</td>
<td>75</td>
</tr>
<tr>
<td>3.3</td>
<td>Large-scale study’s model</td>
<td>81</td>
</tr>
<tr>
<td>3.4</td>
<td>Reflective construct</td>
<td>92</td>
</tr>
<tr>
<td>3.5a</td>
<td>Formative first-order construct</td>
<td>94</td>
</tr>
<tr>
<td>3.5b</td>
<td>Formative first-order, Formative second-order construct</td>
<td>95</td>
</tr>
<tr>
<td>4.1</td>
<td>Final research model based on the empirical findings</td>
<td>118</td>
</tr>
<tr>
<td>4.2</td>
<td>Large-scale study’s final research model based on empirical findings</td>
<td>143</td>
</tr>
<tr>
<td>5.1a</td>
<td>The conditions for flanking complementarity in the pre-implementation stage</td>
<td>151</td>
</tr>
<tr>
<td>5.1b</td>
<td>The conditions for flanking complementarity in implementation stage</td>
<td>152</td>
</tr>
<tr>
<td>5.1c</td>
<td>The conditions for flanking complementarity in post-implementation stage</td>
<td>152</td>
</tr>
</tbody>
</table>
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANOVA</td>
<td>Analysis of One-Way Variance</td>
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<td>AVE</td>
<td>Average variance extracted</td>
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<td>AVE²</td>
<td>Average variance extracted square</td>
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<td>BPK</td>
<td>Business process knowledge</td>
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<td>BPO</td>
<td>Business Process Outcomes</td>
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<td>CBSEM</td>
<td>Covariance based structural equation modelling</td>
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<td>CPT</td>
<td>Completion of Project Targets</td>
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<td>ERP</td>
<td>Enterprise Resource Planning</td>
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<td>EFA</td>
<td>Exploratory factor analysis</td>
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<td>Eff</td>
<td>Efficiency of business operations</td>
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<tr>
<td>Effec</td>
<td>Effectiveness of business operations</td>
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<tr>
<td>Flex</td>
<td>Flexibility of business structure</td>
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<td>G</td>
<td>Governance asset</td>
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<td>GoF</td>
<td>Global Goodness of Fit</td>
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<td>HAR</td>
<td>Hardware</td>
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<td>HR</td>
<td>Human Resource</td>
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<td>ICT</td>
<td>Information and communication technologies</td>
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<td>Imp-HR</td>
<td>Implementation Human resource</td>
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<td>Imp-IT</td>
<td>Implementation IT infrastructure</td>
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<td>Imp-K</td>
<td>Implementation Knowledge</td>
</tr>
<tr>
<td>Imp-OA</td>
<td>Organisational assets in Implementation stage</td>
</tr>
<tr>
<td>Imp-R</td>
<td>Implementation Relationship</td>
</tr>
<tr>
<td>IT</td>
<td>IT infrastructure</td>
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<td>ITS</td>
<td>IT skills</td>
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<tr>
<td>K</td>
<td>Knowledge asset</td>
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<tr>
<td>NET</td>
<td>Networks</td>
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<td>OR</td>
<td>Organisational Readiness</td>
</tr>
<tr>
<td>PLS</td>
<td>Partial least square</td>
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<td>PMK</td>
<td>Project management knowledge</td>
</tr>
<tr>
<td>Post-IT</td>
<td>Post-implementation IT infrastructure</td>
</tr>
<tr>
<td>Post-HR</td>
<td>Post-implementation Human resource</td>
</tr>
<tr>
<td>Post-K</td>
<td>Post-implementation Knowledge</td>
</tr>
<tr>
<td>Post-OA</td>
<td>Organisational assets in post-implementation stage</td>
</tr>
<tr>
<td>Post-R</td>
<td>Post-implementation Relationship</td>
</tr>
<tr>
<td>Pre-HR</td>
<td>Pre-implementation Human resource</td>
</tr>
<tr>
<td>Pre-IT</td>
<td>Pre-implementation IT infrastructure</td>
</tr>
<tr>
<td>Pre-K</td>
<td>Pre-implementation Knowledge</td>
</tr>
<tr>
<td>Pre-OA</td>
<td>Organisational assets in Pre-implementation stage</td>
</tr>
<tr>
<td>Pre-R</td>
<td>Pre-implementation Relationship</td>
</tr>
<tr>
<td>R</td>
<td>Relationship asset</td>
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<td>SEM</td>
<td>Structural Equation Modelling</td>
</tr>
<tr>
<td>TMI</td>
<td>Top management involvement</td>
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<tr>
<td>TRA</td>
<td>Training</td>
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<tr>
<td>UI</td>
<td>User involvement</td>
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<tr>
<td>VIF</td>
<td>Variance inflation factor</td>
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Scholarly outputs

My name is denoted as Kuppusamy, M. (in bold text)

Refereed journal papers


Refereed conference papers


Abstract

Enterprise resource planning (ERP) is used globally to enhance business growth trajectories. Despite widespread acknowledgement in both the academic and industrial literature of the importance of ERP, adoption of this complex business application is often accompanied by a variety of problems. This study investigated the ERP adoption conundrum by addressing two research questions:

- Do organisational assets have flanking complementarity effects on the successes achieved in ERP pre-implementation, implementation and post-implementation stages, and under what conditions does flanking complementarity emerge in each stage?

- Does the success experienced in one stage of an ERP project have significant effect on the configuration and deployment of organisational assets in the next stage?

Our research methodology leveraged on four theoretical perspectives (ERP adoption success factors, the theory of complementarity and the process theory). These theoretical perspectives were used to examine the following three research issues that help to address the above-mentioned research questions.

First, we investigated whether flanking complementarity relationships exist between a set of heterogeneous organisational assets and the effect of this relationship on the success of the ERP pre-implementation, implementation and post-implementation stages. Second, we explored the conditions that facilitate the existence of flanking complementarity in these three stages. Finally, we conducted empirical validation on the notion that an ERP project comprises a series of continuous activities and outputs as advocated in the process theory literature.

Using a sample of 215 ERP using organisations in Malaysia, we found the following results:
(i) The flanking complementarity relationships between four heterogeneous organisational assets do have significant effects on the successes achieved in ERP pre-implementation, implementation and post-implementation stages.

(ii) Different conditions facilitate the existence of flanking complementary relationships between the organisational assets. These conditions are summarised as follows:

   a. Human resource (comprised of IT skills and ERP training) and IT infrastructure (comprised of hardware and software) are the central conditions for flanking complementarity to exist in the pre-implementation stage

   b. Human resource and Knowledge (comprised of business process knowledge and project management knowledge) are the central conditions for flanking complementarity to exist in the implementation stage

   c. Knowledge and Relationship (comprised of top management involvement and user involvement) are the central conditions for flanking complementarity to exist in the implementation stage.

(iii) An ERP project involves several successive and interrelated stages as advocated in the ERP process theory literature.

The contribution of this research is threefold.

First, investigating the ERP adoption ‘black-box’ has highlighted explicit ways in which ERP adoption success can be fostered.

Second, we provide exploratory evidence on how successful ERP system adoption is contingent upon flanking complementarity relationships between different organisational assets.
Finally, the research has demonstrated the importance of a forceful asset management capability in lieu of the complexities in the different stages in an ERP project’s lifecycle.

The theoretical and practical implications highlighted in this research could serve as a focal reference point for researchers, ERP vendors and future ERP clients.
CHAPTER 1: INTRODUCTION

1.1 Background

Large-scale events such as global financial crises, unprecedented health scares and natural calamities have constantly tested the survival capability of businesses. Such ‘push factors’ drive the continuous search for new business growth strategies. The emergence of advanced information systems (IS) applications is heralded as one of the most promising business growth strategies in the new millennium. While traditional IS applications such as accounting packages and payroll systems have been in use for many years, businesses have recently begun adopting advanced IS applications to facilitate complex operations, leading to improved overall business performance (Kayas et al., 2008). One of the most prevalent advanced IS applications nowadays is enterprise resource planning (ERP) (Velcu, 2010). ERP is defined as “configurable information systems packages that integrate information and information-based processes within and cross-functional areas in an organisation” (Kumar & Hillegersberg, 2000, p.22).

Industrial and academic reports (e.g., Davenport, 1998; Cooke et al., 2001; Jacobson et al., 2007) indicate increased adoption of ERP across the globe. For instance, the International Data Group (IDC) has estimated that global ERP sales over the period 2006–2010 had steadily increased by 5 per cent annually (Velcu, 2010). However, such growth in ERP adoption notwithstanding, many cases of failure has been recorded over the years (e.g., Davenport, 1998; Holland & Light, 1999; Hawari & Richard, 2010).

In light of these reported failures, researchers have sought to identify the factors that lead to successful adoption of ERP (e.g., Milford & Stewart, 2000; Umble et al., 2003). Most researchers agree that an organisation’s inherent assets play a crucial role in the success of any ERP application.

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1 In the context of this study, ERP adoption is defined as completion of all the activities involved in the three stages in an ERP project, namely, ERP pre-implementation, implementation and post-implementation stages.
These assets can vary, but commonly include skilled employees (e.g., Sumner, 2000; Aladwani, 2001; Duplaga & Astani, 2003), training (Markus et al., 2000; Robey et al., 2002; Zhang et al., 2005), project management (e.g., Akkermans & Helden, 2002; Nah et al., 2004), business process knowledge (e.g., Parr & Shanks, 2000; Karimi et al., 2007), top management support (e.g., Somer & Nelson, 2001; Zhang et al., 2005), user involvement (e.g., Sumner, 2000; Abdinour-Helm et al., 2003) and technological infrastructure (e.g., O’Leary, 2000; Stratman & Roth, 2002).

Generally, an ERP project is categorised into several successive stages (Markus & Tanis, 2000a), each characterised by execution of certain activities and ending with the successful achievement of certain pre-determined outcomes or objectives. Each stage must be successfully completed before moving on to the next stage. Different versions of such successive stages have been given in the literature (e.g., Ross & Vitale, 2000; Rajagopal, 2002). In this research we relied on the characterisation provided by Abdinour-Helm et al., (2003), in which an ERP project is classified into three successive stages: pre-implementation, implementation and post-implementation.

An ERP project begins with the pre-implementation stage, which involves planning for ERP adoption activities, such as identification and selection of the right ERP vendor, consultants, identification of project team members and its formation structure, preliminary design of the new business process blueprint and allocation of any other required resources. Achievement of these activities indicates the organisation’s readiness to adopt ERP (Abdinour-Helm et al., 2003) – that is, the success of the pre-implementation stage.

The ERP project then moves on to the implementation stage, involving activities such as business process reengineering, prototype development, user training and implementation of the system go-live process. Completion of the implementation stage is proxied by completion of the project’s targets being met; these include minimal resource wastage, not overrunning project budget, scheduled timeline, all users being properly trained and other project objectives (Wang & Chen, 2006; Wu, 2007).
The final stage – post-implementation – is represented by technology migration, fixing bugs, retraining of users, routinisation, and ongoing maintenance of the new system into the existing work system. This stage is completed once the primary aim of adopting ERP has been achieved – that is, improved business process outcomes that in turn increase productivity and minimise operational costs after using the ERP system (Karimi et al., 2007).

Against this background, the following section introduces the research problems addressed in this study. Section 1.3 outlines the research questions and hypotheses. Sections 1.4 and 1.5 discuss the justification for the research and its contributions, respectively. Section 1.6 describes the research design and methodology, and Section 1.7 details the thesis structure.

1.2 The research problems

Despite a significant amount of research on ERP adoption, the literature contains several gaps in knowledge. Most studies have explored ERP’s critical assets in a static environment – that is, the driving organisational assets in a particular stage of an ERP project. In this context, numerous studies have focussed on the importance of organisational assets in the ERP implementation stage (e.g., Holland & Light, 1999; Markus et al., 2000; Nah et al., 2001; Kerimoglu et al., 2008). A different approach has emerged recently, with researchers investigating the critical organisational assets exclusive to either the ERP pre-implementation stage (e.g., Abdinour-Helm et al., 2003; Ho & Lin, 2003), the ERP post-implementation stage (e.g., Yu, 2005; Karimi et al., 2007; Upadhyay & Dan, 2009) and/or all three stages of an ERP project (e.g., Somers & Nelson, 2004; Al-Mashari et al., 2003; Wu, 2007). The present research investigated all three stages. On this note, we highlight some of the key issues that academic scholars have insufficiently addressed in relation to the three stages.
First, while the ERP literature recognises the different stages in an ERP project (e.g., Markus & Tanis, 2000a), very few studies have empirically validated the extent to which organisational assets (e.g., top management support, user involvement, technological infrastructure) facilitate the success achieved in each stage of an ERP project and how successful completion of one stage leads to the next stage.

Our line of argument is similar to the argument put forward by Velcu (2010, p.159) who said that “while previous papers on ERP implementations have identified proxies to measure the success at each stage, there are few empirical analyses of the relationships between the success measures”. Research in this direction would highlight evidence of the link between the organisational assets and the success of each stage could help organisations to strategically allocate their assets in each stage, and that ERP project is indeed enveloped by a series of stages, linearly. This would help to understand and strategise effective execution of the entire ERP project lifecycle progressively, as successful management of one stage increases the likelihood of successfully managing the ensuing stages. Research in this context will also offer insights of the exclusivity of certain assets across the different stages of ERP project’s lifecycle. This will highlight the conditions for successes to be achieved across the different stages.

Second, ERP literature has ignored the notion of complementary relationships between organisational assets and its impact toward ERP project lifecycle’s success. Recent research has concentrated on the complementary relationships between a set of organisational assets to achieving organisational goals. Research by Cassiman and Vueglers (2002), Tanriverdi (2005, 2006), Karimi et al. (2007), Aral and Weill (2007) and Lopez (2008) has shown that complementarity between organisational assets can improve business outcomes. The work by Karimi et al. (2007) has specifically shown that manufacturing organisations using ERP have achieved improved business performance due to the complementarity effects between different organisational assets. The key argument in these studies is that, although the individual effect of organisational assets in achieving success is paramount, the co-presence of complementing assets could deliver optimal success across the different stages of an ERP project.
Finally, research amalgamating these three research dimensions, i.e. ERP adoption success factors, the different stages of ERP project’s lifecycle and the complementarity between organisational assets, are not widespread. Research in this direction would unveil the ‘black-box’ of the ERP adoption process and identify the rationale for organisations to experience adoption failure or challenges.

Evidence of both the effectiveness of complementarity between organisational assets and the driving assets that facilitate such complementarity in each stage in an ERP project could become the focal point of reference on how a successful ERP adoption can be achieved.

1.3 Research questions

This study addressed to the research issues discussed above by drawing on the following concepts and theories: (1) ERP adoption success factors, (2) the process theory, and (3) the theory of complementarity. We investigated ERP using organisations in Malaysia, undertaking both pilot and large-scale studies. The pilot study sought to answer the following research question:

- Do organisational assets (comprising of Governance, Knowledge and Relationship) have complementarity effect toward ERP post-implementation success?

This phase was a preliminary validation of the notion of complementarity between organisational assets in the post-implementation stage. Using the empirical findings of the pilot study, we modified the research model before executing the large-scale study. Note that in-depth explanations about the differences between the pilot and large-scale studies are given in Chapter 2. Addressing the pilot study’s research questions will lead to execution of the large-scale study with wider research scope. It needs to be highlighted at this juncture that the large-scale study focussed in the context of the three stages involved in an ERP project’s lifecycle, while the pilot study focused on a single stage (i.e. ERP post-implementation stage) specifically.
Two research questions formed the backbone of the large-scale study:

1. Do organisational assets have flanking complementarity effects on the successes achieved in ERP pre-implementation, implementation and post-implementation stages, and under what conditions does flanking complementarity emerge in each stage?

2. Does the success experienced in one stage of an ERP project have significant effect on configuration and deployment of organisational assets in the next stage?

Flanking complementarity infers to an environment or situation in which different organisational assets supports the role of each other in a favourable way with potential outcome maximising effect (Horgan & Muhlau, 2006). Greater explanation of this phenomenon is given in Chapter 2.

1.4 Justification for the research

This research aimed to address the gaps in the literature by building a theoretical framework to assist in understanding the ‘black-box’ of ERP adoption success. More precisely, this research moves away from the conventional research style of examining the critical issues for ERP adoption success from a macro perspective. We unlock an ERP project’s complexity by dissecting it into several successive stages. Examining the important organisational assets that drive successful completion of the different stages opens up an ERP project’s ‘black-box’, thus paving way for further understanding of why some organisations are able to reap successful ERP adoption, and vice-versa.

In addition, investigating the complementarity between organisational assets with superior ability to facilitate successful completion of each stage can highlight the importance for organisations to treat and manage their organisational assets collaboratively and not in isolation.

This is especially true in the context of ERP projects being undertaken in developing countries such as Malaysia. A well known research fact is that most developing
countries with different cultural and work backgrounds from those of western countries face significant challenges in successful ERP adoption (Huang & Palvia, 2001). Malaysia, one of the fastest growing South-East Asian countries, has ventured into technology-led economic growth since the 1990s (Nair & Kuppusamy, 2004).

The government’s continuous initiatives to spur technology uptake in the private sector have led to significant reliance on technologies to undertake business activities (Nair et al., 2005). While no official government documentation is yet available, anecdotal information suggests a reasonable level of ERP uptake by the Malaysian private sector (EDGE, 2009). The outcome of the current research in the Malaysian context will provide useful insight and points of reference on how to strategically manage and deploy organisational assets in a complementarity way to facilitate successful ERP adoption.

1.5 Contributions of the research

This research contributes to the extant literature in four ways.

First, investigation of ERP adoption process ‘black-box’ will showcase the explicit reasons why ERP adoption can fail, despite existence of various support mechanisms such as experienced ERP vendors, external project consultants and adequate organisational resources.
Existing studies have identified the critical issues that could lead to successful ERP adoption, but an insight into the critical organisational assets that facilitate the success of different stages could assist diagnose problem areas across the entire ERP project lifecycle. Such a diagnosis could serve as a future reference point for both ERP vendors and future ERP clients.

Second, this research contributes to the literature by integrating various theoretical perspectives (i.e., ERP adoption success factors, the process theory and the theory of complementarity) to examine ERP adoption success. Our research shows that successful ERP adoption is contingent upon flanking complementary relationships a set of heterogeneous organisational assets. The finding is in line with the theory of complementarity’s conceptualisation. The notion of complementarity is paramount in managing the adoption process of a complex IS application such as ERP. Potential ERP clients should adopt a holistic management style and should not perceive existing organisational assets as having individual characteristics and contributions toward the achievement of organisational goals.

An organisation should be ready to find a way to relate and link each organisational asset, so that interactions between different sets of assets are positive and flanking. Thus, we contribute to the body of knowledge by providing empirical evidence on the notion of complementarity between different organisational assets.

Third, our research also reveals the necessary conditions that foster flanking complementarity in each stage of ERP project, thus providing support for the process theory’s argument. An organisation that intends to adopt ERP should engage a flexible managerial direction and be ready to deploy crucial organisational assets at a given time, in accordance to the prevailing requirements in different stage of adoption process.

Lastly, the findings of this research can be considered robust because of its methodological rigour. We used mixed research methods, both quantitative and qualitative, and conducted the study in two phases which provided more depth.
The preliminary pilot study provided insights into the notion of complementarity and the consecutive stages inherent in ERP projects. The modified large-scale study employed a larger sample size that resulted in an increased response rate. The findings from both phases complemented each other and provided a strong platform upon which to base a rigorous conclusion. The utilisation of the partial least square (PLS) modelling technique assisted in the development of a robust theoretical framework which presents an exploratory validation on the following research issues:

(i) The existence of flanking complementarity relationships between a set of heterogeneous organisational assets with significant effects on the successes achieved across the three stages of ERP project’s lifecycle

(ii) The existence of different conditions facilitating the flanking complementary relationships across the three stages

(iii) A confirmation that an ERP project is characterised by several successive stages, thus entailing a strategic management approach in order to experience successful ERP adoption.

1.6 Research design and methodology

This research comprised two phases – pilot and large-scale studies. In each phase, data collection was both quantitative and qualitative. In the pilot study, the target respondents were 488 organisations using ERP, sourced from a private consulting firm. The sample size for the large-scale study increased to 900 organisations, using the same source as for the pilot study. Data from both studies were subjected to descriptive analysis and partial least square (PLS) estimations. The qualitative parts of the pilot and large-scale studies consisted of interviews with 9 and 22 organisations, respectively. Qualitative data obtained from semi-structured interviews were analysed using a manual coding procedure.
1.7 Thesis structure

This chapter has introduced the key research issues related to organisational assets, an ERP project’s lifecycle, the notion of complementarity and the dynamic capability view. It has also highlighted the gaps in the literature and described the research design and methodology, developed to address these gaps.

Chapter 2 presents a critical and comprehensive review of literatures associated with ERP adoption success factors, the process theory and the theory of complementarity. It also discusses the development of the research hypotheses.

Chapter 3 describes and justifies the research methodology, and explores paradigmatic issues in the pilot and large-scale studies. The chapter also explains the sequential mixed methods (quantitative and qualitative research) adopted in both phases. It describes the preliminary tests conducted on the data, as well as the PLS analysis technique.

Chapter 4 presents the findings from the data analysis in both the pilot and large-scale studies.

Chapter 5 discusses the results of the research and the theoretical and practical implications. It outlines the limitations to the research and explores possible future research directions. Finally, it presents the conclusions from the study. A summary of the thesis development process is illustrated in Figure 1.1.
Figure 1.1: Thesis development process

1. Literature review
   - Development of research issues, concepts, questions and hypotheses

2. Research design
   - Two-phase study (pilot and large scale), determination of mixed method research, identification of potential respondents, initial contacts, and other related works

3. Pilot study using preliminary research model
   - Survey with 488 sample ERP using organisations in Malaysia. We obtained 90 responses.
   - Pilot study data analysis using descriptive analysis and PLS modeling
     - Qualitative research (semi-structured interview) with 9 respondents. Data analysis using manual coding process

4. Large-scale study using quantitative research and improved research model
   - Survey with 900 ERP using organizations in Malaysia. We obtained 215 responses
   - Large-scale study data analysis using descriptive analysis and PLS modelling
     - Qualitative research (semi-structured interview) with 22 respondents. Data analysis using manual coding process

5. Interpretations, discussion and conclusions reached
   - Writing and finalising thesis document
CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

The literature review draws from a range of academic disciplines. This cross disciplinary approach integrates theories from divergent schools of thought, including strategic management, information systems, organisation and management science. To this end, we sought information primarily from top academic journals with impact factor in the Social Sciences Citation Index (SSCI), with supplementary dependence on non-refereed publications such as industrial reports and conference papers. Figure 2.1 provides a graphical representation of the research focus, which is an intersection research leveraged on ERP adoption success factors (i.e., ERP adoption), the complementary relationships between different organisational assets (the theory of complementarity) and ERP projects’ lifecycle (the process theory).

![Figure 2.1: Venn diagram of the research direction](image)

This chapter contains three main components. The first reviews three parent literatures: ERP adoption (Section 2.2), the process theory (Section 2.3) and the theory of complementarity (Section 2.4). A summary of these parent theories and their linkage with this research is given in Section 2.5. The final component of the chapter (Section 2.6) deduces the hypotheses established to test the research model.
Two sets of hypotheses were established in this research. The first four hypotheses (H1 – H4) were developed for the pilot study stage with the aim of testing the concept of complementarity in the context of ERP post-implementation stage’s success. The next five hypotheses (H5a, H5b, H5c, H6a and H6b) were established for the large-scale study. The chapter is summarised in Section 2.7. A diagrammatic representation of the literature review is shown in Figure 2.2.

**Figure 2.2: Literature review flow**
2.2 ERP adoption

“I think the world is flat” (Friedman, 2007, p.5) is a rather contentious statement written by Thomas L. Friedman in his popular book on how the world is being flattened by unprecedented technological breakthroughs. Technology is continuously evolving by the minute and new applications are flooding the market, literally overnight. Consumers and business enterprises are spoilt for choices and global boundaries are fading as technology spreads beyond geo-economic borders.

Enterprise resource planning (ERP) is one of the latest examples of technological innovation that has flattened the world. Since its introduction, ERP’s uptake by business enterprises around the world has been phenomenal. The system has enabled widespread connectivity between organisations, both from within and across geographical and political borders. Different definitions of an ERP have been given over the years, and we mention some of the commonly quoted definitions to further elucidate the concept. One of the most popularly cited definition during the 1990s was Davenport’s (1998) definition of ERP as a commercial software package that enables seamless integration of all the information flowing through the company – financial, accounting, human resources and customer information.

Several years later, Kumar and Van Hillsgersberg (2000) defined ERP as configurable information systems packages that integrate information and information-based processes within and across functional areas in an organisation. O’Leary (2001) defined it as computer-based systems designed to process an organisation’s transactions and facilitate integrated and real-time planning, production, and customer response.

Blackstone and Cox (2005, p.38) cited the Eleventh Edition of the APICS Dictionary’s definition “....a framework for organising, defining, and standardising the business processes necessary to effectively plan and control an organisation so the organisation can use its internal knowledge to seek external advantage”. In spite of the different definitions, the underlying meaning is that ERP is an integrated information system that enables seamless communications/interactions between various business processes within an organisation. The integration between different business processes is illustrated in Figure 2.3.
ERP typically comprises a central, state of the art, comprehensive database that collects, stores and disseminates data across all business functions and activities in an organisation. The system is conventionally organised into distinct functional modules, encompassing modules such as the Financials and Controlling (FICO), Human Resources (HR), Materials Management (MM) and Production Planning (PP). Each of these modules caters for the needs of specific job tasks. FICO, for instance, facilitates financial accounting activities, while MM serves the requirements of inventory management activities. Each of these modules is able to work independently or in combination, wherever applicable.

For example, a sales order received in the Sales & Distribution department will prompt issuing of an invoice. The sales details appearing in the invoice will automatically pass through to the accounting department where it will appear in Accounts Receivable and the costs of goods sold component. In this context, data are processed in real time, implying that while data entry is done only once, there will be an automatic and simultaneous data feeding throughout various other departments.
Over the years, ERP vendors began introducing advanced ERP functionalities in tandem to business requirements. As an example, during the 1970s SAP created their SAP R/2 system, which was operationalised using mainframe computer that catered the need for automated business operation. Technological shift in later years enabled SAP to introduce the SAP R/3, which operated under the client server architecture and brought efficiency and control to business. A few years ago, SAP launched SAP ERP, which is based on Service-Orientated Architectures (SOA). SOA is an architectural framework that supports divergent business process integration and real-time access by numerous users over a network. Services are the building blocks of the SOA. Various services are grouped together to form complex, integrated processes that define the sequence in which services will be invoked (Fu et al., 2007). Lately, the emergence of Software as a Service (SaaS) architecture has facilitated provision of ERP services from outside the client’s premise. In other words, SaaS enable a client to outsource a single or multiple module/functionalities to an external provider. Figure 2.4 presents a case example of SAP’s ERP architecture evolution.

**Figure 2.4: ERP architecture evolution, SAP case example**

Source: Adapted from SAP Education (2008)
2.2.1 An overview of ERP history and current state of play

Evolution in the way an organisation operates has entailed gradual dependence on technological advancements. Since 1950s, many organisations began experiencing issues in the management of inventory and labour, due primarily to the increasing complexity in the way business processes are managed (Ptak, 2004). The post-computer invention period offered some comfort, especially the invention of advanced technological systems such as ERP.

The origin of ERP can be traced back to the 1960s era, when the first generation material requirements planning (MRP) was introduced. A joint venture initiative between J.I. Case (a manufacturer of tractors and construction machineries) and IBM Corporation saw the birth of MRP, a system that assisted in materials planning and scheduling for production of complex manufactured products (Jacobs & Weston, 2007). The first-generation MRP, however, was not without its challenges. The MRP usage entailed employment of large number of technical staff to handle the IBM-created first generation mainframe computers (e.g., IBM7094 and IBM 360) that supported MRP processes. Recruitment of a large number of skilled employees entailed huge expenditure.

By the late 1970s, a manufacturing-driven business growth stratagem was introduced. Marketing growth strategy saw the need for a comprehensive integration of marketing and production units. The MRP system catered for such needs through its capability of integrating forecasting, master scheduling, procurement and shop floor control (Jacobs & Weston, 2007).

The capability of MRP was further enhanced by the introduction of IBM’s COPICS (communications orientated production information and control system), which facilitated efficient integration of non-production and production departments. Increased market competition and the emergence of learned and sophisticated users led to the development of material resource planning (MRP II) in the late 1970s (Shehab et al., 2004). The MRP II was an advanced version of MRP but with greater capabilities. MRP II had the capability of integrating key functionalities inherent in an organisation such as production, marketing and engineering (Chen, 2001).
The MRP II was also able to handle several other additional functionalities, such as planning of rough cut capacity and material planning based on production scheduling (Siriginidi, 2000).

The term ‘ERP’ (enterprise resource planning) was introduced by the Gartner Group of the United States in the mid-1970s. ERP was officially launched into the market as an alternative to MRP II in the late 1970s. ERP can handle the planning of internal and external resources at the same time, a feat that was not possible by MRP II (Chen, 2001). ERP is also different from MRP II in the context of the system’s ability of handling advanced functionalities such as order management, financial management, warehousing, distribution production, quality control, sales and marketing management and electronic commerce (Shehab et al., 2004). In other words, ERP can facilitate the entire value chain of an organisation.

There are more than 100 vendors offering ERP-based applications in the market, such as SAP, Oracle, JD Edwards, Baan and Microsoft (Shehab et al., 2004). SAP and Oracle, in particular, are regarded as the market leaders. SAP was established in Germany in 1972. SAP gained significant market share in the mid-1990s and has been pushing the market boundary ever since. In 1997, SAP’s annual revenue was recorded at US$3.1 billion (Scott & Kaindl, 2000). On a more recent note, Panorama Consulting (2008a) reported that SAP maintains a 35 per cent global ERP market share in terms of licenses and sales volume, out of which 30 and 43 per cent of their clients are small and medium sized enterprises and large organisations, respectively (Panorama Consulting, 2008b).

Oracle is perceived the second biggest ERP vendor in the world (Shehab et al., 2004). Founded in 1977 in the United States, Oracle gained a reasonable market share by introducing an ERP system that can be interfaced with other existing systems in an organisation using Oracle’s efficient database management functionality (O’Leary, 2000). By 2008, Oracle’s ERP system (called the eBusiness Suite) had gained 28 per cent of the world’s market share (Panorama, 2008a). All other vendors (e.g., JD Edwards and Microsoft) cumulatively shared 37 per cent of global ERP users. These vendors are relatively small compared to SAP and Oracle, in the context of market share.
The above-mentioned points suggest that ERP adoption across the world has been spectacular. Various industrial reports highlight the growth of ERP in terms of market share, type of industry with high adoption, ERP vendor’s sales revenue and geographic locality of ERP users. SAP’s sales revenue grew significantly from US$500 million in 1992 to US$3.3 billion in 1997 (Davenport, 1998). AMR Research estimated the ERP market as growing from US$13.4 billion in 2003 to US$15.8 billion in 2008 (Richardson, 2004). Jacobson et al. (2007) have demonstrated a significant rise in global ERP vendors’ sales revenue over the period 2005 to 2006 (refer to Table 2.1).

Table 2.1: ERP vendors’ sales revenue, 2005–2006

<table>
<thead>
<tr>
<th>Vendor</th>
<th>Revenue (US$ million) in 2005</th>
<th>Revenue (US$ million) in 2006</th>
<th>Revenue growth rate (in %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SAP</td>
<td>10542</td>
<td>11753</td>
<td>11</td>
</tr>
<tr>
<td>Oracle</td>
<td>5166</td>
<td>6044</td>
<td>17</td>
</tr>
<tr>
<td>Infor</td>
<td>480</td>
<td>2114</td>
<td>340</td>
</tr>
<tr>
<td>Sage Group</td>
<td>1438</td>
<td>1830</td>
<td>27</td>
</tr>
<tr>
<td>Microsoft</td>
<td>844</td>
<td>996</td>
<td>18</td>
</tr>
<tr>
<td>Lawson</td>
<td>346</td>
<td>560</td>
<td>62</td>
</tr>
<tr>
<td>Epicor</td>
<td>291</td>
<td>384</td>
<td>32</td>
</tr>
<tr>
<td>IFS</td>
<td>279</td>
<td>309</td>
<td>11</td>
</tr>
<tr>
<td>Exant software</td>
<td>281</td>
<td>303</td>
<td>8</td>
</tr>
<tr>
<td>Activant</td>
<td>260</td>
<td>289</td>
<td>11</td>
</tr>
<tr>
<td>CDC software</td>
<td>202</td>
<td>240</td>
<td>19</td>
</tr>
<tr>
<td>QAD</td>
<td>222</td>
<td>236</td>
<td>6</td>
</tr>
<tr>
<td>Deltek systems</td>
<td>151</td>
<td>230</td>
<td>52</td>
</tr>
</tbody>
</table>

Source: Adapted from Jacobson et al. (2007)

During these periods, small-sized enterprises (annual revenue of less than $30 million; Jacobson et al., 2007) were the major adopters of the system (27 per cent), while large enterprises’ (more than $1 billion annual revenue) ERP adoption grew at 18 percent (Jacobson et al., 2007). The ERP market saw significant development in 2006, with most vendors starting to offer a broader portfolio of products targeted to specific industries (Jacobson et al. 2007). Conventionally, ERP vendors promote customised ERP system installed in the client’s premises. Recent years however have seen greater promotion and acceptance of software as a service (SaaS) products, in which ERP vendors offer selected ERP modules based on client demand.
Panorama Consulting (2010) conducted a global survey on ERP adoption and found that 62 per cent of worldwide ERP users are located in North America and the Asia-Pacific regions. Overall, ERP systems’ market seems to be growing steadily, with continuous positive future outlook (refer to Table 2.2).

### Table 2.2: ERP market outlook 2006–2011

<table>
<thead>
<tr>
<th>Year</th>
<th>Estimated revenue (in US$ billions)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2006</td>
<td>28.8</td>
</tr>
<tr>
<td>2007</td>
<td>32.3</td>
</tr>
<tr>
<td>2008</td>
<td>35.8</td>
</tr>
<tr>
<td>2009</td>
<td>39.4</td>
</tr>
<tr>
<td>2010</td>
<td>43.4</td>
</tr>
<tr>
<td>2011</td>
<td>47.7</td>
</tr>
</tbody>
</table>

Source: Adapted from Jacobson et al. (2007)

In summary, the advent of technology and a dynamic business environment has seen the emergence of new breed of enterprise management systems. The evolution of enterprise management systems has been phenomenal, starting as a simple inventory control application and now transforming into a crucial operational platform of an enterprise. Table 2.3 presents a summary of the evolution in enterprise management systems from the 1950s to the 1990s.

### Table 2.3: Enterprise management systems evolution

<table>
<thead>
<tr>
<th>Decade</th>
<th>Concept</th>
<th>Functionality</th>
</tr>
</thead>
<tbody>
<tr>
<td>1950s</td>
<td>Inventory control systems</td>
<td>Forecast and inventory management</td>
</tr>
<tr>
<td>1960s</td>
<td>Material requirement planning (MRP)</td>
<td>Requirement calculations based on bills of materials (BoM)</td>
</tr>
<tr>
<td>1970s</td>
<td>Manufacturing resource planning (MRP II)</td>
<td>Closed loop planning and capacity constraints</td>
</tr>
<tr>
<td>1980s</td>
<td>Computer integrated manufacturing (CIM)</td>
<td>Automation of enterprise models</td>
</tr>
<tr>
<td>1990s</td>
<td>Enterprise resource planning (ERP)</td>
<td>Integrated management processes</td>
</tr>
</tbody>
</table>

Source: Adapted from Moller (2005)
2.2.2 ERP adoption failure

The above discussion highlights the growth pattern of ERP adoption over the years. Not all is rosy, however. An equal number of ERP adoption failure stories have also been reported in academic and industrial reports. Since the mid-1990s, a significant number of cases have failed (e.g., Martin, 1998; Stedman, 1999; Levinson, 2001; Fitzsimmons, 2002). Most ERP failure seems to have had minimal adverse impact on the adopting organisation. Marion (2000) and Brown (2002) reported incompatible technical systems and difficulty of accessing proper information as the primary negative effects caused by ERP systems, respectively. Some cases, however, showed stronger adverse impact on the economic health of the adopting organisation. Marion (1999), for example, demonstrated how corporations such as Boeing’s and Kellogg’s ERP adoptions have led to poor business growth. Kellogg’s in particular had to bear a write-off of US$70 million in order to streamline their business processes post adoption of the Oracle system. Stein (1998) enumerated the case of Unisource Worldwide Incorporated that discontinued and wrote off USD$168 million of its ERP project’s cost.

There are also cases of extreme effects. For example, Foxmeyer – once one of the biggest Drug production corporations in the United States – suffered bankruptcy due to failed ERP implementation (Davenport, 1998). While Fox Meyer blamed their ERP vendor (SAP AG) for their failed implementation, part of the failure has been attributed to Fox Meyer’s incompetence in strategically managing their ERP project (Jesitus, 1997). Whilst the top management of Fox Meyer was committed to ERP adoption, the users of the system were non-participative due to low morale and fear of change. Apart from this, heavy reliance on an ERP implementation consultant (Anderson Consultants) seems to have exacerbated the problem (Caldwell, 1998). Many of the external consultants were inexperienced, as SAP had used a lot of trainee consultants to complete the job. This resulted in heavy mismanagement of the project scope and cost.

Another strand of reports highlights ERP failure in the context of project overrunning budget and exceeding project schedule, with Pender (2000), Patton (2001) and SMU (2001) citing Siemens Power Transmission, Nash Finch (supermarket corporation) and Singapore Management University case examples, respectively. Other high-profile ERP adoption failure stories repeatedly mentioned in the literature are the cases of Dell Computers, Dow Chemicals, Hershey Food Cooperation and Whirlpool (Davenport, 1998).
These failures have occurred primarily amongst organisations operating in developed countries, although ERP adoption failures have also been noted in organisations operating in developing countries (e.g., China: Liang et al., 2004; Huang et al., 2004; Xue et al., 2005; Brazil: Franca, 1998; Saba, 1999; India: Erry, 1998).

2.2.3 ERP adoption success

ERP adoption success has a number of definitions. Markus and Tanis (2000a, p.186) conceptualised ERP adoption success as “the best outcomes the organisation could achieve with ERP, given its business situation, measured against a portfolio of projects, early operational and long term business results metrics”. Esteves et al. (2003, p.449) defined success as “finishing on time, on budget, obtaining the expected functionality, the system is being used by its intended users and implemented in the correct way into account the organisational and cultural values of the organisation”. Ifinedo and Nahar (2006, p.1554) generalised success as “the utilisation of such systems to enhance organisational efficiency and effectiveness”.

The various conceptualisations of ERP success signify the vitality of measuring ERP adoption success – a point evidently seen from the numerous industrial and academic reports on ERP adoption success over the years (e.g., Davenport, 1998; Callaway, 1999; Delloite Consulting, 2000; Poston and Grabski, 2001; Harris & Davenport, 2006. As noted by Clearpath SAP Consulting (2011, p.1):

“ERP ……allows organisations to have accurate information real time which saves big time on inventory costs as well eliminating guessing what was sold and how much you need. ERP systems have been so successful in accomplishing this mission, organisations that successfully implement ERP systems have moved to the top of their industry ranking because they become cost leaders effectively managing their day to day operations. The early adopters of ERP systems acquired a strategic advantage over their competition”.

22
The above statement suggests ERP vendors’/consultants’ strong belief in the advantages that an organisation can reap from having an ERP system. Over the years, ERP adoption success has been measured empirically in different dimensions (Markus & Tanis, 2000b), three which have received significant attention in the literature: economic payoffs, business operational efficiency and users’ perceived benefits.

• **Economic payoffs**
   A substantial amount of research has measured success in the context of economic payoffs. Studies have empirically assessed the financial returns gained post-adoption of the system (e.g., Hayes et al., 2001; Hunton et al., 2002; Nicolaou et al., 2003; Matolcsy et al., 2005), and have found evidence that organisations using ERP experience more robust financial performance than non-adopting organisations. Reported financial returns include cost savings, headcount reduction, improved resource management and increased productivity (Shang & Seddon, 2000; Davenport et al., 2004; Yang & Seddon, 2004; Harris & Davenport, 2006).

• **Business operational efficiency**
   ERP presents the opportunity to reduce operational uncertainty produced by poor information sharing mechanisms within an organisation (Ferdows, 2006). The tight integration mechanism inherent in an ERP system can reduce uncertainty by coordinating information sharing, improving information visibility and facilitating easy information sharing amongst interdependent business units. The standardisation of business processes through ERP also facilitates consistent information presentation. These inputs can lead to improved operational planning and decision making processes. This, in turn, can assist managers align their organisation’s structure with strategic goals and thus achieve greater control of operational expenditures (Kouvelis et al., 2005).

• **ERP users’ perceived benefits**
   The perceptions of ERP end users (i.e., employees and managers) have also been significantly explored. From the end user’s viewpoint, a successful system would improve their work performance (Al-Mashari et al., 2003; Lim et al., 2005; Wu & Wang, 2007; Ifinedo, 2007).
The full potential of an ERP system can be leveraged only when the end users are satisfied with the system (Ngai et al., 2008), and thus it is imperative to understand end users’ perspectives on the effectiveness of the system (Somers et al., 2003). One of the most popular tools used to gauge end user satisfaction with ERP is the IS success model developed by DeLone and McLean (1992). This interactive model and taxonomy provide the framework for conceptualising IS success using six dimensions: system quality, information quality, information use, user satisfaction, individual impact and organisational impact. Gable et al. (2003) used the DeLone & McLean success model to re-develop an ERP-D&M success model with four dimensions (system quality, information quality, individual impact and organisational impact). The modified model received widespread acceptance in the literature (e.g., Sehgal & Stewart, 2004; Chiplunkar et al., 2003; Ramayah & Lo, 2007; Rich & Dibbern, 2010). The common consensus in most of these studies is that system quality and information quality are the primary areas of users’ satisfaction.

2.2.3.1 Success across ERP project’s lifecycle

The discussions in the previous section highlight the importance of measuring ERP success. Many of these researches, however, have gauged success in the context of a single dimension of an ERP project’s lifecycle, especially the implementation and post-implementation stages (Zhu et al., 2010)\(^2\). There is a call for researchers to examine the success achieved throughout the ERP project’s lifecycle context (Velcu, 2007). An ERP project’s lifecycle comprises several successive stages: pre-implementation, implementation and post-implementation (Krupp, 1998; Abdinour-Helm et al., 2003). Each stage is represented by execution of certain activities, leading to the completion of the stage before moving on to the next. Each stage is considered completed by the achievement of certain pre-determined successes (Wu, 2007).

The ERP pre-implementation stage entails planning for ERP adoption activities, such as identification and selection of the right ERP vendor, consultants, identification of project team members and its formation structure, preliminary design of the new business process blueprint and allocation of any other required resources.

\(^2\) In-depth discussion of ERP project’s lifecycle is given in Section 2.3: Process Theory. A brief outline of the project’s lifecycle is provided in this section due to the nature of the discussion which is the success across different stages of the project.
Achievement of these activities indicates the organisation’s readiness to adopt ERP (Abdinour-Helm et al., 2003) -- the success of the pre-implementation stage. For the purpose of this study, organisational readiness is characterised as the extent an organisation is prepared to deploy their strategic assets for an ERP project’s purpose.

The ERP project then shifts to the implementation stage, involving activities such as business process re-engineering, prototype development, user training and implementation of the system go-live process. The success of this stage is proxied by completion of the project’s targets being met; these include minimal resource wastage, not overrunning project budget, scheduled timeline, all users being properly trained and other project objectives (Wang & Chen, 2006; Wu, 2007).

The last stage, ERP post-implementation, is represented by activities such as technology migration, fixing bugs, retraining of users, routinisation, and ongoing maintenance of the new system into the existing work system. The success of this stage is often measured by analysing the business performance outcomes post ERP usage, especially in the context of improved business process outcomes such as increased productivity and reduced operational costs (Karimi et al., 2007). Studies by Yu (2005) and Nicolaou and Bhattacharya (2006, 2008) are among the few that have examined the success of the ERP post-implementation stage.

2.2.4 ERP adoption critical success factors

The ERP adoption failure cases gave rise to numerous academic publications exploring the reasons and strategies to achieve successful ERP adoption. Investigation of the ERP adoption success entailed identification of the critical success factors (CSFs). The term ‘CSF’ refers to the few critical areas where things must go right for a business to flourish (Rockhart, 1979).

CSF has been widely used as a methodology in IS research, despite the lack of a theoretical basis, potential for interviewer bias and the absence of established, consistent procedures for identifying CSFs and carrying out CSF studies (Boynton & Zmud, 1994).
Despite the lack of theoretical backing criticism, CSF studies can still be considered as valuable for making sense out of problems where there are many potential factors influencing the outcome, and where a set of practical recommendations can be based on the most influential factors (Lam, 2005).

Empirical examination of the CSFs for ERP can be found in research publications dating back to the early 1980s. One of the earliest empirical identifications of ERP-related CSFs is the work of Duchessi et al. (1988). The authors analysed the CSFs for MRPII (a predecessor to ERP system) and proposed factors such as project champion, project management, business plan and vision, top management support, effective communication and change to the management program as the critical elements for MRPII adoption success. In the direct context of an ERP system, Holland and Light (1999) defined CSFs as “factors needed to ensure a successful ERP project” (p.31). Over the years, various CSFs for successful ERP adoption have been identified in the literature (e.g., Bancroft et al., 1998; Parr et al., 1999; Stefanou, 1999; Kale, 2000; Arnold, 2006; Bradley, 2008; Hanafizadeh et al., 2010). Huang (2010) reviewed ERP-CSFs literature over the period 1998-2007 and highlighted ten factors that have been constantly cited as the most important CSF for ERP adoption’s success:

1. Top management support
2. Teamwork and composition
3. Education and training
4. Project management
5. Clear scope and goals
6. Business process reengineering
7. Change management program
8. Project champion
9. Open communication
10. Appropriate vendor and suppliers

Apart from general identification of ERP adoption success factors, studies by Esteves and Pastor (2000, 2003), Nah et al. (2001) and Somers and Nelson (2001, 2004) identified pertinent CSFs across the different stages of ERP project’s lifecycle. A brief review of these studies is given next due to its direct association with the current research focus.
Esteves and Pastor (2000) reviewed numerous ERP-CSFs studies undertaken prior to the year 2000 and developed an integrated CSF model – called the *unified CSF model*. In this model, the authors divided a number of critical success factors into four cohorts: organisational, technological, strategic and tactical. The organisational perspective is related to concerns like organisational structure and culture, and business processes. The technological perspective focuses on aspects related to the particular ERP product in consideration and on other related technical aspects, such as hardware and base software needs.

The strategic perspective is related to core competencies accomplishing the organisation’s mission and long-term goals, while the tactical perspective affects the business activities with short-term objectives. The matrix relationship between the four cohorts can be described using the following example: project scope management is a strategic success factor and facilitate achievement of organisational level needs. Esteves and Pastor’s model is reproduced in Table 2.4.

**Table 2.4: Unified critical success factors model**

<table>
<thead>
<tr>
<th></th>
<th>Strategic</th>
<th>Tactical</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Organisational</strong></td>
<td>• Sustained management support</td>
<td>• Dedicated staff and consultants</td>
</tr>
<tr>
<td></td>
<td>• Effective organisational change management</td>
<td>• Strong communication inwards &amp; outwards</td>
</tr>
<tr>
<td></td>
<td>• Adequate project team composition</td>
<td>• Formalised project plan/schedule</td>
</tr>
<tr>
<td></td>
<td>• Good project scope management</td>
<td>• Adequate training programs</td>
</tr>
<tr>
<td></td>
<td>• Comprehensive business process redesign</td>
<td>• Preventive trouble shooting</td>
</tr>
<tr>
<td></td>
<td>• Adequate project champion role</td>
<td>• Appropriate usage of consultants</td>
</tr>
<tr>
<td></td>
<td>• Trust between partners</td>
<td>• Empowered decision makers</td>
</tr>
<tr>
<td></td>
<td>• User involvement and participation</td>
<td></td>
</tr>
<tr>
<td><strong>Technological</strong></td>
<td>• Adequate ERP implementation strategy</td>
<td>• Adequate infrastructure and interfaces</td>
</tr>
<tr>
<td></td>
<td>• Avoid customisation</td>
<td>• Adequate legacy systems knowledge</td>
</tr>
<tr>
<td></td>
<td>• Adequate ERP version</td>
<td></td>
</tr>
</tbody>
</table>

Source: Esteves and Pastor (2000)
Several years later, Esteves and Pastor (2003) analysed the evolution of strategic and tactical factors along ERP adoption phases. The authors used SAP’s ASAP implementation model to identify pertinent success factors across the following five stages:

- **Project preparation** – initial planning and preparation of SAP project
- **Business blueprint** – creation of the business blueprint detailing the project scope and system implementation requirements
- **Realisation** – implementation of business and processes requirements on the business blueprint
- **Final preparation** – completion of the final preparation, including testing, user training and
- **Go live and support** – moving from the pre-production environment to live production operation. Long-term support for end users is given.

A summary of the findings by Esteves and Pastor’s (2003) is provided in Table 2.5.

**Table 2.5: Esteves and Pastor’s (2003) critical success factors across SAP ASAP model**

<table>
<thead>
<tr>
<th>SAP project stage</th>
<th>Critical success factors</th>
<th>Perspectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project preparation</td>
<td>Sustained management support</td>
<td>Strategic</td>
</tr>
<tr>
<td></td>
<td>Adequate project champion role</td>
<td>Tactical</td>
</tr>
<tr>
<td></td>
<td>Formalised project plan/schedule</td>
<td>Tactical</td>
</tr>
<tr>
<td>Business blueprint</td>
<td>Adequate organisational change management</td>
<td>Strategic</td>
</tr>
<tr>
<td></td>
<td>User involvement and participation</td>
<td>Strategic</td>
</tr>
<tr>
<td></td>
<td>Adequate project champion role</td>
<td>Strategic</td>
</tr>
<tr>
<td>Realisation</td>
<td>Adequate infrastructure and interfaces</td>
<td>Tactical</td>
</tr>
<tr>
<td></td>
<td>User involvement and participation</td>
<td>Strategic</td>
</tr>
<tr>
<td></td>
<td>Adequate project champion role</td>
<td>Strategic</td>
</tr>
<tr>
<td>Final preparation</td>
<td>Adequate project champion role</td>
<td>Strategic</td>
</tr>
<tr>
<td></td>
<td>Preventive trouble shooting</td>
<td>Tactical</td>
</tr>
<tr>
<td>Go live and support</td>
<td>Adequate project champion role</td>
<td>Strategic</td>
</tr>
<tr>
<td></td>
<td>Sustained management support</td>
<td>Strategic</td>
</tr>
<tr>
<td></td>
<td>Strong communication inwards &amp; outwards</td>
<td>Tactical</td>
</tr>
</tbody>
</table>

The authors concluded that ERP adoption entails careful management of strategic and tactical factors along the different stages of ERP project lifecycle. Further, since the project champion role was found to be crucial in almost all stages, diligent selection of the right person as project champion is essential. Finally, Esteves and Pastor (2003) demonstrated that ERP adoption involves a dynamic multi-success factor management as the most relevant CSFs may change along the project’s lifecycle.

Nah et al. (2001) undertook a comprehensive review of the literature and mapped 11 important CSFs across Markus and Tanis’s (2000) four stages of ERP project’s lifecycle:

- **Chartering** – The chartering phase comprises decisions leading to funding of the ERP system project.
- **Project** – The project phase comprises system configuration and rollout.
- **Shakedown** – The shakedown phase refers to the period of time from “going live” until “normal operation” or “routine use” has been achieved.
- **Onward & upward** -- refers to ongoing maintenance and enhancement of the ERP system and relevant business processes to fit the evolving business needs of the organisation. It continues from normal operation until the system is replaced with an upgrade or a different system.

Nah et al. (2001) found that six factors (ERP teamwork & composition, top management support, business plan & vision, effective communication, project management and project champion) remain important in all the four stages of ERP project’s lifecycle. An appropriate business and legacy system was found to be important in the Chartering stage, while change management program, business process reengineering & minimum customisation, and software development, testing and troubleshooting were found to be important in the Project stage. Finally, monitoring and evaluation of performance were found to be essential in the Shakedown stage. A summary of these findings is given in Table 2.6.
Table 2.6: Summary of Nah et al.’s (2001) critical success across ERP project’s four stages

<table>
<thead>
<tr>
<th>Critical success factor</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP teamwork and composition</td>
<td>Chartering, Project, Shakedown, Onward &amp; Upward</td>
</tr>
<tr>
<td>Top management support</td>
<td>Chartering, Project, Shakedown, Onward &amp; Upward</td>
</tr>
<tr>
<td>Business plan and vision</td>
<td>Chartering, Project, Shakedown, Onward &amp; Upward</td>
</tr>
<tr>
<td>Effective communication</td>
<td>Chartering, Project, Shakedown, Onward &amp; Upward</td>
</tr>
<tr>
<td>Project management</td>
<td>Chartering, Project, Shakedown, Onward &amp; Upward</td>
</tr>
<tr>
<td>Project champion</td>
<td>Chartering, Project, Shakedown, Onward &amp; Upward</td>
</tr>
<tr>
<td>Appropriate business &amp; legacy systems</td>
<td>Chartering</td>
</tr>
<tr>
<td>Change management programs</td>
<td>Project</td>
</tr>
<tr>
<td>Business process reengineering &amp; minimum customisation</td>
<td>Project</td>
</tr>
<tr>
<td>Software development, testing &amp; trouble shooting</td>
<td>Project</td>
</tr>
<tr>
<td>Monitoring &amp; evaluation of performance</td>
<td>Shakedown</td>
</tr>
</tbody>
</table>

Source: Adapted from Nah et al. (2001)

Somers and Nelson (2001) collected survey data from 86 organisations operating in the United States and examined the critical success factors across six different stages (Initiation, Adoption, Adaptation, Acceptance, Routinisation and Infusion) of an ERP project’s lifecycle. Using a ranking procedure, the authors segregated pertinent success factors to its appropriate stages (refer to Table 2.7), based on the responses provided by the surveyed organisations. In this study, Somers and Nelson found that top management support remains critical in almost all the stages (with the exception of the Adoption stage).

On a similar note, interdepartmental communication and interdepartmental cooperation were found to be important in four stages. Somers and Nelson concluded that identification of the pertinent success factors across the different stages would assist in effective management of organisational resources and time across the ERP project lifecycle, thus leading to improved ERP adoption success rate.
Table 2.7: Somers and Nelson’s (2001) critical success factors across ERP project’s six stages

<table>
<thead>
<tr>
<th>ERP stage</th>
<th>Critical success factor</th>
</tr>
</thead>
</table>
| Initiation | 1. Architecture choices  
2. Clear goals and objectives  
3. Partnership with vendor  
4. Top management support  
5. Careful selection of package |
| Adoption | 1. Top management support  
2. Project team competence  
3. Use of steering committee  
4. Partnership with vendor  
5. Dedicated resources |
| Adaptation | 1. Interdepartmental communication  
2. Interdepartmental cooperation  
3. Project team competence  
4. Dedicated resources  
5. Use of vendors’ tools |
| Acceptance | 1. Interdepartmental communication  
2. Interdepartmental cooperation  
3. Top management support  
4. Project team competence  
5. Education on new business processes |
| Routinisation | 1. Interdepartmental communication  
2. Top management support  
3. Interdepartmental cooperation  
4. Vendor support  
5. User training on software |
| Infusion | 1. Interdepartmental communication  
2. Interdepartmental cooperation  
3. Top management support  
4. Vendor support  
5. Partnership with vendor |

Source: Somers and Nelson (2001)
In a subsequent study, Somers and Nelson (2004) collected data from 133 organisations in the United States and again examined the importance 22 CSFs toward ERP adoption success. Whilst the overall empirical results are similar to the previous study, certain differences were observed.

The authors found that the majority of the respondents viewed top management support and clear goals and objectives as pertinent success factors in almost all the stages. User training was found to be critical in four stages (Initiation, Adoption, Adaptation and Routinisation), a different result from their first study, which found user training important only in the Routinisation stage. Another difference was the context of change management and education on business reengineering. These factors were found to be essential in the Initiation stage, in contrast to their previous study which found these factors important only in the later stages.

2.2.4.1 Summary of critical success factors across ERP project’s lifecycle

We also reviewed studies that have examined the critical success factors in a certain stage, exclusively. We need to highlight that different authors presented different classifications to ERP project lifecycle, although the central theme behind the stages remains the same. In this research, we adopted the ERP project lifecycle classifications suggested by Abdinour-Helm et al. (2003): pre-implementation, implementation and post-implementation.

A review of past studies on the critical success factors across these three stages is summarised in Table 2.8. We reviewed stage-based studies over the period 2000–2011. It can be seen from Table 2.8 that top management, user involvement, training and project management factors have been consistently used in independent stage studies (e.g., Parr & Shanks, 2000; Wu, 2007) and also in all stages integrated based studies (e.g., Nah et al., 2001; Somers & Nelson, 2004). The review also illustrates that while independent stage-based studies can be found until 2010 (Zhu et al., 2010), we did not find any integrated stages studies beyond 2004.
Table 2.8: Summary of critical success factors across ERP project’s lifecycle

<table>
<thead>
<tr>
<th>ERP project’s stage *</th>
<th>Critical success factors</th>
<th>Author(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP pre-implementation</td>
<td>Top management support</td>
<td>Parr &amp; Shanks (2000)</td>
</tr>
<tr>
<td></td>
<td>Top management support, Project management</td>
<td>Shanks et al. (2000)</td>
</tr>
<tr>
<td></td>
<td>Top management support</td>
<td>Somers &amp; Nelson (2001)</td>
</tr>
<tr>
<td></td>
<td>Top management support, Project management, IT infrastructure</td>
<td>Nah et al. (2001)</td>
</tr>
<tr>
<td></td>
<td>Top management support</td>
<td>Al-Mashari et al. (2003)</td>
</tr>
<tr>
<td></td>
<td>Top management support, Project management, Training</td>
<td>Guang-hui et al. (2006)</td>
</tr>
<tr>
<td></td>
<td>User involvement, Top management support, Training, Business process knowledge, Project management</td>
<td>Plant &amp; Willcocks (2007)</td>
</tr>
<tr>
<td></td>
<td>IT skills, Business process knowledge, IT infrastructure</td>
<td>Wu (2007)</td>
</tr>
<tr>
<td>ERP implementation</td>
<td>Top management support</td>
<td>Parr &amp; Shanks (2000)</td>
</tr>
<tr>
<td></td>
<td>Top management support, Project management</td>
<td>Shanks et al. (2000)</td>
</tr>
<tr>
<td></td>
<td>Top management support, IT skills, Business process knowledge</td>
<td>Somers &amp; Nelson (2001)</td>
</tr>
<tr>
<td></td>
<td>Top management support, Project management, IT infrastructure</td>
<td>Nah et al. (2001)</td>
</tr>
<tr>
<td></td>
<td>Project management, Training, Business process knowledge</td>
<td>Al-Mashari et al. (2003)</td>
</tr>
<tr>
<td></td>
<td>Training, Top management support</td>
<td>Guang-hui et al. (2006)</td>
</tr>
<tr>
<td></td>
<td>Top management support, Project management, IT infrastructure, User involvement, Training, Business process knowledge, IT skills</td>
<td>Plant &amp; Willcocks (2007)</td>
</tr>
<tr>
<td></td>
<td>Top management support, Project management, User involvement, IT infrastructure</td>
<td>Wu (2007)</td>
</tr>
<tr>
<td>ERP post-implementation</td>
<td>Top management support</td>
<td>Parr &amp; Shanks (2000)</td>
</tr>
<tr>
<td></td>
<td>Top management support, Training</td>
<td>Shanks et al. (2000)</td>
</tr>
<tr>
<td></td>
<td>Top management support, Training</td>
<td>Somers &amp; Nelson (2001)</td>
</tr>
<tr>
<td></td>
<td>Top management support, Project management</td>
<td>Nah et al. (2001)</td>
</tr>
<tr>
<td></td>
<td>Training, Top management support</td>
<td>Guang-hui et al. (2006)</td>
</tr>
<tr>
<td></td>
<td>User involvement, Top management support, Training, Business process knowledge, Project management</td>
<td>Plant &amp; Willcocks (2007)</td>
</tr>
<tr>
<td></td>
<td>Training</td>
<td>Wu (2007)</td>
</tr>
<tr>
<td></td>
<td>Project management, top management support</td>
<td>Zhu et al. (2010)</td>
</tr>
<tr>
<td></td>
<td>IT skills</td>
<td>Ifinedo (2011)</td>
</tr>
<tr>
<td>All stages</td>
<td>Top management support, Project management</td>
<td>Nah et al., (2001)</td>
</tr>
<tr>
<td></td>
<td>Top management support</td>
<td>Somers and Nelson (2001)</td>
</tr>
</tbody>
</table>

*The names of the stages in some reference article were different. The researcher customised the names to suit the classification of ERP stages used in this research*
2.2.5 Summary of ERP adoption

This section of the chapter has discussed ERP adoption, encompassing ERP development history, ERP adoption failure and success stories, definition and measurement of success across ERP project’s lifecycle and ERP adoption critical success factors in a general context, as well as the critical success factors in different stages of an ERP project’s lifecycle. The primary motive of this section is to inform about the limited research attention on ERP’s different stages’ (integrated approach) critical success factors and its linkage to successes achieved in each stage of the project. We intend to fill such research gaps by examining the effects of several contextual factors (referred to as organisational assets in this research) in achievement of success in three stages, that is, pre-implementation, implementation and post-implementation. A detailed explanation about the different stages involved in ERP project’s lifecycle is given next.

2.3 The process theory

Many scholars have attempted to understand the intrinsic issues surrounding technology adoption woes and its solutions over the years. Process theory seems to be a popular research tool to this end (Kwon & Zmud, 1987). Process theory articulates on the importance of social change activities in an organisation (such as change management and project planning processes) in order to reap successful technology adoption (Ginzberg, 1981). This theory provides powerful explanations even when the necessary antecedent factors that normally induce outcomes cannot be determined (Kumar et al., 2003). This is because process theory driven research reflects on the events and behaviours that happens within an organisation that is adopting a new technological innovation. Reflection of events and behaviours is often done by categorising the technology adoption process into several successive stages, and ends with achievement of the desired outputs such as increased productivity or business value (Soh & Markus, 1995).

Tracing the events and behaviours happening within the technological innovation adoption processes is similar to the approach of Rogers (1983) and his popularly known the ‘Diffusion of Innovation’ theory. Rogers conceptualised innovation adoption undergoing two primary stages – adoption and implementation.
Leveraging on this, various other expanded theoretical models have been presented, with authors arguing that innovation adoption comprises more than two stages. Kwon and Zmud (1987) proposed a six-stage technology adoption model consisting of (1) Initiation; (2) Adoption; (3) Adaptation; (4) Acceptance; (5) Routinisation; and (6) Infusion. Following this, Cooper and Zmud (1990) categorised technology adoption into four stages – initiation, adaption, adoption and acceptance. Soh and Markus (1995) used different terms to identify three primary stages: IT expenditure (adoption), IT assets (implementation) and organisational impacts (post-implementation). A summary of the different process theory driven technological innovation adoption stages as highlighted in related literature is given in Table 2.9.

Table 2.9: Key process theory driven technological innovation adoption stages

<table>
<thead>
<tr>
<th>Authors</th>
<th>Stages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rogers (1983)</td>
<td>Adoption and implementation</td>
</tr>
<tr>
<td>Pierce &amp; Delbecq</td>
<td>Initiation, adoption and implementation</td>
</tr>
<tr>
<td>Kwon &amp; Zmud (1987)</td>
<td>Initiation, adoption, adaptation, acceptance, routinisation &amp; infusion</td>
</tr>
<tr>
<td>Cooper and Zmud</td>
<td>Initiation, adaption, adoption and acceptance</td>
</tr>
<tr>
<td>Soh and Markus (1995)</td>
<td>IT expenditure (adoption), IT assets (implementation) and organisational impacts (post-implementation)</td>
</tr>
<tr>
<td>Kumar et al., (1996)</td>
<td>Conceptualisation, development, implementation, program monitoring, qualification, and acceptance</td>
</tr>
<tr>
<td>Markus &amp; Tanis (2000)</td>
<td>Project chartering, project configuration, shakedown, onwards and upwards</td>
</tr>
<tr>
<td>Niemi et al., (2009)</td>
<td>Initial, awareness, establishment, quantitative management, and optimisation</td>
</tr>
</tbody>
</table>

2.3.1 The process theory and ERP adoption

The process stage models presented by Rogers (1983), Cooper and Zmud (1990) and Soh and Markus (1995) generally relate to technological innovation adoption. The work of Markus and Tanis (2000a) was among the first to link the process theory with ERP adoption – one of the foremost technological innovations in modern times. Markus and Tanis presented the “ERP systems experience cycle” framework, which explains an ERP project’s lifecycle in the context of four successive stages and its associated activities and outcomes (refer to Table 2.10). Markus and Tanis’s model is an extension of Soh and Markus’s (1995) framework. The Markus and Tanis model facilitates a greater understanding on successful ERP adoption for three reasons:
• First, the Markus and Tanis (2000a) model presents the necessary conditions for successful outcome in each stage of ERP project’s lifecycle.

• Second, the presentation of the outcome of one stage being the starting condition for the next stage indicates the importance of managerial efficiency, since the decisions and actions taken in a stage may have a positive or negative impact on the overall success.

• Third, this framework highlights the importance of interactions between various activities in each stage in determining the success of a particular stage. Poor interactions due to unsynchronised activities and/or unresolved and cascading problems in a particular stage may produce an unsuccessful outcome.

Markus and Tanis’s (2000a) comprehensive model has been well received in the literature (with Scopus tracking 163 citations by 2011). However, other researchers have also introduced their own versions of the ERP adoption phenomenon/experience. Krupp (1998), for example, classified an ERP project into three stages: pre-implementation, implementation and post-implementation. The pre-implementation stage was defined as the development of organisational vision, selection of project leader and the expectations and deliverables for the system. The implementation stage comprises the transition to ERP with selection of the software package, training, start-up and debugging. The post-implementation stage is the last component of an ERP project’s lifecycle, and is characterised by further training to users, continual monitoring of the new system and solutions to problems encountered. Krupp’s classification has been adopted recently by Abdinour-Helm et al. (2004).

Ross and Vitale (2000) promoted a five-stage model, while Rajagopal (2002) pushed further and provided a six-stage adoption model. Davenport et al. (2002) classified an ERP project’s lifecycle in the context of what the system facilitates across three different stages: integrate, optimize and informate. Davenport et al. (2002) argue that the first stage in an ERP project is integrate – defined as the process of unifying and harmonising data and processes with an organisation’s environment. Optimise is standardisation of business processes using best practices embodied in an ERP system, while Informate is defined as utilisation of information to transform data into knowledge that supports business analysis and decision-making needs. Regardless of the different categorisation of an ERP project’s lifecycle in the literature, the key tenet is that ERP project undergoes a series of successive stages with each stage achieving its own outcomes.
Table 2.10: Markus and Tanis’s (2000a) ERP systems experience cycle

<table>
<thead>
<tr>
<th>Stage and its description</th>
<th>Typical activities</th>
<th>Possible success achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chartering (ideas to dollars)</td>
<td>• Ideas of adopting ERP surfaced</td>
<td>• Decision to proceed with the ERP project with certain parameters</td>
</tr>
<tr>
<td></td>
<td>• Business case for investment</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Definition of key performance indicators and process of measurement</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Current state analysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Selection of software, hardware platform, networking and database</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Initial plan of how the system will be rolled out, supported and maintained</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Communication to organisation</td>
<td></td>
</tr>
<tr>
<td>Project stage (dollars to assets)</td>
<td>• Selection of ERP product, project manager and implementation partners</td>
<td>• Project cost relative to budget</td>
</tr>
<tr>
<td></td>
<td>• Configuration of project team</td>
<td>• Project completion on time relative to schedule</td>
</tr>
<tr>
<td></td>
<td>• Development of detailed project plan</td>
<td>• Completed and installed system functionality relative to original project scope</td>
</tr>
<tr>
<td></td>
<td>• Selection and assignment of project team members</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Ongoing project management</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Training of project team members and acquisition of supportive skills</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Infrastructure upgradation</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Software configuration and “fit with the organisation”</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Testing, bug fixing and rework</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Executive and end user training</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Rollout and start-up</td>
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<td></td>
<td>• Post-implementation investment audit</td>
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<td></td>
<td>• Continuous business improvement</td>
<td>• Formal and informal assessment that project has achieved goals/and or unexpected benefits (i.e., organisation improves its overall competitive position)</td>
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<td></td>
<td>• Technology upgrading/migration</td>
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<td>• Additional end user skill building</td>
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<tr>
<td>Shakedown (assets to impacts)</td>
<td>• System performance tuning</td>
<td>• Normal operation with routine use of the system is achieved</td>
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<td>• Adding hardware capacity</td>
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<td>• Process and procedure changes</td>
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<td>• Retraining, additional training</td>
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<td>• Adding people to accommodate learning and shakedown needs</td>
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<td>Onward and upward (impacts to outcomes)</td>
<td>• Post-implementation investment audit</td>
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Source: Adapted from Markus and Tanis (2000a)
2.3.1.1 Process theory-ERP lifecycle based empirical studies

The process theory driven ERP adoption phenomenon has received some attention in the literature. We say this because, while the academic citations are high (e.g., Markus & Tanis, 2000a; 163 citations as at 2011), direct validation of the different process theory-ERP project lifecycle models in related academic literature is limited. Nah et al. (2001) are amongst the few that have used the Markus and Tanis (2000a) process theory-ERP lifecycle model and identified critical success factors across different stages of ERP project lifecycle. The authors found that the importance of success factors across the different stages is dynamic. Kumar et al. (2003) adopted the Markus and Tanis (2000a) framework and tested the critical factors that facilitate the Shakedown stage (which comprises activities such as system maintenance, addition of hardware capacity and retraining of users) completion. The authors found that managing change, proper training and project management represent the critical issues that require managerial attention in the Shakedown stage.

Hakkinen and Hilmola (2008) used Markus and Tanis’s model and examined how user evaluations of ERP system success can be used to trace the source of potential problems that could arise in the Shakedown phase. The authors concluded that, in the Shakedown phase, assuring quality of information, adequate ERP skills and effective communication are amongst the three key issues that need to be managed to avoid before and after ERP implementation problems.

The theoretical models proposed by Krupp (1998), Ross and Vitale (2000), Rajagopal (2002) and Davenport et al. (2002) have not been empirically validated in the literature, although indirect citations or inferences have generously been made in ERP adoption literature. It seems that only Markus and Tanis (2000a) model have been empirically tested, albeit to a limited degree.
2.3.2 Summary of process theory

This section has presented a review of theoretical and empirical studies on the process theory, which highlights the importance of segmenting an ERP project into several successive stages. The review of related research demonstrates a lack of empirical validation on the different ERP lifecycle models. We fill this gap by examining the causal relationships between several contextual organisational assets in completion of the first stage (pre-implementation) and its impact toward the commencement of the next stage, and so forth. This approach presents a reasonable validation of the notion that ERP project undergoes several successive stages. The next section of the chapter presents a discussion of the theory of complementarity.

2.4 The theory of complementarity

The term ‘complementarity’ has its origin to the Latin word *complere*, or ‘to fill up’ (Ennen & Richter, 2010). Edgeworth (1881) introduced this concept into economics and argued that complementarity will exist when the mixed partial derivatives of a payoff function are positive. In other words, in economic terms, the marginal returns from one factor increase in the level of the other factors (Milgrom & Roberts, 1994).

Drawing on the economic conceptualisation, Milgrom and Roberts (1995a) used mathematical concepts to define complementarity as the synergistic effects that a bundle of organisational activities and practices create by mutual enhancement of each other’s role and contribution. This phenomenon can be explained by using a simple mathematical illustration, reproduced here from Stieglitz and Heine (2007)\(^3\):

Two activities, x and y, may be set either ‘low’ or ‘high’, with \(\pi\) denoting their joint performance. The activities are complementary if \(\pi [x_{\text{low}}, y_{\text{low}}] \geq \pi [x_{\text{high}}, y_{\text{low}}]; \pi [x_{\text{low}}, y_{\text{high}}] \geq \pi [x_{\text{high}}, y_{\text{low}}]; \pi [x_{\text{low}}, y_{\text{high}}] \geq \pi [x_{\text{high}}, y_{\text{low}}]; \pi [x_{\text{low}}, y_{\text{high}}].\) While \(\pi [x_{\text{low}}, y_{\text{low}}]\) and \(\pi [x_{\text{high}}, y_{\text{high}}]\) represent consistent activity systems, the choices \(\pi [x_{\text{high}}, y_{\text{low}}]\) and \(\pi [x_{\text{low}}, y_{\text{high}}]\) are inconsistent, delivering a lower overall performance.

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\(^3\) Detailed discussion on the mathematical derivation of complementarity effect is seen in Milgrom and Roberts (1995a) paper.
Milgrom and Roberts (1995a: 188-189) explained how the concept of network effects fits this definition of complementarities and illustrate this with the example that “the gains for computer users from focusing on just one or two standards is that it eases the development of complementary products including both software (operating systems, operations software) and hardware”. In other words, complementarities between organisational activities and practices will lead to a total effect that is greater than the sum of its parts (Stieglitz & Hiene, 2007).

The complementarity idea has also received attention in other fields, including strategic management since the 1970s (e.g., Rothwell, 1975; Miller, 1986; Miller & Friesen, 1984; Teece, 1986; Hill & Rothaermel, 2003; Stieglitz & Hiene, 2007; Porter & Siggelkow, 2008). The focal argument in a strategic management context is how fit or congruence between different contextual factors, strategy and organisation structure can facilitate competitive advantage to an organisation. Failure to recognise complementarities between different dimensions in an organisation could lead to reduced value creation, revenues and profits (Stieglitz and Hiene, 2007).

Taking cue from early advocates of complementarity, Horgan and Muhlau (2006) conceptualised several sub-dimensions of complementarity. The authors proposed three main dimensions of complementarity: (1) reinforcing complementarity; (2) flanking complementarity; and (3) compensation complementarity. Reinforcing complementarity can occurs when organisational assets deployed to work in the same direction may not necessarily act as substitutes but also reinforce one another’s role. The effect of one organisational asset may not be powerful enough to achieve an intended outcome and therefore needs the support of another asset to achieve the required outcome. Flanking complementarity refers to the achievement of intended organisational goals contingent on the supportive conditions between organisational assets. Training for example will become more effective if employees are motivated to learn and have better cognitive skills. Compensation complementarity refers to a situation where one organisational asset’s activities blocks any unintended negative effects caused by another organisational asset.
Further to the importance of recognising complementarities, scholars such as Thompson (1967), Simon (1976) and Milgrom and Roberts (1990) have stressed the strategic ‘coordination’ and ‘deployment’ of organisational assets to foster complementarities to achieve the intended objectives (Grabski & Leech, 2007). This is because coordination and deployment of incompatible assets may lead to undesirable outcomes (Milgrom & Roberts, 1995b). Since complementarities involve interactions between a variety set of assets, an organisation needs to establish and use multiple coordination and deployment modes simultaneously. This is especially true in the context of complex systems adoption projects (Sambamurthy & Kirsch, 2000; Kirsch et al., 2002; Ko et al., 2005).

2.4.1 The theory of complementarity and ERP adoption

In recent years, studies have begun to use the theory of complementarity in the context of information systems (IS) adoption. These studies can be categorised into four cohorts. The first cohort (e.g., Bharadwaj, 2000; Zhu, 2004; Bendoly & Kaefer, 2004) has explored the complementarity effects between the various types of IS applications such as information technology (IT) infrastructure and e-commerce (Zhu, 2004) and Computer Aided Design (CAD) and Computer Numerically Controlled Machine Tools (CNC) (Asterbo et al., 2009). The second cohort has examined the complementary relationships between different assets inherent and available within an organisation and its effect to achievement of outcomes (e.g., Tanriverdi, 2005; Bharadwaj et al., 2007; Jeffers et al., 2008; Percival & Cozzarin, 2010). The third cohort has explored the complementarities between organisational assets and IT adoption (e.g., Bresnahan et al., 2002; Hollenstein, 2004; Bocquet et al., 2007)

The fourth cohort has used the theory of complementarity in the context of ERP adoption (Grabski & Leech, 2007; Karimi et al., 2007). This cohort is the focus of this study. It is a relatively small group, with only two studies conducted by Grabski and Leech (2007) and Karimi et al. (2007). Grabski and Leech (2007) investigated the complementary relationships between 25 success factors in an ERP implementation stage’s completion. Using survey data from 76 internal auditors employed in ERP using organisations in the United States, and 58 CEOs of the same organisations, Grabski and Leech conducted factor analysis and multiple regressions on the obtained datasets.
The factor analysis returned five success factor cohorts: (i) project management, (ii) change management, (iii) alignment of business with new system, (iv) internal audit activities and (v) consultant and planning activities. Using these five success factor cohorts, the authors found that multiple complementary relationships between the success factors have had significant effect toward successful ERP implementation in the sample organisations.

In a slightly different context, Karimi et al. (2007) examined the complementarity effects between three factors (relationship, knowledge and IT infrastructure) toward ERP post-implementation success. The authors used survey data from 123 organisations in the United States and demonstrated that the complementary relationships amongst the three factors magnified the individual effects of these factors toward ERP post-implementation success.

2.4.2 Summary of theory of complementarity

This section has reviewed the theory of complementarity and highlighted the growing importance that business management scholars place on this theory. The review also highlighted the lack of ERP-theory of complementarity intersectional studies. We address this void in research by investigating whether organisational assets exhibit complementary relationships in the lead-up toward achievement of a particular stage.

2.5 Summary of parent theories review

Sections 2.2–2.4 have presented reviews of the four core parent theoretical lens used in this research. The review began by highlighting ERP adoption background issues, including the various critical success factors that have been highlighted in various studies of ERP adoption success (Section 2.2). The review then moved on to discuss the process theory, with particular attention on the different definitions of ERP project lifecycles provided in the literature (Section 2.3). An outlook of the theory of complementarity was presented in Section 2.4. The central tenet of these reviews is to identify research gaps and address the gaps. We identify the following research gaps:
• Very few studies have identified the critical success factors (or organisational assets in the context of this research) across the different stages of ERP project’s lifecycle. More specifically, there has been little effort to examine the complementary relationships between a set of heterogeneous organisational assets in facilitating the completion or achievement of different stage’s success. We aim to address this issue, which leads to integration of ERP adoption (i.e., critical success factors/organisational assets), the theory of complementarity and the process theory (i.e., the successive stages of ERP project’s lifecycle).

• Very few studies have taken the initiative to empirically validate the successive stages argument presented by the process theory. We address this gap by undertaking an empirical evaluation on the dynamics of organisational assets management and achievement of successes, from one stage to another.

The review of the parent theories assists in the establishment of the research hypotheses, as discussed in the next section.

2.6 Hypotheses development

The discussions presented in the previous sections have highlighted the absence of research on an ERP adoption ‘black-box’. We use the term ‘black-box’ to infer to the cursory review of the complex processes involved in an ERP system’s adoption, with a view of recognising the strategic managerial directions that organisations should adopt to minimise ERP adoption failure. Our main argument here is that whilst a snap-shot outlook (i.e., on a particular stage of an ERP project’s lifecycle) of the factors that could contribute toward ERP adoption success is commendable, an integrated investigation of the entire lifecycle of ERP (i.e., pre-implementation, implementation and post-implementation stages) would highlight new dimensions that have not previously been explored. For instance, a detailed analysis across the ERP project’s lifecycle would highlight the specific problem areas that need attention before moving on to the next level. This would assist in reducing resource wastage such as money, manpower and infrastructure, thus achieving the intended organisational objectives.
At this juncture we need to cite our appreciation to the iconic research conducted by Markus and Tanis (2000a, 2000b) and Somers and Nelson (2001, 2004) pertaining to an ERP project’s lifecycle. Markus and Tanis (2000a) especially introduced the notion of how an ERP project’s lifecycle is embedded within the process theory domain and is characterised by several successive stages. We leveraged on the conceptualisation of an ERP project presented by Abdinour et al. (2003), characterised by three stages: pre-implementation, implementation and post-implementation.

Before proceeding further, we recap our research aims. First, we aim to examine the complementary relationships between a set of heterogeneous organisational assets and its effect toward the successes achieved across the different stages of an ERP project’s lifecycle. We contend that reviewing the interactive relationships amongst the key organisational assets commonly used throughout an ERP project’s lifecycle would showcase the importance of establishing and managing organisational assets in such a way that these assets supports each other’s roles and functionalities.

This contention is drawn from the theory of complementarity (Milgrom & Stewart, 1990). Authors such as Tanriverdi (2005, 2006) and Karimi et al. (2007) have demonstrated that the integrated support between different organisational assets would have synergistic paramount effect in achievement of organisational objectives. We draw a similar line of argument – the flanking complementarity effects between a set of heterogeneous organisational assets would increase the possibility of reaping the successes aimed to be achieved across the different stages of an ERP project lifecycle. The term ‘flanking complementarity’ refers to a situation in which different organisational assets supports the role of each other in a favourable way with potential outcome maximising effect (Horgan & Muhlau, 2006). We present graphical representations of the flanking complementary relationships and its effect toward the success of the ERP pre-implementation, implementation and post-implementation stages in figures 2.5, 2.6 and 2.7.
Figure 2.5: Complementary relationships between organisational assets and achievement of pre-implementation stage’s success

Double arrows represent the complementary relationships between organisational assets and achievement of pre-implementation stage’s success.

Success at this stage

Organisational readiness

Double arrows represent the complementary relationships between organisational assets and achievement of pre-implementation stage’s success.

Figure 2.6: Complementary relationships between organisational assets and achievement of implementation stage’s success

Success at this stage

Completion of Project Targets

Double arrows represent the complementary relationships between organisational assets and achievement of implementation stage’s success.
In this research we conducted a pilot study in order to strengthen our complementary relationship argument. The pilot study used a smaller sample and tested two research models (refer to Figures 2.8 and 2.9). These models were used to showcase empirical support for the notion of complementary effects between organisational assets. The first research model (Figure 2.8) represents the individual direct effect that each organisational asset toward ERP post-implementation success (refer explanation of hypotheses development in sub-section 2.6.2). We chose to test post-implementation success exclusively due to the availability of validated measurement scales drawn from the work of Karimi et al. (2007). The testing of the post-implementation stage exclusively was motivated by two reasons.

- A large number of studies have examined the critical success factors in ERP post-implementation stage exclusively (e.g., Parr & Shanks, 2000; Guang-hui et al., 2006; Plant & Willcocks, 2007); however, few studies have explored the interactions between different organisational assets toward the post-implementation stage’s success (Zhu et al., 2010). We aimed to test the complementarity phenomenon in this stage to address the research gap.
The sample frame of this study consisted of organisations that had completed their ERP project in the previous two to three years and are using the system. We believe that getting the sample respondents’ reflections on past asset management activities would be much easier for the post-implementation stage (since it would be the most recent event than the pre-implementation or implementation stages). The reflections obtained in the pilot study would assist us to frame the right set of questions to explore pre-implementation and implementation stages reflections. Further discussion about the pilot study’s research models is presented below.

Second, we aimed to validate the argument of an ERP project undergoing several successive stages put forward by the process theory. The complexity of ERP project entails successive evolving stages. For instance, achievement of the pre-implementation stage’s success is characterised by an organisation getting ready (organisational readiness) to embrace the implementation stage. To achieve this outcome, a set of heterogeneous organisational assets need to be strategically coordinated and deployed as a condition to meet the requirement of this stage. Advancing to the next stage of the lifecycle will again require strategic assets management to address the activities of that stage. Thus, ERP adopting organisation must have the capability to manage their organisational assets in accordance to the needs of successive stages.

2.6.1 Organisational assets

In this study, we examined the complementary relationships between five organisational assets: Human resource, Governance, Knowledge, Relationships and IT infrastructure. We selected these five organisational assets based on the following rationale. Following the ERP critical success factor literature, we chose four most commonly tested organisational assets:

1. Human resource → comprising IT skills (Parr & Shanks, 2000) and training (Guang-hui et al., 2006) dimensions. Human resource is an important component of ERP technology transfer or adoption process (Lengnick-Hall & Lengnick-Hall, 2006). The capability of human resource to absorb new technology skills is contingent on their technical skills and exposure to training.
2. Knowledge → comprising project management (Nah et al., 2001) and business process knowledge (Somers & Nelson, 2001). One of the core functionalities of an ERP system is to facilitate the management of knowledge flows within the firm (Jones, 2005). The implementation process of an ERP system also entails extensive knowledge creation, sharing and dissemination, both from external consultant to project members, as well from the project members to system users (Stenmark, 2000; Vandaie, 2008). In line with the suggestions provided in the ERP and knowledge management literatures (e.g., Sumner, 2000; Soh et al. 2000), we argue that effective management of his knowledge is essential in ensuring successful ERP implementation.

3. Relationships → comprising user involvement (Karimi et al., 2007) and top management involvement (Al-Mashari et al., 2003). Adoption of a complex and time-consuming ERP project requires strong cooperation and relationship building between all those involved in the project. Managing cooperation and relationship building is pertinent to ensure ERP adoption success (Kuppusamy et al., 2009). Most critical success factor studies (e.g., Bingi et al., 1999; King & Burgess, 2006) have identified effective management of the relationship amongst the ERP project members are essential for ERP success.

4. IT infrastructure → comprising hardware and software (Stratman & Roth, 2002). IT infrastructure is a core platform that facilitates ERP adoption process (Nah et al., 2001). An examination of ERP adoption success without exploring this asset may be incomplete due to its nature of being a core element in an ERP project.

Governance, the fifth asset used in this research, is a single dimension construct developed from technology management and governance literature (e.g., Brown & Sambamurthy, 1999; Brown & Nasuti, 2005; Salle & Rosenthal, 2005; Weil & Woodham, 2005). This asset is not commonly used in the ERP literature. We used governance because technology adoption in current business landscape requires adherence and utilisation of various governance mechanisms (Bernroider, 2008; Bowen et al., 2007).
As ERP is known to be a complex system that adheres to ‘best-practices’, effective governance processes are essential to safeguard the system’s reliability and success (Bernroider, 2008). Thus, assessing the effects of governance assets would indicate the role and support of governance mechanisms in successful adoption of ERP system.

2.6.2 Research hypotheses formation

Following the selection of the five organisational assets, the research hypotheses were formulated. The discussion of the hypothesis development will follow the following format. First, we use ERP adoption theoretical lens to theorise how Governance, Knowledge and Relationship can have significant effects in ERP post-implementation success (Sections 2.6.2.1–2.6.2.3). Such theorisation is done to cater for the pilot study’s framework that aimed to test the following three research hypotheses:

- Hypothesis 1 (H1)
- Hypothesis 2 (H2)
- Hypothesis 3 (H3)

These hypotheses relate to the individual direct effects that the three organisational assets can have toward ERP post-implementation success. Second, we leverage on the theory of complementarity (Section 2.6.2.4) to argue that the complementary relationships between these three organisational assets used in the pilot study will have greater effects toward ERP post-implementation success (Hypothesis 4 (H4)).

Following the discussion of the pilot study hypotheses, we focus on the large-scale study hypotheses. The discussion begins with explanations of the importance of Human resource, Knowledge, Relationship and IT infrastructure dimensions toward ERP adoption success (Sections 2.6.2.5–2.6.2.8). Note that we do not repeat a discussion of the Governance asset, mainly because the single dimension is a continuation in the large-scale study.
This is followed by theorisation of the flanking complementarity relationships between the five organisational assets (Governance, Knowledge, Relationship, Human resource and IT infrastructure) toward the successes achieved across the different stages in ERP project’s lifecycle. We also present the argument of how the conditions that facilitate flanking complementarity to prevail could be dependent upon a particular asset or a group of assets. In line with the critical success factors conceptualisation, we anticipate finding the exclusivity of certain assets in promoting flanking complementarity across the three stages of ERP project (Hypotheses 5a–5c). Second, we present our theorisation pertaining to the large-scale study’s hypothesis (Hypotheses 6a and 6b) that validates the ERP-process theory argument of ERP project comprises of a series of successive stages (Section 2.6.2.9).

2.6.2.1 Governance asset

One of the most enduring problems faced by an organisation undertaking innovative activities is governing their technology functionalities, as well as the processes and activities pertaining to financial issues. Having a sound governance strategy will provide better monitoring and control mechanisms to achieve the intended goal as efficiently as possible. In the IS literature, the term ‘governance’ has been used to broadly describe the policies, structures and processes involved in managing technological functions (Brown & Sambamurthy, 1999; Weill & Broadbent, 2000). Governance is perceived to be critical in the case of ERP adoption as it involves adaptation to the ‘best practices’ of global business operation standards (Brown & Nasuti, 2005). Adhering to the best practices entails compliance to several standards, such as the Sarbanes Oxley Act (SOX), Section 302 (disclosure of internal controls), Section 404 (annual assessment of internal control effectiveness), Section 409 (disclosure to the public on material changes to firm’s financial condition) and Section 802 (authentic and immutable record retention).

In recent years, new governance frameworks have emerged to induce greater control and adherence to best practices. In this context, the Control Objectives for Information Technology (COBIT), the Institute of Internal Auditors Research Foundation’s Systems Electronic Security Assurance and Control (eSAC) and the IT Infrastructure Library (ITIL) stand out (Brown & Nasuti, 2005; Salle & Rosenthal, 2005).
The literature recognises the COBIT standard as one of the best governance standard for technology implementation (Pathak, 2003; Ramos, 2004). The COBIT standard governs most aspects of technology implementation good practices that a business must follow in order to reap expected pay-offs from technological investment (Ramos, 2004). We believe that ERP post-implementation success will require constant and effective coordination and deployment of governance mechanism that entails adherence to guidelines or standards such as COBIT and Sarbanes Oxley, throughout the system’s usage process. Following this contention, we hypothesise:

**Hypothesis 1 (H1): Governance has a significant direct effect on ERP post-implementation success**

### 2.6.2.2 Knowledge

There is a growing interest on knowledge as a critical source of competitive advantage in the literature (e.g., Corso & Paolucci, 2001; Malhotra et al., 2005). Firms are giving significant attention on effective management of knowledge in undertaking innovative activities (Hargadon, 1998). The importance of knowledge asset in ERP implementation has been explored in several studies (Chan et al., 2009; Parry & Graves, 2008; Pan et al., 2006; Vandaie, 2008; Xu et al., 2006). While one of the primary aim for firms to adopt ERP system is to improve knowledge sharing activities within the firm (Vandaie, 2008), ERP adoption process requires effective knowledge management capability (Jones, 2005). Successful ERP adoption requires engagement of a variety of expertise from both within and outside the firm, cross-functional and cross-divisional knowledge transfer (Baskerville et al., 2000). Possession of skilled employees is also critical in ERP implementation (Vandaie, 2008) as their tacit and explicit knowledge will be valuable in the process of getting the system up and running (Robey et al., 2002).

In this study, knowledge asset facilitates successful ERP post-implementation in the context of knowledge acquisition, conversion, transfer and dissemination (Li et al., 2006). An ERP project demands the adopting firm acquire significant knowledge from external parties such as the consultants and vendors. Proper acquisition of new knowledge is vital to ensure that the knowledge is utilised effectively.
Further, throughout the system post-implementation stage, new tacit knowledge will emerge through discussions, communication and practice between various interested people. The emerging new knowledge needs to be converted into internal information to be used by all other parties, especially by the ERP project team and the end users. In addition, ERP adoption could create knowledge gaps due to different understanding or absorptive capacity between vendors, consultants, internal experts and end users. Firms need to ensure that the obtained ERP knowledge is successfully transferred between these parties post-implementation. Apart from transferring the knowledge, firms also need to have adequate processes to facilitate access to important and relevant knowledge. Effective management of organisational processes relative to these knowledge activities could become a conductive platform for successful ERP implementation. Hence, we propose:

_Hypothesis 2 (H2): Knowledge has a significant direct effect on ERP post-implementation success_

2.6.2.3 Relationship

The relationship asset is defined as the ability to coordinate and engage communication and cooperation between IT and business groups (Karimi et al., 2007). Engagement of different parties, primarily the IT business unit and other management units also entails sharing of risk and responsibilities relative to ERP project. Good relationship is also about trust emerging through interactions between different people (Nahapet & Goshal, 1998). Effective adoption of technology is chiefly associated with the quality of relationship between different user/implementer groups (Ravichandran & Lertwongsatien, 2005). Appreciation and understanding of different parties’ environment can help to deliver expected IT implementation business value (Ravichandran & Rai, 2000). Apart from internal relationships (between people within the firm), successful technology adoption is also dependent on external partnerships with vendors and consultants. This notion is vital in the context of ERP post-implementation as the project involves cooperation and participation of both internal staff and external people.
Good relationship management ensures efficient knowledge sharing and trust building between involved parties (Ross et al., 1996; Wang et al., 2006), including in the post-implementation stage. Such a commodity is not easily tradeable as it is based upon trust and cooperation between different people within and outside the firm, and often involves a long period of time (Karimi et al., 2007). Organisational processes enabling relationship building and maintenance could play pertinent role in ERP post-implementation success. We thus propose:

*Hypothesis 3 (H3): Relationship has a significant direct effect on ERP post-implementation success*

Figure 2.8 presents the pilot study’s individual direct effect research model developed based on these three hypotheses H1, H2 and H3. In the individual direct effect model, the three organisational assets (Governance, Knowledge and Relationship) is conceptualised as reflective constructs with five indicators each. The post-implementation success outcome (i.e., business process outcomes) is framed as a formative construct with thirteen indicators.
Figure 2.8: Individual direct effect model

Indicators of reflective Governance (G), Knowledge (K) and Relationship (R) (independent constructs)

13 indicators of formative ERP post-implementation success (dependent construct)

Hypothesis paths

Note: the definitions of the terms ‘reflective’ and ‘formative’ is given in Chapter 3
2.6.2.4 Complementary relationships

Following the theory of complementarity, we theorise that Governance, Knowledge and Relationship assets will complement each other’s roles and functionalities, thus leading to improved post-implementation success. As discussed earlier, Governance mechanisms are critical to ensure effective coordination, monitoring and controlling of ERP post-implementation activities. In the post-implementation stage, a monitoring system and control over the system’s routinisation is essential to avoid delays and possible undesirable activities. Such governance at this stage will assist or complement the role played by the Knowledge asset. The management of knowledge transfer, sharing and dissemination mechanisms in the post-implementation stage can be enhanced by having a sound technology adoption related governance mechanism. At the post-implementation stage, newly created knowledge will still be tacit in nature (Li & Tsai, 2009). Over time, the tacit knowledge will become quite explicit. The process of converting tacit knowledge to explicit will require strong governance system to avoid resistance of knowledge sharing.

Apart from the interactions between governance and knowledge, building and maintaining a good relationship with internal and external parties is also crucial in the post-implementation stage. At the post-implementation stage, an organisation would probably need to manage suppliers who have been newly linked with the ERP system or who continuously engage with external ERP consultants in the context of after sales service. Management of such relationships could be fostered if the governance mechanism is efficient because a controlled environment (at the post-implementation level) would cater for smooth relationship management. In another context, there could be three-way interactions between the three assets, denoting mutually reinforcing effects. In sum, the role of each organisational asset can be enhanced by another asset’s support at the post-implementation stage. No prior studies have examined the complementary relationships between these three assets. We thus make inference that the mutually complementing relationships between these three assets would lead to the following hypothesis:

Hypothesis 4 (H4): Complementarity between organisational assets has a significant effect on ERP post-implementation success

The research model for Hypothesis 4 is presented in Figure 2.9. This model shows the complementary relationships between Governance, Knowledge and Relationship and the
magnified effect toward ERP post-implementation success, denoted by achievement of positive business process outcomes. Note that testing for complementary relationships entailed testing the different mutually complementing paths between the three assets. The optimal complementing effects will be determined based on the highest t-statistics value obtained from the partial least square (PLS) computation.

**Figure 2.9: Complementarity effect model**

- Indicators of reflective Governance (G), Knowledge (K) and Relationship (R) (independent constructs)
- 13 indicators of formative ERP post-implementation success (dependent construct)
- Hypothesis paths
- Complementarity between organisational assets (identified by testing the path associations for the optimum complementarity effect)
2.6.2.5 Human resource

The importance of human resource in technology adoption has been widely acknowledged in the technology management literature (e.g., Snell et al., 1995; Gratton et al., 1999; Lai, 2001; Carroll & Wagar, 2010). A similar trend is seen in the ERP adoption literature (Boyle & Strong, 2006; Kim et al., 2006; Sager et al., 2006). Human resource management is seen as an important mechanism for effective delivery of ERP knowledge and skills. In fact, ERP vendors such as SAP cooperate with academia in promoting ERP knowledge and skills to universities, thus facilitating growth in ERP skilled human resource. The ERP literature (e.g., Stratman & Roth, 2002) suggests the ERP-related human resource is dissected into several elements. Two important elements are IT skilled employees (called IT skill hereafter) and training programs (called training hereafter).

IT skill is defined as the ability to process and understand new knowledge that will be implemented within an organisation (Ravichandran & Lertwongsatien, 2005). The ability to process and understand new knowledge encompasses both technical and business process knowledge (Wang et al., 2008). Such skills would form a solid foundation upon which more specific knowledge related to ERP can be built (Ifinedo, 2011). Prior studies on ERP adoption (e.g., Markus & Tanis, 2000a; Sedera et al., 2003; Wang & Chen, 2006) have identified IT skill as an important element in successful ERP adoption. Bingi et al. (1999), for example, advocated that knowledge transfer in the context of new technology adoption would be easy if the adopting organisation have technology-literate employees.

In the context of the ERP project lifecycle, studies by Bancroft et al. (1998), Davenport (1998), Stratman and Roth (2002) and Wang and Chen (2006) suggest that IT skill is vital in the successful completion of both ERP pre-implementation and post implementation stages. This is because in the pre-implementation phase, skilled IT personnel often assist in the development of the new system’s blueprints, system mapping, software and hardware requirements and other related technical issues. In the post-implementation phase, IT skills are required in user training programs, system maintenance and system upgrade processes.
The training element of human resource represents another important component in ERP adoption success. The literature presents significant support in this context. Studies by Loh and Koh (2004), Dowlatshahi (2005) and Choi et al. (2007), for instance, have demonstrated empirical evidence for the effectiveness of training in successful ERP adoption. Training activities for users represents an important ingredient for successful ERP system’s effective usage (Al-Mashari et al., 2003). Non-commitment to conduct relevant and focused training for new users could lead to poor or failed ERP implementation (Crowley, 1999). Botta-Genoulaz and Millet (2006) demonstrated that training does not only assist in software mastery; it also helps in the realisation of ERP’s full potential.

2.6.2.6 Knowledge

The literature highlights two forms of knowledge assets critical for ERP project success: business process and project management knowledge (Karimi et al., 2007). Business process knowledge is defined as knowledge related to ERP project domain (Ross et al., 1996). Effective management of this knowledge facilitates creation of precise system requirements, accurate data conversion and smooth data integration across the business value-chain (Kapp, 1998). Since most organisations may not have in-house ERP expertise with adequate business process knowledge, engagement of external consultants to guide and drive ERP project is a common practice (Brown & Vessey, 2003). It is therefore imperative for the adopting firm to effectively manage external consultants to facilitate deployment of business process knowledge to contribute towards completion of an ERP project. Business process knowledge is critical in both pre- and post-implementation phases (Somers & Nelson, 2004), since issues such as data conversion and data integration are not a one-off activity; these are recurring activities throughout the ERP project lifecycle.

Apart from business process knowledge, project management knowledge is equally important. The term ‘project management’ refers to the utilisation of skills and knowledge in coordinating the scheduling, and monitoring the defined activities to ensure that the stated objectives of project implementation are achieved (Stratman & Roth, 2002, p.611). Project management is generally associated with the initial stages of new projects implementation, including new IT system applications.
However, scholars such as Weill and Vitale (2002) and Wade and Hulland (2004) argue that technology-related project management encompasses the entire implementation life cycle, as opposed to just the initial stages. A similar call has been made in the context of ERP system implementation. Ettlie (1998) highlighted that the importance of project management capability extends beyond the initial stages of implementation on an incremental basis.

### 2.6.2.7 Relationships

Effective implementation of technology is associated chiefly with the quality of the relationship between different user and implementer groups (Ravichandran & Lertwongsatien, 2005). Two main elements of relationship asset are user involvement and top management support.

Users of ERP system are often invited to help in determining system functional and design requirements so that the customised system meets the expected standard (Tait & Vessey, 1988). Technology projects with vigorous user involvement often have greater success rate (Beath, 1991; Boynton et al., 1994). User involvement in both pre and post-implementation phases is important as this could help to minimise user resistance. This is because user participation in the ERP project lifecycle could increase acceptance of the new system.

Apart from user involvement, the ERP literature cites top management support as a primary contributor to the project’s success (Esteves et al., 2002; Nah et al., 2001). Top management executives usually play a major role in the initiation and continuation of a large technology project such as ERP. The executives provide the required funding and other forms of support for the ERP project (Karimi et al., 2007). Their support usually escalates as the project progresses, and top management’s monitoring, control and direction over the project remains critical (Bingi et al., 1999).
2.6.2.8 IT infrastructure

Successful technology implementation would fail if it is not supported by the appropriate infrastructures. IT infrastructure, comprising a firm’s shared IT hardware, software, tools, networks, databases and data centres (Karimi et al., 2007), is one of the main supporting platforms in this context. These platforms aid in the development of the customised ERP blueprint or architecture (Ross, 2003). Dedicated and reliable IT infrastructure is significantly important in the ERP pre-implementation phase, in contrast to the later phases (Somers & Nelson, 2004). This is because determination of the appropriate IT infrastructure normally takes place in the beginning process, as replacement for non-relevant or weak infrastructure at the later stage will cause the firm to incur loss. Both the hardware and software dimensions of IT infrastructure will have significant impacts toward ERP adoption success.

2.6.2.9 Flanking complementarity relationships between organisational assets

Drawing on the theory of complementarity perspective, we theorise that the existence of flanking complementary relationships between Governance, Knowledge, Relationship, Human resource and IT infrastructure can magnify success in the pre-implementation, implementation and post-implementation stages. The importance of deployment of these assets for different stages’ success is well documented (e.g., Wu, 2007; Plant & Willcocks, 2007; Zhu et al., 2010; Ifinedo, 2011). The complementary relationship nexus between these assets is discussed next. As a recap, we present the five organisational assets (and their dimensions) in Table 2.11.

<table>
<thead>
<tr>
<th>Organisational assets</th>
<th>Dimension 1</th>
<th>Dimension 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance (single dimension)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Knowledge</td>
<td>Project management knowledge</td>
<td>Business process knowledge</td>
</tr>
<tr>
<td>Relationship</td>
<td>User involvement</td>
<td>Top management involvement</td>
</tr>
<tr>
<td>Human resource</td>
<td>IT skill</td>
<td>Training</td>
</tr>
<tr>
<td>IT infrastructure</td>
<td>Hardware</td>
<td>Software</td>
</tr>
</tbody>
</table>
An ERP project entails direct involvement of top management (Dong et al., 2009). Such involvement throughout the ERP project lifecycle enables direct control and monitoring of the project’s progress, as well as the performance of the project team members. Often, decisions pertaining to critical issues such as budget release and so on require the ratification of top management, thus ensuring the direct involvement of the top management people in the project (Whitten & Bentley, 1998). Top management’s involvement from the commencement (i.e., pre-implementation stage) right through to the routinisation and evaluation of the system’s effectiveness (i.e., post-implementation stage) also raises the perceived importance of ERP adoption within the organisation (Raghunathan & Raghunathan, 1998). This, in turn, could motivate users and team members’ involvement as well. Top management involvement in the ERP lifecycle also permeates effective control and monitoring mechanisms over the project. This form of governance by the top management team can assist in reducing resistance to change, which often takes place when a complex and large-scale technology adoption takes place in an organisation (Bingi et al., 1999). To this end, top management’s involvement in the ERP project complements the governance of the ERP project.

Another form of governance relates to the internal auditing of the ERP project. Internal auditing consists of checking the trails of various activities, thus maintaining control over the tasks in which all parties are involved (Glover et al., 1999). As pointed out by Grabski (1986), internal control can support knowledge management processes, in the context of comprehension of the organisation’s operational processes and the strengths and weaknesses inherent in the organisation’s current governance structure. Lu (1999) suggested that internal control governance can also inform top management of the project’s risk status and the monthly progress reports. Here, complementary relationships between three different organisational assets are evident: governance, knowledge and relationship (i.e., top management involvement).

Apart from the above-mentioned complementary relationships, mutually complementing relationships between project management and human resource elements are also possible in an ERP project’s lifecycle. Project management activities such as system implementation plans and performance metrics are used to study and understand the complexity of the ERP project.
Such an understanding can assist in identifying the skills and knowledge of the project team members (Grabski & Leech, 2007), so members with poor skill and knowledge can be retrained by experts. The cooperative nexus between project management and a skilled project team can complement each others’ effectiveness throughout the ERP project lifecycle.

Complementary relationships between the Relationship asset and the Human resource asset are also possible across the ERP adoption stages. For instance, an ERP adopting organisation needs to manage its relationship with external consultants, who bring ERP related knowledge into the organisation. A close working relationship between consultants and IT-skilled employees (or project team members) can lead to valuable skill transfer (Bowen, 1998). In addition, good management of the relationship between consultants and the organisation also fosters effective training exercises targeted to users and/or project team members. The synergistic support mutually showed by Relationship elements and Human resource elements could play an important role in ERP adoption success.

In sum, the complementary relationships between these five organisational assets can have a significant effect on the success of the three stages. More specifically, we anticipate that the complementarity relationship effects between the five assets will accelerate the achievement of the following success:

- Pre-implementation stage → Organisational readiness
- Implementation stage → Completion of project targets
- Post-implementation stage → Business process outcomes

Apart from the complementarity between the organisational assets issue, we also theorise that certain asset or a combination of assets would be the facilitating condition for flanking complementarity to prevail in the different stages of ERP project. Our theorisation is based on Markus and Tanis’s (2000a) conceptualisation of process theory, which shows the necessary conditions that influence successful outcome in each stage of ERP project’s lifecycle. Markus and Tanis presented these conditions in the context of the critical success factors.
Using a similar line of theorisation, we contend that the conditions that foster flanking complementarity across the three stages are different. The limited treatment of CSF-Process theory in the literature highlights the importance of certain success factors (i.e., organisational assets in the context of this research) in pre-implementation, implementation and post-implementation stages.

Studies by Parr and Shanks (2000), Somers and Nelson (2001, 2004), Al-Mashari et al. (2003) and Plant and Willcocks (2007) have identified the importance of top management involvement in all the stages of ERP project lifecycle. Somers and Nelson (2004) and Plant and Willcocks (2007) suggested that users’ involvement in the ERP project is vital in the pre-implementation, implementation and the post-implementation stages. Thus, the Relationship asset (comprising top management involvement and user involvement) seems to be an important condition in all three stages.

Knowledge asset’s business process knowledge and project management have been cited as important in the pre-implementation and implementation stages (Somers & Nelson, 2004; Plant & Willcocks, 2007), whilst IT skill and training (i.e., elements of the Human resource asset) have been demonstrated as critical elements for pre-implementation and implementation stages’ success (Somers & Nelson, 2004; Wu, 2007). Whilst none of the available studies have associated the Governance asset with a specific stage of ERP project, we theorise that this asset will play an important role throughout the entire project’s lifecycle, primarily because of the continuous need to adhere and implement control, audit and monitor all key tasks executed in all the stages. The importance of IT infrastructure has been associated with pre-implementation (Nah et al., 2001; Wu, 2007) and implementation stages (Plant & Willcocks, 2007).

Based on the complementary relationships and conditions for the existence of complementary, we posit the following three hypotheses:
Hypothesis 5a (H5a): Pre-implementation stage’s organisational assets have flanking complementarity effect on Organisational Readiness; with certain assets becoming the condition for flanking complementarity in this stage

Hypothesis 5b (H5b): Implementation stage’s organisational assets have flanking complementarity effect on Completion of Project Targets; with certain assets becoming the condition for flanking complementarity in this stage

Hypothesis 5c (H5c): Post-implementation stage’s organisational assets have flanking complementarity effect on Business Process Outcomes; with certain assets becoming the condition for flanking complementarity in this stage

The argument put forward in process theory (e.g., Markus & Tanis, 2000a, 2000b; Ross & Vitale, 2000; Abdinour-Helm et al., 2004) is clear – an ERP project entails experiencing or undergoing several successive stages. The conceptualisations made by Markus and Tanis (2000a) and Abdinour-Helm et al. (2004) characterise each stage with execution of several key activities and achievement of certain outcomes. The explanation provided by Markus and Tanis (2000a) needs to be singled out, as the authors provided a good definition of how failing to achieve success in one stage will not allow the adopting organisation to move to the next stage. We make an inference that failing to achieve success in one stage will not enable the organisation to carry out the next stage’s activities, by utilising the required organisational assets. Based on the scant available information on ERP project lifecycle, we propose the following two hypotheses:

Hypothesis 6a (H6a): The achievement of Organisational Readiness (i.e., success in ERP pre-implementation stage) has a significant effect on configuration and deployment of ERP implementation stage’s organisational assets.

Hypothesis 6b (H6b): The achievement of Completion of Project Targets (i.e., success in ERP implementation stage) has a significant effect on configuration and deployment of ERP post-implementation stage’s organisational assets.

Figure 2.10 shows the large-scale study’s research model that encompasses the five research hypotheses discussed above and combines all the stages in ERP project’s lifecycle and its associated success/outcome.
Figure 2.10: Large-scale research model

Notes:

TRA (Training); ITS (IT skills); HR (Human Resource); BPK (Business process knowledge); PMK (Project management knowledge); K (Knowledge); TMI (Top management involvement); UI (User involvement); R (Relationship); HAR (Hardware); NET (Networks); IT (IT infrastructure); G (Governance); Pre-OA (Organisational assets in Pre-implementation stage); Imp-OA (Organisational assets in Implementation stage); Post-OA (Organisational assets in post-implementation stage); OR (Organisational Readiness); CPT (Completion of Project Targets); BPO (Business Process Outcomes).
2.7 Chapter summary

This chapter has reviewed the pertinent literatures and used these as a basis for the research framework. The literature review covered three parent theories (ERP adoption, the process theory and the theory of complementarity) and empirical studies with evidence on the importance of critical success factors toward ERP adoption success. This chapter also discussed the development of the research hypotheses.

The next chapter discusses the research methodology.
CHAPTER 3: RESEARCH METHODOLOGY AND DATA ANALYSIS TECHNIQUES

3.1 Introduction

The previous chapter highlighted the literature review and synthesis. This chapter discusses the research methodology employed to address the research questions as well as the research hypotheses discussed in the previous chapter. On this note, the chapter begins with a discussion of the ontological and epistemological views in Section 3.2, followed by an overview of the research design in Section 3.3. Sections 3.4 and 3.5 describe the pilot and large-scale studies, respectively. Section 3.6 explains the techniques used to analyse data collected from the quantitative and qualitative research approaches. Section 3.7 provides an overview of ethical considerations, while Section 3.8 summarises the chapter.

3.2 Ontological and epistemological views

Social science research is undertaken to understand the nature in which people live in this world. Such an understanding helps in determining or establishing appropriate guidelines or policies to spur socio-economic growth (Ticehurst & Veal, 2000). Research undertakings are driven by ontological and epistemological assumptions. Ontological assumption is defined as “a branch of philosophy concerned with articulating the nature and structure of the world” (Wand & Weber, 1993, p. 220). Epistemological assumption is defined as “the nature of human knowledge and understanding that can possibly be acquired through different types of inquiry and alternative methods of investigation” (Hirschheim et al., 1995, p.20).
The ontological and epistemological views of a quantitative research paradigm are enveloped within a positivist stance, which views research outcome as singular and objective in nature. The idea is to find one answer that could be true in multiple situations. On the other hand, the ontological and epistemological assumptions of a qualitative research paradigm are subjective with multiple possible answers (Creswell, 1994). Qualitative research is a post-positivist stance and seeks to gain people’s personal experience regarding the topic of interest without the need to find causal or factual reality. In this paradigm there are multiple truths which are all valid.

3.3 Research design

Research design is the road map of research, the means or guide that helps researchers in achieving their research objectives (Davis, 2005). Establishing the research design entails identifying whether the type of research is experimental or ex post factor.

3.3.1 Experimental research

In experimental research the researcher has some form of control over the independent variable(s) under study. Field and laboratory-based research is usually experimental. Field research is done in a realistic setting in where the researcher can manipulate and control independent variables as far as it is allowable. Laboratory research occurs in an artificial environment or setting, and the extent of manipulation or control of independent variables is very high.
3.3.2 Ex post factor research

In the ex post factor research design, the researcher identifies events that have already occurred or conditions that are already present, and then collects data to investigate a possible relationship between these factors and subsequent characteristics or behaviours (Leedy & Ormrod, 2001). The research design does not attempt to influence or manipulate independent variables because it is assumed the cause has already taken place; this research method seeks possible answers by walking back through the data obtained from a variety of primary and secondary sources. Davis (2005, p. 145) describes the method as a “combination of literature searches, experience surveys and single or multiple case studies where the researcher attempts to identify significant variables and their relationships in a problem situation”.

This particular study is leveraged on the ex post factor research design. This design allowed for data collection directly from organisations that had implemented and were using ERP system through quantitative and qualitative research approaches.

Quantitative research is defined as:

...inquiry that is grounded in the assumption that features of the social environment constitute an objective reality that is relatively constant across time and settings. The dominant methodology is to describe and explain features of this reality by collecting numerical data on observable behaviours of samples and by subjecting the data to statistical analysis. (Gall et al., 1996, p. 767)

Qualitative research, on the other hand, is described as:

...inquiry that is grounded in the assumption that individuals construct social reality in the form of meanings and interpretations, and that these constructions tend to be transitory and situational. The dominant methodology is to discover these meanings and interpretations by studying cases intensively in natural settings, and by subjecting the resulting data to analytical induction. (Gall et al., 1996, p. 767)
Both research approaches have different contextual differences, as highlighted in Table 3.1. Quantitative research has gained a strong foothold in various research disciplines. The focus of this research approach was to use statistical numbers to represent values to theoretical constructs and concepts. These numbers portray strong scientific evidence of how an event works or takes place. Researchers often transform the concepts or theoretical constructs into quantifiable values using a survey instrument consisting of either closed or open-ended questions. All the questions in this study were closed questions. Qualitative research complements quantitative research (Davis, 2005) and uses interviews as one of the primary information-gathering techniques (Flick, 1998). Interviews can be structured, unstructured or semi-structured (Bryman, 2004). The semi-structured interview is widely used in current research (Pallant, 2009), as it enables the interviewer to obtain descriptions of the interviewee’s world with respect to interpreting the meaning of the described phenomena (Kvale, 1996). Burns (1973) has highlighted some of the advantages of semi-structured interviews:

- The interviewer spends longer with the interviewee, which increases rapport.
- The interviewee’s perspective is provided rather than the perspective of the researcher being imposed.
- The interview uses language natural to the participants, rather than trying to understand and fit into the concepts of the study.

Using a mixed research approach can increase the validity of the research findings (Mathison, 1988; Greene & Caracelli, 1997). This is because mixed method research enhances evaluation of an event or phenomenon by allowing for triangulation of findings through different instruments, thus complementing results from different methods (Green et al., 1989; Davis, 2005).
Table 3.1: Quantitative and qualitative research approach differences

<table>
<thead>
<tr>
<th>Area</th>
<th>Quantitative</th>
<th>Qualitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objective</td>
<td>Quantification of characteristics or behaviour</td>
<td>In-depth understanding of characteristics or behaviour</td>
</tr>
<tr>
<td>Approach</td>
<td>Structured</td>
<td>Largely unstructured</td>
</tr>
<tr>
<td>Sample size</td>
<td>Large</td>
<td>Small (fewer than 12)</td>
</tr>
<tr>
<td>Representativeness to population</td>
<td>Yes, if random</td>
<td>No</td>
</tr>
<tr>
<td>Interviewer skill required</td>
<td>Moderate to low</td>
<td>High</td>
</tr>
<tr>
<td>Length of interview</td>
<td>Relatively short (generally less than 30 minutes)</td>
<td>Longer (more than 30 minutes)</td>
</tr>
</tbody>
</table>

Source: Davis (2005)

3.4 Pilot study

A pilot study was undertaken to test the preliminary research models. The primary aim of the pilot study was to test the notion of complementarity between organisational assets and its effects toward ERP post-implementation’s success. We anticipated that the findings from the pilot study would strengthen and validate the large-scale study’s research model.

The pilot study tested two research models, as shown in figures 3.1 and 3.2. Figure 3.1 depicts the individual direct effect model while the complementarity effect is shown in Figure 3.2. Note that the complementarity effect in Figure 3.2 is shown as the possible path with optimum complementarity effect that can be exuded from the three organisational assets.
Figure 3.1: Individual direct effect model

- Indicators of reflective Governance (G), Knowledge (K) and Relationship (R) (independent constructs)
- 13 indicators of formative ERP post-implementation success (dependent construct)
- Hypothesis paths
Figure 3.2: Complementarity effect model

Indicators of reflective Governance (G), Knowledge (K) and Relationship (R) (independent constructs)

13 indicators of formative ERP post-implementation success (dependent construct)

Hypothesis paths

Complementarity between organisational assets (testing for the optimum complementarity effect)
3.4.1 Pilot study’s unit of analysis and sampling

The unit of analysis in the pilot study was ERP system using service organisations operating in Malaysia. Using a purposive sampling technique, we sought the assistance of the EDGE to obtain a list of ERP using service organisations.

The EDGE is a management consulting firm that assists Malaysian organisations in sourcing, securing and implementing ERP systems. The researcher has a good long-term relationship with one of the firm’s key executives. The EDGE provided a list of 488 ERP using service organisations.

3.4.2 Pilot study’s survey instrument (quantitative phase)

The survey instrument consisted of three sections. The first section comprised the sample organisations’ profiles (number of years in business, size of firm, type of business, revenue per annum, preferred ERP vendor and the time taken to implement their ERP).

The second section contained questions on the role of three organisational assets – Governance, Knowledge and Relationship – toward ERP system post-implementation success. Governance questions were based on the technology management and governance literature. Knowledge and Relationship questions were taken from Karimi et al. (2007). These questions were measured using a 5-point Likert scale (1 = not important at all to 5 = very important). The third section comprised questions on ERP usage in the context of the gains experienced in the post-implementation stage.

Questions on successful gains in the context of operational efficiency, effectiveness and flexibility were also taken from Karimi et al. (2007). These questions were again measured using a 5-point Likert scale (1 = strongly disagree to 5 = strongly agree). Table 3.2 presents the details of the survey instrument questions.
<table>
<thead>
<tr>
<th>Construct</th>
<th>Questions</th>
<th>Reference source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance asset (Reflective</td>
<td>1. IT infrastructure auditing (G1)</td>
<td>Technology management and governance literatures (e.g., Brown &amp; Sambamurthy, 1999;</td>
</tr>
<tr>
<td></td>
<td>3. IT security review (G3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Unauthorised access to knowledge (G4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Auditing of project financial budget (G5)</td>
<td></td>
</tr>
<tr>
<td>Knowledge asset (Reflective</td>
<td>1. Knowledge sharing between departments (K1)</td>
<td>Karimi et al. (2007)</td>
</tr>
<tr>
<td>construct)</td>
<td>2. Project management tools &amp; techniques (K2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Engagement of experienced project champion (K3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Engagement of experienced consultants (K4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Transfer of ERP technical knowledge to project team (K5)</td>
<td></td>
</tr>
<tr>
<td>Relationship asset (Reflective</td>
<td>1. Employee acceptance of ERP (R1)</td>
<td>Karimi et al. (2007)</td>
</tr>
<tr>
<td>construct)</td>
<td>2. Employee involvement in ERP project (R2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Relationship between ERP project team members (R3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Interactions between consultants and project team (R4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Relationship between suppliers and clients (R5)</td>
<td></td>
</tr>
<tr>
<td>ERP success achieved in the</td>
<td>Operational efficiency:</td>
<td>Karimi et al. (2007)</td>
</tr>
<tr>
<td>post-implementation stage</td>
<td>1. Improved operational efficiency (Eff1)</td>
<td></td>
</tr>
<tr>
<td>(Formative construct)</td>
<td>2. Lower operational costs (Eff2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3. Reduced amount of rework for data entry errors (Eff3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operational effectiveness:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4. Added value of operations (Effec1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>5. Improved timely access to corporate data (Effec2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>6. High level of enterprise wide data integration (Effec3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>7. Better sales forecasts (Effec4)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>8. Adequately meet the requirements of jobs (Effec5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>9. Improved quality of operations (Effec6)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Operational flexibility:</td>
<td></td>
</tr>
<tr>
<td></td>
<td>10. More ways to customise business processes (Flex1)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>11. Company more agile (Flex2)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>12. More adaptive to changing environment (Flex3)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>13. Improve flexibility of operations (Flex4)</td>
<td></td>
</tr>
</tbody>
</table>
3.4.3 Pilot study’s interviews (qualitative phase)

Following the quantitative data collection phase using the survey instrument, we conducted semi-structured interviews with nine of the 90 organisations that had participated in the survey. These organisations were contacted based on their willingness to participate in future research, as indicated in their response to the survey. Telephone interviews were conducted in June 2009. Typical interview questions are given in Table 3.3.

<table>
<thead>
<tr>
<th>Research issue</th>
<th>Core interview questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Importance of organisational assets</td>
<td>Could you please tell us more on the importance of Governance asset toward ERP post-implementation success?</td>
</tr>
<tr>
<td></td>
<td>Could you please tell us more on the importance of Knowledge asset toward ERP post-implementation success?</td>
</tr>
<tr>
<td></td>
<td>Could you please tell us more on the importance of Relationship asset toward ERP post-implementation success?</td>
</tr>
<tr>
<td>Complementarity between organisational assets and post-implementation success</td>
<td>What is your opinion on the complementarity between different organisational assets in achieving post-implementation success?</td>
</tr>
</tbody>
</table>

3.5 Large-scale study

The analysis of the data collected in the pilot study will lead to execution of the large-scale study with modified research model and bigger sample size. The large-scale study was also undertaken using quantitative and qualitative research methods. Figure 3.3 shows the large-scale study’s model. As discussed in Chapter 1 and 2 previously, the large-scale study’s research model is different than the pilot study’s model in the following contexts:
• Inclusion of three successive stages in ERP project’s lifecycle:
  
  o ERP pre-implementation stage
  
  o ERP implementation stage
  
  o ERP post-implementation stage

• Inclusion of three success outcomes in these three stages:
  
  o ERP pre-implementation stage’s success \(\rightarrow\) organisational readiness (OR)
  
  o ERP implementation stage \(\rightarrow\) completion of project targets (CPT)
  
  o ERP post-implementation stage \(\rightarrow\) business process outcomes (BPO)

• Inclusion of two additional organisational asset dimensions:
  
  o IT infrastructure (network and hardware)
  
  o Human resource (IT skills and training)

• Inclusion of additional dimensions within some of the existing organisational assets:
  
  o Knowledge (business process knowledge and project management knowledge)
  
  o Relationship (user involvement and top management involvement)

3.5.1 Large-scale study’s unit of analysis and sampling

The unit of analysis in the large-scale study was organisations that had implemented and were using an ERP system. The sampling framework aimed to capture as many organisations as possible, regardless of their industry classifications.
We once again sought the assistance of the EDGE in order to obtain a wider list of organisations using an ERP system in Malaysia. Thus, purposive sampling technique was also used in the large-scale study. The EDGE provided a list of 900 ERP using organisations located throughout Malaysia.

3.5.2 Large-scale study’s survey instrument (quantitative phase)

The survey instrument used in the large-scale study incorporated information from the pilot study. The instrument contained three parts (see Appendices A-C). The ten questions in the first part explored the profile of both the participating organisations and the person responding.

The second part (Sections 2.1-2.4) contained questions that explored the perceived importance of organisational assets across the ERP pre-implementation, implementation phase and post-implementation stages. The four assets were: human capital dimensions (IT skills and training), knowledge dimensions (business process knowledge and project management knowledge), relationship dimensions (user involvement and top management involvement) and IT infrastructure dimensions (hardware and networks). These assets were measured using a 7-point Likert scale (1 = not at all important to 7 = very important).
Figure 3.3: Large-scale study’s model

Notes:
TRA (Training); ITS (IT skills); HR (Human Resource); BPK (Business process knowledge); PMK (Project management knowledge); K (Knowledge); TMI (Top management involvement); UI (User involvement); R (Relationship); HAR (Hardware); NET (Networks); IT (IT infrastructure); G (Governance); Pre-OA (Organisational assets in Pre-implementation stage); Imp-OA (Organisational assets in Implementation stage); Post-OA (Organisational assets in post-implementation stage); OR (Organisational Readiness); CPT (Completion of Project Targets); BPO (Business Process Outcomes).
The third part contained sections 3.1–3.3. Section 3.1 explored the respondents’ reflections on the success achieved at the end of the each stage of their ERP project, with 25 questions probing pre-implementation success, represented by Organisational Readiness (OR) to adopt and commence their ERP project. Section 3.2 addressed ERP implementation success with five questions that explored the Completion of Project Targets (CPT) in the context of resource wastage, budget, schedule, user training and meeting project goals/objectives.

Finally, Section 3.3 contained 13 questions on business process outcomes experienced after system implementation and usage. From an enterprise perspective, ERP implementation could result in reduced cost, cycle time and improved quality (business process efficiency), improved decision making and planning (effectiveness) and reduced IT cost and improved connectivity with customers and suppliers (flexibility) (Karimi et al., 2007). All questions in the third part were measured using a 7-point Likert scale (1 = strongly disagree to 7 = strongly agree). Table 3.4 presents details of the measurement scale operationalisation.
Table 3.4: Measurement scale operationalisation

<table>
<thead>
<tr>
<th>Sections</th>
<th>Scales</th>
<th>Dimensions</th>
<th>Questions</th>
<th>Reference source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Section 1: Demographics</td>
<td>NA</td>
<td>10</td>
<td>Own</td>
<td></td>
</tr>
<tr>
<td>Section 2.1: Human capital</td>
<td>IT skills</td>
<td>10</td>
<td>Stratman &amp; Roth (2002)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Training</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 2.2: Knowledge</td>
<td>Business process</td>
<td>3</td>
<td>Karimi et al. (2007)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Project management</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 2.3: Relationship</td>
<td>User involvement</td>
<td>3</td>
<td>Karimi et al. (2007)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Top management involvement</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 2.4: IT infrastructure</td>
<td>Hardware</td>
<td>3</td>
<td>Ravichandran &amp; Lertwongsatien (2005)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Networks</td>
<td>4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 3.1: Organisational</td>
<td>NA</td>
<td>25</td>
<td>Abdinour-Helm et al. (2003)</td>
<td></td>
</tr>
<tr>
<td>Readiness (Reflective construct)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Targets (Reflective construct)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Section 3.3: Business Process</td>
<td>NA</td>
<td>13</td>
<td>Karimi et al. (2007)</td>
<td></td>
</tr>
<tr>
<td>Outcomes (Reflective construct)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Pretesting of survey instrument**

The content validity of the survey instrument was pretested to reduce design fault errors and to maximise response rates, question applicability and question performance (Sarantakos, 1993). The pretesting consisted of two stages. First, the survey instrument was appraised by five senior academics: three from marketing (from the University of Western Sydney) and two from strategic management and information management (both from the University of Wollongong). This first stage provided useful feedback about the questionnaire’s perceived length, appearance and layout, and the time required to complete it. The revised questionnaire was then pretested with five experienced ERP consultants in Malaysia. Their feedback required changes to wording of several items and the deletion of several demographic questions deemed inappropriate. The feedback from both stages provided guidelines for designing a simple, well-presented and highly content-valid questionnaire.
Survey administration

Administering the survey instrument involved several steps. First, we contacted each of the 900 organisations to validate the identity of the contact person given in the sample list. These contact persons were employees in senior managerial roles such as Directors or General Managers. The key informant approach was selected since the respondent was identified by virtue of their position in the organisation and was expected to provide reasonable and valid opinions in the capacity of a key decision maker in the organisation (Li & Atuahene-Gima, 2002). These contact persons were then briefed on the nature and aim of the survey to solicit their participation. Most contact persons were willing to participate, while others nominated more appropriate personnel in their organisations who were also willing to take part in the survey.

Following the initial contact, we posted the questionnaire package to the sample organisations in August 2009. The package contained the questionnaire, participant information sheet with a concise explanation of the survey, and a self-addressed return envelope. We made a follow-up telephone call in October 2009.

Several important design issues as proposed by Dillman (1978) were followed to increase the response rate. The questionnaire package was addressed personally to the key informant in each firm. The questionnaire was printed on light blue paper to look attractive and professional, it was printed on both sides to reduce bulkiness and each section was printed on one page to reduce density. Answering the questions was made easy as the participants were asked to make a simple circle on a number scale. As a further incentive to increase the response rate, we offered a copy of the study findings to all participants.
3.5.3 Large-scale study’s interviews (qualitative phase)

As with the pilot study, we undertook follow-up interviews to validate and strengthen the empirical findings obtained from the survey data. Twenty-two organisations were purposively selected from the sampling frame of 215 organisations that participated in the survey, representing approximately 10 per cent of the sample. We used two criteria to select organisations for interviews. First, organisations that had shown interest in participating in the next phase of study by ticking an indicator in the questionnaire were shortlisted. Second, we selected eleven of the shortlisted organisations with the most negative responses (i.e., ‘Not important at all’ and ‘Strongly disagree’) and another eleven with the most positive responses (i.e., ‘Very important’ and ‘Strongly agree’). Table 3.5 shows the large-scale study’s interview questions.

Table 3.5: Large-scale study’s interview questions

<table>
<thead>
<tr>
<th>Research issue</th>
<th>Core interview questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flanking complementarity effects of organisational assets</td>
<td>How did your company manage the configuration and deployment of organisational assets to foster flanking complementarity effects?</td>
</tr>
<tr>
<td></td>
<td>Can you reflect on the importance of specific organisational asset(s) in facilitating the condition for flanking complementarity?</td>
</tr>
<tr>
<td>Configuration and deployment of organisational assets for different stages’ needs</td>
<td>Can you reflect on the configuration and deployment of your organisational assets for the different stages’ needs?</td>
</tr>
</tbody>
</table>

**Interview administration**

The interview sessions were conducted with the aim of obtaining further information on the management of organisational assets across the ERP project lifecycle. Interview questions were based on the empirical findings from quantitative data. Participants were first contacted by telephone during business hours to organise interview.
Fifteen interviewees agreed to be interviewed via telephone. Another seven participants were interviewed in their office. Before each interview session, the participants were briefed about the aim of the interview and the study in general, and the justification for selecting them for the interview.

The semi-structured interviews were conducted in February and March 2010. Each interview lasted about 20–30 minutes. Interview questions were asked systematically and the interview was taped. When necessary, comments were checked. All participants were pleased to be involved in the research and requested a copy of the completed research report.

3.6 Data analysis

This section discusses the analytical tools employed to evaluate the data obtained from the quantitative and qualitative components of the research.

3.6.1 Quantitative data analysis

Quantitative data obtained in the pilot study were subjected to respondents’ profile analysis and research model estimations using structural equation modelling (SEM) via the partial least square (PLS) technique. Data gathered in the large-scale study were analysed in the following contexts: (a) response rate and informant competency, (b) non-response bias and common method bias, (c) respondents’ profile analysis, and (d) partial least square estimations.
Pilot study’s data analyses

The profile of the pilot study participants was analysed using SPSS version 11 statistical software with the aim of understanding the background of both the individual who answered the questionnaire and the organisation concerned. This process helped to qualify the quality of the responses provided by the respondents. The collected data were also subjected to SEM via PLS estimations. Detailed explanation of the PLS estimation technique is given in Section 3.5.2.

Large-scale study’s data analyses

Analysis of the survey data began with the data coding process. Data coding enables researchers to attain answers to research questions by assigning numbers to the responses and categorising them into meaningful groups (Cooper & Schindler, 2006). All questions were coded, and to maintain consistency in the direction of the questionnaire items, some items were re-coded to overcome conflicting directions associated with the Likert scale responses, especially item 2.3.3 of Question 2.3, item 2.4.3 of Question 2.4, and items 3.1.16 and 3.1.23 of Question 3.1. The need to reverse the score on a number of items in the questionnaire was paramount in forming the composite variables because a positive response was actually a negative indicator toward the variable. Adoption of this coding procedure would not contaminate the meaning of the original data (Manning & Munro, 2004).

Response rate and informants’ competency

We calculated the response rate of participation to determine the success of the quantitative data collection, using the following formula:

\[
\text{Response rate} = \left( \frac{\text{Number of returned survey}}{\text{Total sample size}} \right) \times 100
\]
Apart from the response rate, the participants’ competency was assessed to determine the quality of the responses. The aim of the survey was to obtain responses from a person in a senior managerial role with sound experience and knowledge about their firm’s ERP project and its associated activities.

Non-response bias

Data in the quantitative phase were collected over two different time periods. A total of 120 participants returned the questionnaire in the first round in October 2009 (referred to as early respondents) while another 95 returned the questionnaire in the second round in November 2009 (late respondents). To investigate differences in the responses provided by early and late respondents, we conducted a non-response bias test using the time trend extrapolation technique proposed by Armstrong and Overton (1971), whereby persons responding later are assumed to be more similar to non-respondents. Data obtained from the first 20 per cent of early respondents group were compared with the last 20 per cent of the late respondents group using three descriptive items in the questionnaire (type of industry, number of employees and revenue per annum), following the methods used by Mirchandani and Lederer (2006) and Hall (2007). The Analysis of One-Way Variance (ANOVA) test was used to identify any significant differences between early and late respondents. ANOVA is a statistical technique that indicates whether two or more independent random samples come from populations with different means (Stern, 2008), by examining the differences between group means and the spread of the values within the groups (Corston & Colman, 2003; Veal, 2005).

Common method bias

This study relied heavily on a single respondent from each sample firm, thus risking common method bias (Ganster, Hennessey & Luthans, 1983). Common method bias is defined as “variance that is attributable to the measurement method rather than to the construct of interest.”
The term common method refers to the form of measurement, at different levels of abstraction such as content specific items, scale type, response format and the general context” (Fiske, 1982, pp. 81–84).

Common method bias is a risk in most research as it represents the main sources of measurement error (Podsakoff et al., 2003). Measurement error can have a serious detrimental effect on empirical results, resulting in potentially misleading interpretations of conclusions (Campbell & Fiske, 1959). To test for existence of such risk, we used the Harman single factor evaluation method developed by Podsakoff and Organ (1986). This technique specifies that the individual measures for each construct be loaded into an exploratory factor analysis (EFA) to identify if the first extracted factor accounts for the majority of the variance amongst all measures (Anderson et al., 2009, p. 228). If all the measures in this study converged into one single dimension, common method bias would be a concern.

3.6.2 Structural equation modelling (SEM) with partial least square (PLS)

The full-scale survey data that had been cleaned using the factor analysis were further analysed using PLS estimation. SEM and PLS are among the more recent forms of statistical analysis. For many years, empirical analysis had included various statistical premises such as multiple regression, discriminant analysis or cluster analysis. Well known academic works (e.g., Spearman, 1904; Altman, 1968; Hofstede, 1983) had relied on these first-generation statistical techniques to examine how the world behaves. These techniques, however, are not without drawbacks. Haenlein and Kaplan (2004, p. 284) highlighted three main problems with these approaches: (a) the postulation of a simple model, (b) the assumption that all variables can be considered as observable, and (c) the conjecture that all variables are measured without error. These issues to a certain extent restrict their application in some research environments.
The search for an alternative analytical technique to address some of the weaknesses of first-generation statistical techniques led to the development of SEM. SEM is a second-generation analytical technique that was conceptualised and formalised by Herman Wold (1966, 1970). SEM facilitates modelling relationships between observed and latent variables (Bagozzi 1981).

Chin (1998) argues that SEM overshadows first-generation statistical techniques due to its ability to facilitate relationship modelling among multiple predictor and criteria variables, model errors in measurements for observed variables and perform statistical evaluation on a priori research models. In the words of Diamantopoulos (1994, p. 108), “SEM distinguishes between the exogenous and endogenous latent variables, the former being variables which are not explained by the postulated model (i.e., act always as independent variables) and the latter being variables that are explained by the relationships contained in the model”.

Over the years, SEM has become one of the most widely used statistical techniques in various research disciplines, such as psychology (MacCallum & Austin, 2000), management (Williams, Edwards & Vanderberg, 2003), marketing (Baumgartner & Homburg, 1996), management information systems (e.g., Dibbern, Goles, Hirschheim & Jayatilaka, 2004) and strategic management (e.g., Hulland, 1999; Tanriverdi, 2005). SEM estimation commonly employs two techniques: covariance (CBSEM) and variance. CBSEM uses a maximum likelihood function with the assumptions of joint multivariate distribution and independence of observations (Chin, 2010). Software such as LISREL, AMOS and EQS facilitate CBSEM estimations. Employing CBSEM requires non-violation of the normal distribution of data and a large sample size. Research that cannot fulfil these assumptions is more suited to variance-based SEM techniques, such as partial least square (PLS) (Reinartz et al., 2009).
Variance-based SEM - Partial Least Square (PLS) estimation

PLS estimation was introduced by Wold (1975) with the aim of maximising the variance of the dependent variables explained by the independent variables. The PLS estimation, as in any SEM technique, involves estimations of the relationship between the latent variables (structural), and between the latent variables and its indicators (measurement). However, PLS also has an additional component, known as the weight relations that estimate the case values for the latent variable (Chin & Newstead, 1999). The background operation of PLS is quite straightforward. First, the weight relations that link the indicators to its unobservable variables are estimated.

Then case values are calculated for each unobservable variable. Lastly the case values are used in a set of regression equations to determine the parameters for the structural relations (Fornell & Bookstein, 1982). Some of the most popular statistical tools used for PLS estimation are PLS graph version 3.0 (Chin, 2001) and SmartPLS version 2.0 (Ringle et al., 2005).

PLS have several advantages over CBSEM. First, PLS estimation is apt for theory development-based studies (Barclay et al., 1992). This, however, does not mean that PLS is not suitable as a theory-testing platform. PLS has an incremental characteristic that can help in building or extending a priori research models using new measures or structural paths (Chin, 2010). Second, PLS estimation is useful for research with a small sample size, and therefore it may be used in situations where other approaches are unsuitable. Using the Monte Carlo simulation, Chin and Newstead (1999) have shown that PLS can garner meaningful information from sample sizes as low as 20.

Third, as explained by Fornell and Bookstein (1982, p. 443) PLS inference “involves no assumptions about the population or scale of measurement”. This statement suggest that PLS works well without the assumption of normal distribution of data of nominal, ordinal and interval scale characteristics. Fourth, probably one of the most vital criteria of PLS is that it can model both reflective (effect) and formative (cause) indicators. In CBSEM technique, a construct is always assumed to be reflective (Chin, 2010). Reflective and formative constructs are discussed at length below.
Lastly, PLS path modelling can estimate complex models with numerous latent and manifest variables (Henseler, Ringle & Sinkovics, 2009). Chin (2010) provides further explanation of PLS modelling issues.

**Why PLS in this study?**

The PLS estimation technique was selected for this study for two main reasons. First, PLS is suitable for testing theories in early stage of development (Fornell & Bookstein, 1982). Theoretical models on the strategic management of organisational assets across the ERP project lifecycle are still in their infancy.

Only a few studies have formally addressed and tested models for this purpose, either directly or indirectly (e.g., Somers & Nelson, 2004; Abdinour-Helm et al., 2005; Karimi et al., 2007). Thus far, Karimi et al. (2007) have used PLS exclusively for data analysis. It was therefore useful to use PLS in this study since it could help in both developing and testing more robust measures and models of dynamic management of organisational assets across the ERP project lifecycle. Second, this study incorporates both formative and reflective constructs. The CBSEM-based analytical tools such as LISREL or AMOS implicitly assume that all constructs are reflective. Thus PLS is deemed to be more convenient in testing combinative reflective and formative constructs (Chin, 2010).

**Reflective and/or formative constructs**

A latent variable can be part of a reflective or a formative construct, or a combination both. Figures 3.4, 3.5a and 3.5b show graphical representations of the reflective and formative constructs.
Reflective constructs

The idea of reflective constructs has its roots with the classical test theory (Diamantopoulos, Riefler & Roth, 2008). The test theory argues that measures denote effects or manifestations of an underlying latent construct (Bollen & Lennox, 1991) and thus causality will run from the construct to the measures. In other words, since the indicators manifest the construct, any changes in the indicators’ value do not cause changes in the construct. Changes in the construct, however, will have an effect on the indicators. Measures of reflective constructs are normally interchangeable and have a common theme.

As pointed out by Petter et al. (2007, p. 633), “good reflective measures, by definition, should be one-dimensional and reflect this common theme”. Dropping any one of the measures would not have an effect on the construct’s meaning since all measures shares a common theme. Reflective measures will positively covary with one another (Bollen, 1984).

This implies that should the value of one of the measure change, the values of all the other measures will also move in the same direction. Covariance of the reflective measures is essential to show internal consistency of the measures, suggesting that all the measures are assessing the same phenomenon.

The interchangeable nature of reflective measures entails the same antecedents and consequences. In other words, the cause for changes to happen in reflective measures would emerge from the same source. The measurement errors are assumed to be independent and unrelated to the latent variable.
The pilot study contained three reflective constructs: independent constructs (i.e., Governance, Knowledge and Relationship). The outcomes in ERP pre-implementation, implementation and post-implementation stages (dependent constructs) were designed as reflective constructs in the large-scale study.

Formative constructs

The formative construct conceptualisation was mooted by Curtis and Jackson (1962), who challenged the concept of all measures in a construct having positive correlations. Such an argument was further refined by Blalock (1964, 1971), who suggested that the causal relationship direction in a formative construct stems from the construct to the measures. Any changes in the measures cause changes in the construct, but changes in the construct do not have any effect on the measures (Petter et al., 2007).

Formative measures are not interchangeable and comprise different themes. Elimination of one of the measures would have an impact on the meaning of the construct since the construct is defined by these measures. Formative construct measures should not co-vary with each other as this implies multicolinearity.
This essentially is a non-desirable phenomenon as it can destabilise the formative measures (Petter et al., 2007) and makes it difficult to separate the distinct influence of individual indicators on the latent variable (Diamantopoulos et al., 2008). Formative constructs inherently are composites of different measures. These different measures by default would not have the same antecedents or consequences. Formative construct can be specified as a multidimensional construct. The model shown in Figure 3.5a is a first-order construct.

A multidimensional model will have two layers of analysis: the first level links the manifest indicators to the first-order dimensions, while the second level relates the individual dimensions to the second-order emergent construct (McKenzie et al., 2005). The term ‘latent variable’ is denoted as emergent variable for formative models (Chin, 2010). Jarvis et al. (2003) proposed four types of multidimensional constructs: (a) formative first-order and formative second-order, (b) reflective first-order and formative second-order, (c) formative first-order and reflective second-order, and (d) reflective first-order and reflective second-order.

In this study, the focus has been on the first multidimensional construct: i.e. formative first-order and formative second-order (refer to Figure 3.5b). Human capital, Organisational knowledge, Relationship and IT infrastructure are formative second-order constructs, with each construct being formed by two formative first-order constructs. This type of formative dimension has received substantial attention in past studies (e.g., Arnett, Laverie & Meiers, 2003; Brewer, 2007; Venaik et al., 2004; Bruhn et al., 2008). Formative constructs are able to capture complementarity between organisational assets (Karimi et al., 2007). This is because complementarity suggest comingling effects between different assets, thus a formative construct is represented in terms of co-existence of multitude factors working collaboratively to achieve the intended target (Tanriverdi, 2006).
Figure 3.5a: Formative first-order construct

\[ \eta = \gamma_1 Y_1 + \gamma_2 Y_2 + \gamma_3 Y_3 + \xi \]

\[ \eta = \text{Emergent variable}; Y = \text{formative indicator}; \xi = \text{measurement error on latent variable level}; \gamma = \text{weight} \]

Figure 3.5b: Formative first-order, Formative second-order construct

\[ \eta = \text{Emergent variable}; Y = \text{formative indicator}; \xi = \text{measurement error on first-order and construct level}; \gamma = \text{weight} \]
The formative first-order and formative second-order models contain error terms, at both the individual or first-order level and the overall construct level. A second-order model can be formed in line with Chin and Gopal’s (1995) molar or molecular modelling techniques. Selection of the modelling technique relies on how the first-order construct is perceived: as causes of the second-order construct or as indicators of the second-order construct. Chin and Gopal (1995, p. 58) argue further that “if a change in one of the first order variables results in similar changes in the other variables, then a molecular model is appropriate”. This implies that the relationship between the first-order and second-order constructs is of a reflective nature. The molar modelling technique, on the other hand, leans toward the formative nature. Table 3.6 presents an integrated summary of the characteristic differences between reflective and formative constructs, as well as the key decision rules (as proposed by Jarvis et al., 2003) that influence the determination of whether a construct should be established as reflective or formative.

Based upon the key decision rules highlighted in Table 3.6, the four independent constructs in the large-scale study (Human resource, Knowledge, Relationship and IT infrastructure) were identified as formative constructs. These four independent constructs define the characteristics of pre-implementation, implementation and post-implementation organisational assets. In other words, since organisational assets are formed by these four indicators, any changes in these indicators will cause some changes in organisational assets’ strength, and thus could have an impact on the value of the firm.

Further, eliminating or excluding one of the constructs would modify the meaning of organisational assets altogether. Although these four constructs may not comprehensively cover all components of an organisation’s asset, in the context of this study they were taken to represent valuable components of the tangible and intangible assets inherent or owned by a firm. Removal of either one of them would alter the organisational assets domain, as combinations of tangible and intangible assets are necessary to spearhead efficient business operations (Wade & Hulland, 2004; Karimi et al., 2007).
Table 3.6: Summary of characteristics and decision rules to determine reflective or formative construct

<table>
<thead>
<tr>
<th>Characteristics &amp; Decision rule</th>
<th>Formative model</th>
<th>Reflective Model</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Direction of causality from construct to measure implied by the following conceptual definition:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the indicators (a) defining characteristics or (b) manifestations of the construct?</td>
<td>Direction of causality is from indicators to construct</td>
<td>Indicators are defining characteristics of the construct</td>
</tr>
<tr>
<td>Would changes in the indicators cause changes in the construct or not?</td>
<td>Changes in the indicators should cause changes in the construct</td>
<td>Changes in the indicators should not cause changes in the construct</td>
</tr>
<tr>
<td>Would changes in the construct cause changes in the indicators?</td>
<td>Changes in the construct do not cause changes in the indicators</td>
<td>Changes in the construct do cause changes in the indicators</td>
</tr>
<tr>
<td><strong>Interchangeability of the indicators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Should the indicators have similar content? Do the indicators share a common theme?</td>
<td>Indicators need not be interchangeable</td>
<td>Indicators should be interchangeable</td>
</tr>
<tr>
<td>Would dropping one of the indicators alter the conceptual domain of the construct?</td>
<td>Indicators need not have similar content/indicators need not share a common theme</td>
<td>Indicators should have similar content/indicators should share a common theme</td>
</tr>
<tr>
<td><strong>Covariation among the indicators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Should a change in one of the indicators be associated with changes in the other indicators?</td>
<td>Not necessary for indicators to covary with each other</td>
<td>Indicators are expected to covary with each other</td>
</tr>
<tr>
<td>Not necessarily</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td><strong>Nomological net of the construct indicators</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are the indicators expected to have the same antecedents and consequences?</td>
<td>Nomological net for the indicators may differ</td>
<td>Indicators are not required to have the same indicators and consequences</td>
</tr>
<tr>
<td>Indicators are required to have the same antecedents and consequences</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Adapted from Jarvis et al. (2003, p. 203)

Meanwhile the three dependent constructs (organisation’s readiness, target completion and positive business process outcomes) are reflective in nature. Table 3.7 presents the determination of reflective and formative constructs for this study based upon the guidance given in Table 3.6.
Table 3.7: Determination of reflective and formative constructs in this study

<table>
<thead>
<tr>
<th>Decision rule question</th>
<th>Pre-implementation organisational assets</th>
<th>Implementation organisational assets</th>
<th>Post-implementation organisational assets</th>
<th>Organisation’s Readiness</th>
<th>Completion of Project Targets</th>
<th>Business Process Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Are the indicators defining the characteristics of construct?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Do changes in the indicators cause changes in the construct?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Do changes in the construct cause changes in the indicators?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Do the indicators necessarily share the common theme?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Does eliminating an indicator alter the conceptual domain of the construct?</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Is a change in one indicator necessarily associated with a change in all other indicators?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Are the indicators expected to have the same antecedents and consequences?</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Scale type</th>
<th>Formative</th>
<th>Formative</th>
<th>Formative</th>
<th>Reflective</th>
<th>Reflective</th>
<th>Reflective</th>
</tr>
</thead>
</table>
Evaluation of a reflective construct’s outer model

The evaluation of a reflective construct begins with examining the strength of the reflective measures (indicators) used in the construct (also termed as outer model measurement) based on the convergent and discriminant validity (Chin, 1998). This sequence of tests ensures that the established construct measures are valid and reliable before attempting to draw conclusions regarding the relationships among constructs, termed structural (inner) model evaluation.

Convergent validity involves three form of tests: (a) individual reliability of each indicator, (b) composite reliability of constructs, and (c) the average variance extracted (AVE) by constructs (Fornell & Larcker, 1981). The individual reliability of each indicator should be more than 0.707 (Chin, 1998), while composite reliability of constructs upholds a threshold value of 0.80 (Fornell & Larcker, 1981).

The discriminant validity, on the other hand, entails evaluation of (d) correlations among the constructs, and (e) the square root of the AVE with the correlations among constructs – referred to as AVE$^2$. An AVE value above 0.50 (Fornell & Larcker, 1981) ensures a good fit between the constructs and the underlying indicators. The AVE$^2$ value should be greater than the correlation value among the constructs.

Evaluation of a formative construct’s outer model

Evaluation of convergent and discriminant validities is not possible for a formative construct’s outer model (Coltman et al., 2008; Roberts & Thatcher, 2009). This is because formative constructs lack the requirement for correlation (either to exist or to be in a particular magnitude) between indicators (Rossiter, 2002), which does not facilitate testing for convergent and discriminant validity (Bollen & Lenox, 1991). In this study, a concise review of PLS literature suggested that a formative construct’s outer model could be evaluated based on the multicolinearity of indicators.
Unlike a reflective construct, the existence of multicollinearity in a formative construct is not preferred since it causes estimation difficulties (Diamantopoulos & Winklhofer, 2001). Indeed, “substantial correlations among a formative construct’s indicators result in unstable estimates for the indicator coefficients and it becomes difficult to separate the distinct influence of individual indicators on the latent variable” (Diamantopoulos, Riefler & Roth, 2008, p. 1212). One of the commonly used approaches to assess the degree of multicollinearity is the variance inflation factor (VIF) statistic (Diamantopoulos & Winklhofer, 2001) that can be used to test if formative measures are highly correlated. The VIF was tested using the regression function in SPSS version 17, and computed using the following formula:

$$\text{VIF} = \frac{1}{(1-R^2_i)}$$

where $R^2_i$ is the variance explained from regressing the independent variable $X_i$ on all other independent variable $X_s$.

The VIF statistic that is lower than 3.3 indicates non-existence of multicollinearity, and vice-versa (Diamantopoulos & Siguaw, 2006).

**Reflective and formative constructs’ inner model evaluation**

Having established the appropriateness of the reflective and formative constructs’ measures, the next step was to provide evidence supporting the theoretical model as demonstrated by the structural (inner) component of the construct. Unlike outer model assessment, the inner model assessment is similar for both reflective and formative constructs. The inner model evaluation entailed the following procedures:

- The predictive power of the inner model was determined based on the $R^2$ of the endogenous constructs. Chin (1998) suggests that $R^2$ values below or equal than 0.33, more than 0.34 but less than 0.50, and greater than 0.51, denotes weak, strong and very strong predictive power, respectively.
Apart from the $R^2$ of the endogenous constructs, the assessment also looked at the predictive relevance of the inner model using Stone-Geisser $Q^2$ test (Stone, 1974; Geisser, 1975). The $Q^2$ is a measure of how well the observed values are reproduced by the model and its parameter estimates. A $Q^2$ value greater than 0 indicates good predictive relevance, and vice-versa. Two forms of $Q^2$ can be evaluated: communality $Q^2$ and redundancy $Q^2$. The communality $Q^2$ can be obtained if prediction of the omitted data points in the blindfolding block of indicators is made by the underlying latent variable. Redundancy $Q^2$ is obtained if prediction is made by those latent variables that predict the block of indicators (Chin, 2010). Both forms of $Q^2$ were evaluated in this study. The $Q^2$ was evaluated using the blindfolding procedure available in the SmartPLS software.

On a more recent note, PLS path modelling advocates (e.g., Tenenhaus et al., 2005) began looking at the Global Goodness of Fit (GoF) as an additional criterion to validate the inner model. The GoF is defined as the geometric mean of the average communality and average R-square [GoF = (\sqrt{\text{Communality} \times R^2})] (Wetzels et al., 2009). Wetzels et al. (2009) proposed that the computed GoF values should be within the three thresholds, akin to Cohen’s effect size thresholds. The GoF thresholds are: \text{GoF}_{\text{small}} = 0.1; \text{GoF}_{\text{medium}} = 0.25 and \text{GoF}_{\text{large}} = 0.36. In the words of Wetzels et al., (2009, p. 187), “this can serve as baseline values for validating the inner model globally”. According to Vinzi et al. (2010), while the GoF index is conventionally apt for reflective measurement model, it can also be interpreted with formative models.

Finally, the stability of the path estimates using the t-statistics obtained from the bootstrapping re-sampling procedure was examined. This is a non-parametric approach to assess the precision of path relationships determined by the t-values. Often, the t-values need to be greater than 2.0 (Chin, 1998) for a path to be considered significant.
3.6.3 Qualitative data analysis

We reviewed and manually coded the qualitative data obtained from the semi-structured interviews, identifying major and minor themes and seeking patterns in themes or concepts. Analytical software such as QSR and NVivo was not used in this study. The use of electronic techniques has produced considerable debate about the benefits and problems associated with coding qualitative data (Richards, 1999; Denzin & Lincoln, 2003). The justification of manual coding for this study is embedded in the following comments by Denzin and Lincoln (2003, p. 268):

_No matter how helpful computer programs may prove for managing these parts, we can see only their fragments on the screen. And these fragments may seem to take on an existence of their own, as if objective and removed from their contextual origins and from our constructions and interpretations._

Therefore by using manual coding for themes we become further immersed in the worlds and lives of the sample organisations and their organisational assets management experiences throughout their ERP project lifecycles. These themes and concepts provided clarification of the research issues and were used in triangulation with the quantitative phase data.

3.7 Ethical considerations

The research methodology literature advocates that research involving human participation requires strong ethical considerations (e.g., Davis, 2005; Cooper & Schindler, 2006). Ethics can be defined as the standards of behaviour that guide relationships with others. Essentially, the conduct of a research study should not have any adverse effects on the participant (Cooper & Schindler, 2006). Researchers such as Bouma (1996) and Berg (1998) have highlighted several core ethical concerns:
• **Voluntary participation**

It is important to inform the participants that their participation in the study is voluntary and that they can withdraw from the study at any time without penalty or coercion. In the quantitative phase of this study, the participant information sheet highlighted this statement and we also informed the participants during the semi-structured interview sessions.

• **Informed consent**

Participants must be clearly informed of the objective, scope and nature of the research and requested to provide informed consent for the data collection. This is important to minimise any potential psychological and physical harm to participants. In this study, completion of the questionnaire inferred informed consent to participate. This was clearly noted in the participant information sheet that was provided with the questionnaire. During the interview sessions (Phase 2) we also obtained verbal informed consent.

• **Privacy and confidentiality**

The participants’ privacy needs to be well protected. Direct or indirect links of the participants’ details with the research outputs must not be revealed, although it is quite common for the details to be used solely for administration purpose. Any research outputs/publications resulting from this study will not identify individuals or organisations. Privacy was also maintained in the context of protection against theft or malicious usage by limiting access to research data. In this study, the collected data were stored in computer files and password protected. Hard copy documents were stored in a locked cabinet file.

The quantitative research involved distribution of the survey instrument together with a participant information sheet that explained core issues related to the research as per the National Ethics Committee’s suggestion. These core issues are summarised in Table 3.8.
Table 3.8: Issues in participant information sheet

<table>
<thead>
<tr>
<th>Core elements</th>
<th>Issues highlighted</th>
</tr>
</thead>
<tbody>
<tr>
<td>About the project</td>
<td>Full title of research&lt;br&gt;Plain language description of the project&lt;br&gt;Purpose / aim of the project and research methods as appropriate&lt;br Demands, risks, inconveniences, discomforts of participation in the project&lt;br&gt;Outcomes and benefits of the project&lt;br&gt;Project start &amp; finish duration</td>
</tr>
<tr>
<td>About the investigator/organisations</td>
<td>Researchers conducting the project&lt;br&gt;Organisations which are involved / responsible&lt;br&gt;Organisations which have given approvals&lt;br&gt;Relationship between researchers and participants and organisations</td>
</tr>
<tr>
<td>Participant description</td>
<td>How and why participants are chosen&lt;br&gt;How participants are recruited&lt;br&gt;How many participants are to be recruited</td>
</tr>
<tr>
<td>Participant experience</td>
<td>What will happen to the participant, what will they have to do, what will they experience?&lt;br&gt;Benefits to individual, community and contribution to knowledge&lt;br&gt;Risks to individual and community&lt;br&gt;Consequences of participation</td>
</tr>
<tr>
<td>Participant options</td>
<td>Alternatives to participation&lt;br&gt;Whether participation may be for part of project or only for whole of project&lt;br&gt;Whether any of the following will be provided: counselling, post research follow-up, or post research access to services, equipment or goods</td>
</tr>
<tr>
<td>Participant rights and responsibilities</td>
<td>That participation is voluntary&lt;br&gt;That participants can withdraw, how to withdraw and what consequences may follow&lt;br&gt;Expectations on participants, consequences of non-compliance with the protocol&lt;br&gt;How to seek more information&lt;br&gt;How to raise a concern or make a complaint</td>
</tr>
<tr>
<td>Handling of information</td>
<td>How information will be accessed, collected, used, stored, and to whom data will be disclosed&lt;br&gt;Can participants withdraw their information, how, when&lt;br&gt;Confidentiality of information&lt;br&gt;Ownership of information&lt;br&gt;Subsequent use of information&lt;br&gt;Storage and disposal of information</td>
</tr>
<tr>
<td>Results</td>
<td>What will participants be told, when and by whom&lt;br&gt;Will individual results be provided&lt;br&gt;What are the consequences of being told or not being told the results of research&lt;br&gt;How will results be reported / published&lt;br&gt;Ownership of intellectual property and commercial benefits</td>
</tr>
</tbody>
</table>

Source: Adapted from NEAF website (www.neaf.gov.au)
This study was examined and approved by the University of Western Sydney Human Research Ethics Committee on 17\textsuperscript{th} December 2008 with the approval number H6627. Copy of the ethics approval letter is attached in Appendix C.

3.8 Chapter summary

This chapter has presented a discussion of the research methodology. Following the ontological and epistemological views, it discussed the sequential mix method research approaches. This was then followed by explanations of the pilot and large-scale studies, including the processes and procedures involved. The chapter also discussed the techniques used to analyse data collected and explained the relevant ethical considerations. The next chapter discusses the quantitative and qualitative research findings.
CHAPTER 4: RESEARCH FINDINGS FROM PILOT STUDY

4.1 Introduction

The previous chapter outlined the research methodology and discussed the evolution of this research’s scope. This chapter presents the research findings from the pilot study. Based on this backdrop, the rest of the chapter is organised as follows. Section 4.2 discusses the pilot study’s quantitative and qualitative research findings. The pilot study’s research finding summary is given in Section 4.3. The chapter summary is given in Section 4.4.

4.2 The pilot study’s empirical findings

The quantitative research data analysis entailed seeking answer to the question of do organisational assets (comprising of Governance, Knowledge and Relationship) has complementarity effect toward ERP post-implementation success. This was done by evaluating two research models, as discussed in chapters 2 and 3. The first model explored the individual direct effects of three organisational assets – Governance, Knowledge and Relationship – on ERP post-implementation success.

We compared the empirical results from this model with those from the second model, which investigated the complementarity effect of the three organisational assets on ERP post-implementation success. Such comparison is vital to determine whether complementarity effects prevail over the direct effects.
The individual direct effects of the Governance (G), Knowledge (K) and Relationship (R) assets on ERP post-implementation success were conceptualised via three hypotheses, reproduced below from Chapter 2. Each independent construct contained five indicators. The dependent construct (i.e., ERP post-implementation success) contained 13 indicators.

Hypothesis 1 (H1): Governance has a significant direct effect on ERP post-implementation success

Hypothesis 2 (H2): Knowledge has a significant direct effect on ERP post-implementation success

Hypothesis 3 (H3): Relationship has a significant direct effect on ERP post-implementation success

We undertook a series of path relationship estimations in order to identify the optimum complementarity effect (Hypothesis 4).

Hypothesis 4 (H4): Complementarity between organisational assets has a significant effect on ERP post-implementation success

4.2.2 Findings from quantitative research

The results from the quantitative research consist of the survey response rate, the respondents’ profile analysis and the partial least square (PLS) research model estimations.
Response rate

A questionnaire on the effects of Governance, Knowledge and Relationship assets on ERP post-implementation success (see Appendix A) was distributed to a sample of 488 service organisations operating in Malaysia in December 2008. By April 2009, 90 organisations had responded to the survey, representing a response rate of 18.4 per cent.

The respondents’ profile

Table 4.1 presents the details of the respondents’ profile analysis. Participating service organisations were almost equally divided between those involved in ICT services (51 per cent, N = 46) and those in wholesale and retail services (49 per cent, N = 44). While the targeted 488 service organisations also included those involved in financial service, tourism, logistics and utilities, these organisations did not participate in this study.

The majority of the ICT service organisations (56 per cent, N = 50) had been in business for more than 10 years, followed by those in business for 5–10 years (42 per cent, N = 38). A very small percentage of ICT service organisations had been in business for less than five years (2 per cent, N = 2). Over half of the wholesale and retail organisations had been in business 5–10 years (58 per cent, N = 52), and about 37 per cent (N = 33) had been in operation for more than 10 years. Again, a very small proportion (5 per cent, N = 5) of the wholesale and retail organisations had been in business for less than five years. These results suggest that most of the ICT service and wholesale and retail organisations were mature entities and probably had a stable business and operational structure.
Respondents in both ICT service and wholesale and retail services were patrons of the SAP ERP system. In the context of sales turnover, a large percentage (58 per cent, N = 52) of ICT service organisations had an annual sales turnover between RM 200,000 and RM 1 million (approximately US$57,000–286,000), while 36 per cent (N = 32) had an annual turnover of RM 1–5 million (US$286,000–1.4 million). Only 6 per cent (N = 5) of these organisations were making less than RM 200,000 (US$57,000) in sales per year.

The majority of the wholesale and retail organisations (65 per cent, N = 59) had earnings of RM 1–5 million (US$286,000–1.4 million) per annum. Another 28 per cent (N = 25) of these organisations were making between RM 200,000 (US$57,000) and RM 1 million (US$286,000) per year, followed by 7 per cent (N = 6) with an annual sales revenue of less than RM 200,000 (US$57,000).

Over half of the ICT service organisations (55 per cent, N = 50) had spent between RM 200,000 (US$57,000) and RM 1 million (US$286,000) on their ERP project. About 35 per cent (N = 31) of the ICT service organisations had spent less than RM 200,000 (US$57,000) for this purpose, while another 10 per cent (N = 9) had invested RM 1–5 million (US$286,000–1.4 million). Almost two-thirds of the wholesale and retail organisations (65 per cent, N = 59) had invested between RM 200,000 (US$57,000) and RM 1 million (US$286,000), followed by another 20 per cent (N = 18) who had invested RM 1–5 million (US$286,000–1.4 million) on their ERP project. Finally, 15 per cent (N = 13) of the wholesale and retail organisations had invested less than RM 200,000 (US$57,000) on their ERP project.
Table 4.1: Pilot study respondents’ profiles

<table>
<thead>
<tr>
<th></th>
<th>ICT services (51%)</th>
<th>Wholesale &amp; retail (49%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years in business</td>
<td>&lt; 5 yrs (2%)</td>
<td>&lt; 5 yrs (5%)</td>
</tr>
<tr>
<td></td>
<td>5–10 yrs (42%)</td>
<td>5–10 yrs (58%)</td>
</tr>
<tr>
<td></td>
<td>&gt; 10 yrs (56%)</td>
<td>&gt; 10 yrs (37%)</td>
</tr>
<tr>
<td>ERP vendor</td>
<td>SAP (100%)</td>
<td>SAP (100%)</td>
</tr>
<tr>
<td></td>
<td>SAP (100%)</td>
<td>SAP (100%)</td>
</tr>
<tr>
<td></td>
<td>SAP (100%)</td>
<td>SAP (100%)</td>
</tr>
<tr>
<td>Sales turnover per year</td>
<td>&lt; RM 200k (6%)</td>
<td>&lt; RM 200k (7%)</td>
</tr>
<tr>
<td></td>
<td>RM 200k–RM 1m (58%)</td>
<td>RM 200 – RM 1m (28%)</td>
</tr>
<tr>
<td></td>
<td>RM 1–5m (36%)</td>
<td>RM 1–5m (65%)</td>
</tr>
<tr>
<td>ERP investment value</td>
<td>&lt; RM 200k (35%)</td>
<td>&lt; RM 200k (15%)</td>
</tr>
<tr>
<td></td>
<td>RM 200k–RM 1m (55%)</td>
<td>RM 200 – RM 1m (65%)</td>
</tr>
<tr>
<td></td>
<td>RM 1–5m (10%)</td>
<td>RM 1–5m (20%)</td>
</tr>
</tbody>
</table>

Note: RM = Malaysian currency denomination (RM 1 = US$0.35 in 2010)

Pilot study model estimations from partial least squares (PLS) modelling

As explained in Section 3.5.2 of Chapter 3, in order to undertake PLS estimations of the individual direct effect and the complementarity effect in the models (figures 3.1 and 3.2 in Chapter 3) we need to evaluate the outer and inner models of the reflective and formative constructs. This sub-section reports the PLS estimations for the quantitative data from the pilot study, discussing first the outer model evaluation for both individual direct effect and complementarity effect models, followed by the inner model evaluations for both models.

Individual direct effect model – evaluation of reflective constructs’ outer model

The research models in the pilot study had three reflective constructs: Governance, Knowledge and Relationship. Table 4.2 contains the results of the outer model evaluation of the reflective constructs (i.e., convergent validity: individual item reliability, composite reliability and AVE; and discriminant validity: correlations and AVE²).
The individual reliability assessment of the three reflective constructs indicated non-reliability of several items in the three constructs, since these indicators had loading values smaller than 0.707. Three indicators in the Governance construct (G3, G4 and G5), three in Knowledge (K1, K3, K4) and one in Relationship (R4) had small loading values, and so were removed from the estimation model before commencing further analysis (Chin, 1998). Once the model was cleaned, the outer model was re-evaluated. The composite reliability, AVE, $AVE^2$ and correlations showed in Table 4.2 are the values gained after removal of the weak indicators. The remaining indicators in each reflective construct posted satisfactory loading values, thus providing adequate explanatory power for the model.
The composite reliability values of the three reflective constructs posted greater than 0.80 threshold values. The AVE for these constructs was above the 0.50 cut-off points, thus indicating a good fit between the constructs and its underlying indicators.

In the context of discriminant validity, the correlations between the three reflective constructs were positive. In addition, the AVE$^2$ values were greater than the correlations between the independent constructs. These results suggested that the selected construct measures were valid and reliable.

*Individual direct effect model – evaluation of formative constructs’ outer model*

As discussed in Chapter 3, convergent and discriminant validity tests cannot be executed in a formative construct because of the lack of requirement for correlations between indicators (Bollen & Lenox, 1991).

Conventional methods used to test validity and reliability is inappropriate for formative constructs (Diamantopoulos & Winklhofer, 2001). In the individual direct effect model, ERP post-implementation success (the dependent construct) is a formative construct. The outer model evaluation of this construct was undertaken using the multicolinearity (VIF) test. The VIF value should be lower than 3.3 points (Diamantopoulos & Siguaw, 2006).

Table 4.3 provides the multicolinearity test outputs for the formative construct (ERP success) in the individual direct effect model. The ERP success formative construct consisted of 13 indicators that captured the operational benefits experienced after using ERP system. The result suggested that multicolinearity was not an issue with this formative construct, thus indicating good validity of the construct.
Table 4.3: Multicolinearity statistics - individual direct effect model’s formative construct

<table>
<thead>
<tr>
<th>Individual direct effect model (ERP success construct – 13 indicators)</th>
<th>Colinearity statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tolerance</td>
</tr>
<tr>
<td>EFF1</td>
<td>0.543</td>
</tr>
<tr>
<td>EFF2</td>
<td>0.567</td>
</tr>
<tr>
<td>EFF3</td>
<td>0.612</td>
</tr>
<tr>
<td>EFFE1</td>
<td>0.654</td>
</tr>
<tr>
<td>EFFE2</td>
<td>0.721</td>
</tr>
<tr>
<td>EFFE3</td>
<td>0.678</td>
</tr>
<tr>
<td>EFFE4</td>
<td>0.567</td>
</tr>
<tr>
<td>EFFE5</td>
<td>0.687</td>
</tr>
<tr>
<td>EFFE6</td>
<td>0.567</td>
</tr>
<tr>
<td>FLEX1</td>
<td>0.715</td>
</tr>
<tr>
<td>FLEX2</td>
<td>0.687</td>
</tr>
<tr>
<td>FLEX3</td>
<td>0.588</td>
</tr>
<tr>
<td>FLEX4</td>
<td>0.611</td>
</tr>
</tbody>
</table>

**Complementarity effect model – evaluation of reflective constructs’ outer model**

The validity and reliability of the measures were computed for the complementarity effect model using similar indicators as for the individual/direct effect model. The complementarity effect model involved running a series of path estimations to evaluate the optimum complementarity effect between the three organisational assets. This procedure was necessary because of a lack of empirical results on the complementarity effect between these three organisational. The complementarity effect of the Governance asset in ERP context, in particular, has received little empirical attention. The validity and reliability of the measures in this context are reported based on the optimum complementarity effect result.

The optimum complementarity effect was determined from the highest \( t\)-statistics value obtained for path relationship estimations as well as the effect size computation. The statistical results of validity and reliability of the complementarity effect outer model are given in Table 4.4.
Table 4.4: Statistical results of complementarity effect model

<table>
<thead>
<tr>
<th>Construct</th>
<th>Indicator</th>
<th>Loading</th>
<th>Composite reliability</th>
<th>AVE</th>
<th>AVE^2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Governance</td>
<td>G1</td>
<td>0.823</td>
<td>0.81</td>
<td>0.73</td>
<td>0.83</td>
</tr>
<tr>
<td></td>
<td>G2</td>
<td>0.798</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G3</td>
<td>0.553*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G4</td>
<td>0.523*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>G5</td>
<td>0.456*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Knowledge</td>
<td>K1</td>
<td>0.596*</td>
<td>0.80</td>
<td>0.56</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>K2</td>
<td>0.790</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>K3</td>
<td>0.678*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>K4</td>
<td>0.691*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>K5</td>
<td>0.767</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relationship</td>
<td>R1</td>
<td>0.811</td>
<td>0.83</td>
<td>0.55</td>
<td>0.74</td>
</tr>
<tr>
<td></td>
<td>R2</td>
<td>0.834</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>R3</td>
<td>0.880</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>R4</td>
<td>0.417*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>R5</td>
<td>0.801</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Akin to the outcome from the individual direct effect model, the validity and reliability of the reflective measures in the complementarity effect model were proven to be satisfactory in the context of individual reliability, composite reliability, AVE, AVE^2 and correlations between the constructs.

Complementarity effects model – evaluation of formative constructs’ outer model

Table 4.5 presents the multicolinearity statistics for the formative construct (ERP post-implementation success) of the complementarity effect model. Again, the VIF values for all indicators were less than 3.3, suggesting absence of multicolinearity in this construct (Diamantopoulos & Siguaw, 2006).
### Table 4.5: Multicolinearity statistics for complementarity effect model

<table>
<thead>
<tr>
<th>Individual direct effect model (ERP success construct – 13 indicators)</th>
<th>Colinearity statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tolerance</td>
</tr>
<tr>
<td>EFF1</td>
<td>0.651</td>
</tr>
<tr>
<td>EFF2</td>
<td>0.667</td>
</tr>
<tr>
<td>EFF3</td>
<td>0.701</td>
</tr>
<tr>
<td>EFFE1</td>
<td>0.711</td>
</tr>
<tr>
<td>EFFE2</td>
<td>0.601</td>
</tr>
<tr>
<td>EFFE3</td>
<td>0.780</td>
</tr>
<tr>
<td>EFFE4</td>
<td>0.650</td>
</tr>
<tr>
<td>EFFE5</td>
<td>0.589</td>
</tr>
<tr>
<td>EFFE6</td>
<td>0.619</td>
</tr>
<tr>
<td>FLEX1</td>
<td>0.687</td>
</tr>
<tr>
<td>FLEX2</td>
<td>0.724</td>
</tr>
<tr>
<td>FLEX3</td>
<td>0.568</td>
</tr>
<tr>
<td>FLEX4</td>
<td>0.510</td>
</tr>
</tbody>
</table>

**Structural (inner) model evaluations**

The requirements of convergent and discriminant validities were fulfilled in both models, with the estimated values for all tests holding above the threshold. The next step, therefore, was to evaluate the structural (inner) component of both models (refer to Table 4.6).
Table 4.6: Structural inner model evaluation for individual direct and complementarity effect research models

<table>
<thead>
<tr>
<th>Paths hypothesised relationships:</th>
<th>Research model 1</th>
<th>Research model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$R^2 = 0.194$</td>
<td>$R^2 = 0.192$</td>
</tr>
<tr>
<td></td>
<td>$Q^2 = 0.00$</td>
<td>$Q^2 = 0.00$</td>
</tr>
<tr>
<td>$G \rightarrow$ ERP (H1)</td>
<td>0.018 (0.147)</td>
<td>$NA$</td>
</tr>
<tr>
<td>$K \rightarrow$ ERP (H2)</td>
<td>0.203 (1.859)*</td>
<td>$NA$</td>
</tr>
<tr>
<td>$R \rightarrow$ ERP (H3)</td>
<td>0.346 (4.205)***</td>
<td>$NA$</td>
</tr>
<tr>
<td>$G \rightarrow$ K</td>
<td>$NA$</td>
<td>0.083 (0.845)</td>
</tr>
<tr>
<td>$K \rightarrow$ ERP (H4)</td>
<td>$NA$</td>
<td>0.683 (11.838)**</td>
</tr>
<tr>
<td>$R \rightarrow$ K</td>
<td>$NA$</td>
<td>0.208 (2.519)**</td>
</tr>
<tr>
<td>$G \rightarrow$ ERP (H4)</td>
<td>$NA$</td>
<td>0.393 (5.345)***</td>
</tr>
<tr>
<td></td>
<td>$NA$</td>
<td>0.348 (6.129)***</td>
</tr>
</tbody>
</table>

Notes: *** $p < 0.001$; ** $p < 0.05$; + $p < 0.10$

**Individual direct effect model**

The result presented in Table 4.6 showed that the structural link from the Governance asset to ERP post-implementation success was positive but insignificant ($\beta = 0.018; t = 0.147$). The result did not provide support for Hypothesis 1: *Governance has a significant direct effect on ERP post-implementation success*. The path relationship between the Knowledge asset with ERP post-implementation success was positive but only marginally significant ($\beta = 0.203; t = 1.859; p < 0.10$), indicating a rejection of Hypothesis 2: *Knowledge has a significant direct effect on ERP post-implementation success*.

Relationship asset on the other hand, had a positive and statistically significant structural link with ERP post-implementation success ($\beta = 0.346; t = 4.205; p < 0.001$), indicating a strong support for Hypothesis 3: *Relationship has a significant direct effect on ERP post-implementation success*. The individual direct effect model explained a 19.4 per cent variance, with a $Q^2$ value of zero. This indicated a good predictive relevance model.
In the complementarity effects model, the structural link emerging from the Governance asset to the other two assets produced the optimum complementarity effect. Such a decision was statistically supported by the measurement of this path’s large effect size of 0.34, which was based on the formula: 
\[
\frac{R^2_{\text{included}} - R^2_{\text{excluded}}}{1 - R^2_{\text{included}}}
\]
(Ringle et al., 2005). As shown in Table 4.6, there was a significant and positive structural path emerging from the Governance asset toward the Knowledge asset \((\beta = 0.683; t = 11.838; p < 0.001)\). This seems to have reinforced the Knowledge asset’s effect on ERP post-implementation success, since the estimation value was positive and significant \((\beta = 0.208; t = 2.519; p < 0.05)\). In contrast, as discussed above, the Knowledge asset had a very marginal effect on ERP post-implementation success in the individual direct effect model.

The Governance asset also had a positive and significant effect on the Relationship asset \((\beta = 0.393; t = 5.345; p < 0.001)\). Subsequently, the reinforced path effect emerging from the Relationship asset toward ERP post-implementation success was significantly stronger than its individual direct effect, as seen by the Relationship asset’s higher t-statistics value in the complementarity effect model \((\beta = 0.348; t = 6.129; p < 0.001)\).

These results indicated that Hypothesis 4: **Complementarity between the organisational assets has a significant effect on ERP post-implementation success** was well supported. This result also shows that the complementarity between organisational assets in the pilot study context was of a reinforcing complementarity -- which is one type of complementarity dimension proposed by Horgan and Muhlau (2006).

The complementarity effects model explained a 19.2 per cent variance, which was marginally lower than the variance in the individual direct effect model. While the R-square value was quite weak (i.e., lower than 0.33) (Chin, 1998), the Q² value was zero, indicating a good predictive relevance model. The final research model based on these empirical findings is given in Figure 4.1.
The final model implies that the three different organisational assets that were used to achieve ERP post-implementation success did not have significant individual effects, but rather reinforced one another. Individually, each asset does not have a powerful contribution toward success. Each asset needs the support of another to achieve optimal success, with the fundamental complementarity arising from the Governance asset. The management of Governance practices has added crucial impetus to the Knowledge and Relationship assets effects, thus leading to improved positive gains post ERP usage.

**Figure 4.1: Final research model based on the empirical findings – reinforcing complementarity**

**Notes:** +, Sig = positive and significant path; +, Not sig = positive but insignificant
4.2.3 Findings from qualitative research

We conducted follow-up telephone interviews with selected respondents (N = 9) after the quantitative data analyses. The respondents were asked to discuss the importance of organisational assets in leading to ERP post-implementation success:

Could you please tell us more about the importance of Governance, Knowledge and Relationship assets on ERP post-implementation success? The responses provided by the respondents for this question can be segmented into two major themes: (a) the importance of the three organisational assets and (b) the role of Governance.

(a) The importance of the three organisational assets

Most respondents perceived the three organisational assets as important elements in their ERP project:

...indeed our organisational assets are vital to complete any projects, including ERP system usage.

Our organisational knowledge is important for our business performance. The system consultants have briefed us on the importance of proper knowledge management – a thing that ERP system does primarily, but we also emphasise on knowledge sharing between the different users. We want efficient knowledge sharing to get the expected results.

Certainly Knowledge and Relationship is crucial in system usage because of the large amount of technical knowledge transfer from ERP consultants to the users as well as between the users (i.e., between different department’s users). Only when this happens we could see good return from ERP investment.

...knowledge exchange process requires good communication and management of people – a trait we try to uphold extensively in our organisation. We do reap the benefit.
(b) The role of Governance asset

A substantial number of respondents perceived the role of the Governance asset as very important for effective ERP usage. This seems to be primarily because of the continuous need to monitor and control the system’s usage by its users, particularly in the early stage of routinisation:

*Governance is utmost important for us. ERP usage needs constant monitoring and review of the technology. We can’t get away from this. That is why we get good operational output.*

*Of course governance is important. Without governance, we could not have completed the project first of all. We are still practicing stringent governance of ERP usage and its associated outputs. We do not want fraudulent activities to happen.*

*Governance our activities after implementing the system was critical to ensure proper knowledge transfer happens and that the users’ cooperation remains at the required level.*

These three responses complement the results obtained from the quantitative research data, that is, Governance practice complements the effect of Knowledge and Relationship assets, leading to improved operational business process outcomes.

The participating respondents were also asked to express their thoughts on the following question: *What is your opinion on the complementarity between different organisational assets in achieving post-implementation success?* There was general agreement that some form of complementarity between the assets leads to post-implementation success.

*Yes, our assets do complement each other. Without governance, we can’t effectively manage knowledge or relationships. Careful management of these assets have indeed helped us to achieve our objective after using the ERP system.*
I think organisational assets do complement one another. The absence of one asset will weaken another. Each asset complements one another – they are equally important for us. We experienced this the hard way after implementing ERP system. We didn’t realise that poor concentration on effective communication with users would delay achievement of business performance. We made amends once we realised this.

Governance, knowledge and relationship management was equally important to us – we relied on the cooperation between these resources to achieve positive outcomes.

The responses in the interviews were consistent with the quantitative findings. While all the three assets were perceived as important toward ERP post-implementation success, the respondents perceived the Governance asset as the predominant reinforcing element. Further managing these assets in a complementary approach are perceived as an important element in achieving post-implementation success.

4.3 Summary of findings from the pilot study

The interview excerpts presented above validated the empirical findings from the quantitative research phase. Overall, the quantitative and qualitative findings gathered from the pilot study phase validated the notion of reinforcing complementarity between three organisational assets and its superseding effect in achievement of ERP post-implementation success.

Apart from this, the pilot study’s finding also indicate that Governance asset perhaps can be excluded from the large-scale study due to its nature of being a primal foundation for reinforcing complementarity between organisational assets to prevail in ERP project context. This implies that the role of Governance will most probably remain static condition across the different stages of an ERP project. The nature of the large-scale study is to try to explore the different conditions for flanking complementarity effects across ERP project lifecycle.
In this context, since Governance asset seem to be displaying a static and fundamental condition for complementarity, we decided to remove this asset from the large-scale study. Hence a moderate modification to the large-scale study’s research model is deemed necessary and this is presented in the next chapter (Chapter 5). Note that exclusion of the Governance asset from the large-scale study will not have any impact to the established research questions and hypotheses as this is just a practice of reducing an independent construct from the structural path modelling based on previous empirical analysis.

4.4 Chapter summary

This chapter presented the results of the quantitative and qualitative data analyses from the pilot study. The findings in this study led to a moderate modification of the large-scale research model as discussed in Section 4.3 above. On that note, the next chapter highlights the findings from the large-scale study.
CHAPTER 5: RESEARCH FINDINGS FROM LARGE-SCALE STUDY

5.1 Introduction

This chapter presents the research findings from the large-scale study. As mentioned in Chapter 4 earlier, the large scale study’s research model has been modified to exclude Governance asset from further analysis. Against this backdrop, the rest of the chapter is organised as follows. Section 5.2 discusses the large-scale study’s quantitative and qualitative research findings, with the large-scale study’s summary presented in Section 5.3. The overall chapter summary is given in Section 5.4.

5.2 The large-scale study’s empirical findings

Preliminary analysis of data gathered in the full-scale study included response rate and respondents’ profile, as for the pilot study. In addition, we evaluated the data in terms of informants’ competency, non-response bias and common method bias in order to ensure the quality of the quantitative information gathered. The following sub-sections report, first, the quantitative findings and, second, the qualitative findings of the large-scale study.

5.2.1 Findings from quantitative research

Quantitative data were analysed for response rate, informant competency, profile analysis, non-response bias test, common method bias test and PLS estimations.
**Response rate**

As discussed in Chapter 3, the EDGE provided a list of 900 locally established organisations that were using ERP and had completed their ERP adoption in the previous three years.

The questionnaire package was mailed to the target respondents in August 2009. By October 2009, 120 people had responded and, after follow-up telephone calls, another 95 responses had been received by mid-November 2009. In total, 215 responses were received, giving a response rate of 23.8 per cent.

**Informants’ competency**

Data quality was evaluated based on the informants’ competency level. Survey respondents were employed in the following positions: 48.8 per cent (N = 105) general managers; 33 per cent (N = 71) managing directors; 12.6 per cent (N = 27) project managers; 3.3 per cent (N = 7) other senior executive posts; and 2.3 per cent (N = 4) IT managers.

The average organisational tenure of respondents was 9.7 years. Collectively, the majority of the respondents were in senior managerial positions with at least nine years in their current employment role. It can be safely assumed that the informants were knowledgeable and highly competent to answer the questions and thus the data quality obtained can be presumed to be of high.

**Respondents’ profile analysis**

Table 5.1 presents a summary of the respondents’ profiles. The largest group of respondents occupied a general manager role in the company (48.8 per cent, N = 105). Over half of the respondents had been working in their organisation for 5–7 years (55.8 per cent, N = 120), with 20.5 per cent (N = 44) with the organisation for less than three
years. Almost half of the respondents had completed their bachelor’s degree (47.9 per cent, N = 103). Slightly more than half of the organisations had been in operation for 5–7 years (52.6 per cent, N = 113). In terms of size of organisation, the distribution was fairly equally divided among 250–499 employees (29.3 per cent, N = 70), 100–249 employees (30.2 per cent, N = 65) and 50–99 employees (29.3 per cent, N = 63). Only 17 organisations (7.9 per cent) had 500 or more employees.

The largest group – one-third of the organisations (33.5 per cent, N = 72) – were earning RM 50–99 million (US$17–33 million) in sales per year. Almost as many (29.3 per cent, N = 63) were earning less than RM 10 million (US$3.33 million), while only 17 organisations (7.9 per cent) were earning RM 500 million (US$166 million) or more. In terms of the industry in which the companies were involved, no industry was particularly dominant: 34.9 per cent (N = 75) of the responding organisations were in manufacturing, 27.9 per cent (N = 60) were in ICT services, 20.54 per cent (N = 44) were in engineering and 16.7 per cent (N = 36) were in trade.
### Table 5.1: Large-scale study respondents’ profile

<table>
<thead>
<tr>
<th>Profile</th>
<th>Breakdown</th>
<th>Frequency</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Role in the organisation</td>
<td>Managing director</td>
<td>71</td>
<td>33.0</td>
</tr>
<tr>
<td>Role in the organisation</td>
<td>General Manager</td>
<td>105</td>
<td>48.8</td>
</tr>
<tr>
<td>Role in the organisation</td>
<td>Project manager</td>
<td>27</td>
<td>12.6</td>
</tr>
<tr>
<td>Role in the organisation</td>
<td>IT manager</td>
<td>5</td>
<td>2.3</td>
</tr>
<tr>
<td>Role in the organisation</td>
<td>Other senior executive post</td>
<td>7</td>
<td>3.3</td>
</tr>
<tr>
<td>Years working in the organisation</td>
<td>&lt; 3 yrs</td>
<td>44</td>
<td>20.5</td>
</tr>
<tr>
<td>Years working in the organisation</td>
<td>3–5 yrs</td>
<td>51</td>
<td>23.7</td>
</tr>
<tr>
<td>Years working in the organisation</td>
<td>5–7 yrs</td>
<td>120</td>
<td>55.8</td>
</tr>
<tr>
<td>Highest education level</td>
<td>Diploma</td>
<td>75</td>
<td>34.9</td>
</tr>
<tr>
<td>Highest education level</td>
<td>Bachelor</td>
<td>103</td>
<td>47.9</td>
</tr>
<tr>
<td>Highest education level</td>
<td>Masters</td>
<td>36</td>
<td>16.7</td>
</tr>
<tr>
<td>Years company operating</td>
<td>&lt; 3 yrs</td>
<td>51</td>
<td>23.7</td>
</tr>
<tr>
<td>Years company operating</td>
<td>3–5 yrs</td>
<td>51</td>
<td>23.7</td>
</tr>
<tr>
<td>Years company operating</td>
<td>5–7 yrs</td>
<td>113</td>
<td>52.6</td>
</tr>
<tr>
<td>Number of employees</td>
<td>50–99</td>
<td>63</td>
<td>29.3</td>
</tr>
<tr>
<td>Number of employees</td>
<td>100–249</td>
<td>65</td>
<td>30.2</td>
</tr>
<tr>
<td>Number of employees</td>
<td>250–499</td>
<td>70</td>
<td>32.6</td>
</tr>
<tr>
<td>Number of employees</td>
<td>500 and above</td>
<td>17</td>
<td>7.9</td>
</tr>
<tr>
<td>Sales revenue earned per annum (RM)</td>
<td>&lt; 10 m</td>
<td>63</td>
<td>29.3</td>
</tr>
<tr>
<td>Sales revenue earned per annum (RM)</td>
<td>10–49 m</td>
<td>24</td>
<td>11.2</td>
</tr>
<tr>
<td>Sales revenue earned per annum (RM)</td>
<td>50–99 m</td>
<td>72</td>
<td>33.5</td>
</tr>
<tr>
<td>Sales revenue earned per annum (RM)</td>
<td>100–499 m</td>
<td>39</td>
<td>18.1</td>
</tr>
<tr>
<td>Sales revenue earned per annum (RM)</td>
<td>500m and above</td>
<td>17</td>
<td>7.9</td>
</tr>
<tr>
<td>Industry in which the organisation is involved</td>
<td>Engineering</td>
<td>44</td>
<td>20.5</td>
</tr>
<tr>
<td>Industry in which the organisation is involved</td>
<td>Manufacturing</td>
<td>75</td>
<td>34.9</td>
</tr>
<tr>
<td>Industry in which the organisation is involved</td>
<td>ICT services</td>
<td>60</td>
<td>27.9</td>
</tr>
<tr>
<td>Industry in which the organisation is involved</td>
<td>Trading</td>
<td>36</td>
<td>16.7</td>
</tr>
</tbody>
</table>

**Non-response bias**

We used the Analysis of One-Way Variance (ANOVA) technique to test for non-response bias, by comparing the first 20 per cent of the early respondents with the last 20 per cent of the late respondents using three descriptive items: type of industry, number of employees and sales revenue per annum. The results are shown in Table 5.2.
### Table 5.2: Non-response bias test results

<table>
<thead>
<tr>
<th>Comparison indicators</th>
<th>Groups</th>
<th>p-value</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of industry</td>
<td>Early respondents</td>
<td>p = 0.126</td>
<td>Not significant; non-response bias does not exist</td>
</tr>
<tr>
<td></td>
<td>Late respondents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of employees</td>
<td>Early respondents</td>
<td>p = 0.133</td>
<td>Not significant; non-response bias does not exist</td>
</tr>
<tr>
<td></td>
<td>Late respondents</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales revenue per annum</td>
<td>Early respondents</td>
<td>p = 0.213</td>
<td>Not significant; non-response bias does not exist</td>
</tr>
<tr>
<td></td>
<td>Late respondents</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Common method bias**

The common method bias was tested using exploratory factor analysis (EFA) with Varimax rotation. No single factor was dominant. A total of 17 components were extracted, with the variance ranging from 2.58 to 78.45 per cent. This suggests that common method bias was not a major concern. Table 5.3 shows the EFA output summary.
Table 5.3: Exploratory factor analysis output

<table>
<thead>
<tr>
<th>Component</th>
<th>Initial Eigenvalues</th>
<th>Extraction Sums of Squared Loadings</th>
<th>Rotation Sums of Squared Loadings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total</td>
<td>% of Variance</td>
<td>Cumulative %</td>
</tr>
<tr>
<td>1</td>
<td>17.37</td>
<td>25.92</td>
<td>25.92</td>
</tr>
<tr>
<td>2</td>
<td>5.81</td>
<td>8.67</td>
<td>34.59</td>
</tr>
<tr>
<td>3</td>
<td>3.87</td>
<td>5.77</td>
<td>40.37</td>
</tr>
<tr>
<td>4</td>
<td>3.18</td>
<td>4.75</td>
<td>45.11</td>
</tr>
<tr>
<td>5</td>
<td>2.78</td>
<td>4.14</td>
<td>49.26</td>
</tr>
<tr>
<td>6</td>
<td>2.66</td>
<td>3.97</td>
<td>53.23</td>
</tr>
<tr>
<td>7</td>
<td>2.45</td>
<td>3.66</td>
<td>56.88</td>
</tr>
<tr>
<td>8</td>
<td>2.06</td>
<td>3.08</td>
<td>59.96</td>
</tr>
<tr>
<td>9</td>
<td>1.80</td>
<td>2.69</td>
<td>62.65</td>
</tr>
<tr>
<td>10</td>
<td>1.66</td>
<td>2.48</td>
<td>65.12</td>
</tr>
<tr>
<td>11</td>
<td>1.51</td>
<td>2.26</td>
<td>67.38</td>
</tr>
<tr>
<td>12</td>
<td>1.42</td>
<td>2.12</td>
<td>69.50</td>
</tr>
<tr>
<td>13</td>
<td>1.41</td>
<td>2.10</td>
<td>71.60</td>
</tr>
<tr>
<td>14</td>
<td>1.35</td>
<td>2.01</td>
<td>73.61</td>
</tr>
<tr>
<td>15</td>
<td>1.17</td>
<td>1.75</td>
<td>75.36</td>
</tr>
<tr>
<td>16</td>
<td>1.06</td>
<td>1.58</td>
<td>76.94</td>
</tr>
<tr>
<td>17</td>
<td>1.02</td>
<td>1.52</td>
<td>78.45</td>
</tr>
</tbody>
</table>

Estimations of large-scale study model from partial least squares modeling

PLS estimations for the large-scale study research model involved answering the second and third research questions (which follows the pilot study’s first research question) and their related hypotheses. The second research question of the large-scale study investigated whether organisational assets have flanking complementarity effects toward the successes achieved in ERP pre-implementation, implementation and post-implementation stages. This research question also explored the conditions that foster flanking complementarity in each stage. Three hypotheses (H5a, H5b and H5c) were established to answer this question (note that the numbering of these hypotheses follows the four hypotheses given in the pilot study stage):
Hypothesis 5a (H5a): ERP pre-implementation stage’s organisational assets have flanking complementarity effect on Organisational Readiness; with certain assets becoming the condition for flanking complementarity in this stage

Hypothesis 5b (H5b): ERP implementation stage’s organisational assets have flanking complementarity effect on Completion of Project Targets; with certain assets becoming the condition for flanking complementarity in this stage

Hypothesis 5c (H5c): ERP post-implementation stage’s organisational assets have flanking complementarity effect on Business Process Outcomes; with certain assets becoming the condition for flanking complementarity in this stage

The third research question explored whether the success experienced in one stage of ERP project lifecycle has a significant effect on the configuration and deployment of organisational assets in the next stage. Two research hypotheses were established to address this question:

Hypothesis 6a (H6a): The achievement of Organisational Readiness (i.e., success in ERP pre-implementation stage) has a significant effect on configuration and deployment of ERP implementation stage’s organisational assets.

Hypothesis 6b (H6b): The achievement of Completion of Project Targets (i.e., success in ERP implementation stage) has a significant effect on configuration and deployment of ERP post-implementation stage’s organisational assets.
**Evaluation of reflective constructs’ outer model**

In the large-scale study, the dependent constructs in each ERP project stage (i.e., pre-implementation, implementation and post-implementation) were reflective. These constructs were subjected to validity and reliability tests (outer model evaluation) using the individual item reliability, composite reliability, AVE, correlations and AVE\(^2\) tests. Table 5.4 presents these results.

The initial reliability test showed that several indicators in Organisational Readiness (OR), Completed Project Targets (CPT) and Business Process Outcomes (BPO) had loading values smaller than 0.707 (18 indicators in OR, two in CPT and nine in BPO constructs). These indicators were removed from the model. Follow-up assessments entailed evaluation of composite reliability, average variance extracted (AVE), AVE\(^2\) and correlations.

The composite reliability value was above 0.80, AVE was above 0.50, the constructs had positive correlations, while the AVE\(^2\) recorded above the correlations values. These results suggested that the selected construct measures were valid and reliable.
Table 5.4: Statistical results of outer model evaluation for large-scale study

<table>
<thead>
<tr>
<th>Dependent Reflective construct</th>
<th>Indicator</th>
<th>Loading</th>
<th>Composite reliability</th>
<th>AVE</th>
<th>AVE²</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR</td>
<td>OR5</td>
<td>0.783</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR6</td>
<td>0.802</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR8</td>
<td>0.812</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR10</td>
<td>0.833</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR11</td>
<td>0.758</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR14</td>
<td>0.757</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR17</td>
<td>0.746</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPT</td>
<td>CPT3</td>
<td>0.882</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CPT4</td>
<td>0.907</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CPT5</td>
<td>0.862</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BPO</td>
<td>BPO2</td>
<td>0.760</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BPO11</td>
<td>0.822</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BPO12</td>
<td>0.822</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BPO13</td>
<td>0.737</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Correlations of latent variable

<table>
<thead>
<tr>
<th>Correlations of latent variable</th>
<th>BPO</th>
<th>CPT</th>
<th>OR</th>
</tr>
</thead>
<tbody>
<tr>
<td>BPO</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPT</td>
<td>0.019</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>OR</td>
<td>0.849</td>
<td>0.0129</td>
<td>1</td>
</tr>
</tbody>
</table>

Evaluation of formative constructs’ outer model

ERP pre-implementation organisational assets, implementation organisational assets and post-implementation organisational assets were formative constructs (which captures complementarity between organisational assets). Evaluating the outer model of the formative constructs required an assessment of the construct’s multicolinearity. Table 5.5 shows the multicolinearity test outputs for the three formative constructs. All the VIF values were below the 3.3 threshold value (Diamantopoulos & Siguaw, 2006), and so there was no multicolinearity within the formative constructs.
### Table 5.5: Multicolinearity statistics for large-scale study model

<table>
<thead>
<tr>
<th>Pre-implementation organisational assets (formative construct)</th>
<th>Colinearity statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tolerance</td>
</tr>
<tr>
<td>Pre-Human resource</td>
<td>0.425</td>
</tr>
<tr>
<td>Pre-Knowledge</td>
<td>0.356</td>
</tr>
<tr>
<td>Pre-Relationship</td>
<td>0.485</td>
</tr>
<tr>
<td>Pre-IT infrastructure</td>
<td>0.808</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Implementation organisational assets (formative construct)</th>
<th>Colinearity statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tolerance</td>
</tr>
<tr>
<td>Imp-Human resource</td>
<td>0.934</td>
</tr>
<tr>
<td>Imp-Knowledge</td>
<td>0.625</td>
</tr>
<tr>
<td>Imp-Relationship</td>
<td>0.608</td>
</tr>
<tr>
<td>Imp-IT infrastructure</td>
<td>0.998</td>
</tr>
</tbody>
</table>

| Post-implementation organisational assets (formative construct) | Colinearity statistics |
|                                                               | Tolerance | VIF  |
| Post-Human resource                                           | 0.368      | 2.716|
| Post-Knowledge                                                | 0.460      | 2.175|
| Post-Relationship                                              | 0.534      | 1.873|
| Post-IT infrastructure                                         | 0.923      | 1.083|

Notes: Pre = Pre-implementation stage; Imp = Implementation stage; Post = Post-implementation stage

**Structural (inner) model evaluation (hypotheses testing)**

Satisfactory outer model evaluation results led to the estimation of the structural (inner) model, which enabled testing of the various hypotheses established in the full-scale study. Table 5.6 provides a summary of the structural model estimation.
Table 5.6: Structural model estimation statistics for large-scale study

<table>
<thead>
<tr>
<th>Path hypothesis</th>
<th>Pre-OA → OR</th>
<th>OR → Imp-OA</th>
<th>Imp-OA → CPT</th>
<th>CPT → Post-OA</th>
<th>Post-OA → BPO</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Complementarity effect observation</strong></td>
<td>β = 0.40, t = 4.00 ***</td>
<td>β = 0.56, t = 13.86 ***</td>
<td>β = 0.44, t = 9.77 ***</td>
<td>β = 0.29, t = 4.22 ***</td>
<td>β = 0.64, t = 16.10 ***</td>
</tr>
<tr>
<td>Pre-HR → Pre-OA (β = 0.66, t = 3.99)***</td>
<td>NA</td>
<td>Imp-HR → Imp-OA (β = 0.98, t = 28.27)***</td>
<td>NA</td>
<td>Post-HR → Post-OA (β = 0.33, t = 2.67) **</td>
<td></td>
</tr>
<tr>
<td>Pre-K → Pre-OA (β = 0.33, t = 2.62) **</td>
<td>Imp-K → Imp-OA (β = 0.42, t = 6.24) ***</td>
<td>Post-K → Post-OA (β = 0.53, t = 6.29) ***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-R → Pre-OA (β = 0.28, t = 2.02) **</td>
<td>Imp-R → Imp-OA (β = 0.31, t = 2.23) **</td>
<td>Post-R → Post-OA (β = 0.89, t = 9.26) ***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-IT → Pre-OA (β = 0.37, t = 2.97) **</td>
<td>Imp-IT → Imp-OA (β = 0.34, t = 2.72) **</td>
<td>Post-IT → Post-OA (β = 0.36, t = 2.88) **</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-square</td>
<td>0.165</td>
<td>0.317</td>
<td>0.202</td>
<td>0.285</td>
<td>0.413</td>
</tr>
<tr>
<td><strong>Q-square:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communality</td>
<td>0.128</td>
<td>0.618</td>
<td>0.067</td>
<td>0.781</td>
<td>0.036</td>
</tr>
<tr>
<td>Redundancy</td>
<td>0.128</td>
<td>0.086</td>
<td>0.037</td>
<td>0.152</td>
<td>0.273</td>
</tr>
</tbody>
</table>

Notes: *** p < 0.001; ** p < 0.05

Pre-HR (Pre-implementation Human resource), Imp-HR (Implementation Human resource), Post-HR (Post-implementation Human resource)
Pre-K (Pre-implementation Knowledge), Imp-K (Implementation Knowledge), Post-K (Post-implementation Knowledge)
Pre-R (Pre-implementation Relationship), Imp-R (Implementation Relationship), Post-R (Post-implementation Relationship)
Pre-IT (Pre-implementation IT infrastructure), Imp-IT (Implementation IT infrastructure), Post-IT (Post-implementation IT infrastructure)
Pre-OA (Pre-implementation organisational assets); OR (Organisational Readiness); Imp-OA (Implementation organisational assets); CPT (Completed project targets); Post-OA (Post-implementation organisational assets); BPO (Business process outcomes)
Hypothesis 5a (H5a): ERP pre-implementation stage’s organisational assets have flanking complementarity effect on Organisational Readiness; with certain assets becoming the condition for flanking complementarity in this stage

The path relationship estimation for H5a using the bootstrap procedure (N = 215, 500 re-sampling) revealed statistically significant paths in all three stages of ERP project. The structural path from pre-implementation organisational assets (Pre-OA) to organisational readiness (OR) [Pre-OA $\rightarrow$ OR] was statistically significant ($\beta = 0.40; t = 4.00; p < 0.001$). The R-square of 16.5 per cent suggested that the predictive power of this path relationship was weak. The communality (0.218) and redundancy (0.218) of Q-square values drawn from blindfolding test (as shown in Table 5.6), however, were well above zero, providing evidence that this structural path had good predictive relevance (Chin, 1998). The Global Goodness of fit (GoF) for this path hypothesis was 0.189, implying a small goodness of fit.

Previous studies of formative constructs in PLS (e.g., Diamantopoulos & Winklhofer, 2001; Edwards, 2001; Karimi et al., 2007) suggest that complementarity effects can be captured by forming several first order constructs (i.e., Human resource, Knowledge, Relationship and IT infrastructure) that characterise the second order latent construct (i.e., Pre-implementation, Implementation and Post-implementation organisational assets). As pointed by Karimi et al. (2007, p. 242) “while no minimum threshold values for weights has been established, the statistical significance of the weights can be used to determine the relative importance of the indicators in forming the construct”. The relative importance of the indicators can assist in determining the conditions that foster flanking complementarity in each stage of adoption. In the pre-implementation stage, all the four organisational assets had statistically significant weights with Pre-OA. Nevertheless, the weights of Human resource ($\beta = 0.66; t = 3.99; p < 0.001$) and IT infrastructure ($\beta = 0.37; t = 2.97; p < 0.05$) seemed to be more prevalent than the Knowledge ($\beta = 0.33; t = 2.66; p < 0.05$) and Relationship ($\beta = 0.28; t = 2.02; p < 0.05$) assets.
The finding implies that Human resource and IT infrastructure seem to play an important role in formation of complementarity between the four organisational assets. These results suggested a strong support for hypothesis 5a.

**Hypothesis 5b (H5b): ERP implementation stage’s organisational assets have flanking complementarity effect on Completion of Project Targets; with certain assets becoming the condition for flanking complementarity in this stage**

The structural path relationship that tested Hypothesis 5b [Imp-OA → CPT] suggested significant association between these two constructs. Specifically, configurations and deployment of organisational assets in ERP implementation stage had a significant effect toward completion of project targets, which was the measure of this stage’s success. This causal effect was statistically significant ($\beta = 0.44; t = 9.77; p < 0.001$). The R-square was 20.2 per cent (again, a weak predictive power), with the Q-square 0.067 (communality) and 0.037 (redundancy). The GoF of 0.11 indicated a small goodness of fit value.

A detailed review of the flanking complementarity effect in implementation stage suggested two primary drivers of complementarity: Human resource ($\beta = 0.98; t = 28.27; p < 0.001$) and Knowledge ($\beta = 0.42; t = 6.24; p < 0.001$) weights were higher than those of Relationship ($\beta = 0.31; t = 2.23; p < 0.05$) and IT infrastructure ($\beta = 0.34; t = 2.72; p < 0.05$). Thus, Human resource and Knowledge assets were the key drivers of complementarity between assets in this stage of ERP project. Hypothesis 5b was well accepted.
Hypothesis 5c (H5c): ERP post-implementation stage’s organisational assets have flanking complementarity effect on Business Process Outcomes; with certain assets becoming the condition for flanking complementarity in this stage

The bootstrapping analysis for the path from Post-OA toward post-implementation success (i.e., business process outcomes) was statistically significant ($\beta = 0.64; \ t = 16.14; \ p < 0.001$). The predictive power of this path was strong (R-square = 41.3 per cent), with good Q-square values (commonality = 0.036 redundancy = 0.273). The GoF was 0.121, indicating a small goodness of fit.

With regard to the complementarity effect, the weights of Relationship ($\beta = 0.89; \ t = 9.26; \ p < 0.001$) and Knowledge ($\beta = 0.53; \ t = 6.29; \ p < 0.001$) were predominantly larger than Human resource ($\beta = 0.33; \ t = 2.67; \ p < 0.05$) and IT infrastructure ($\beta = 0.36; \ t = 2.88; \ p < 0.05$).

At the post-implementation stage, Relationship and Knowledge assets had played a bigger role in creation of complementarity effects between the four organisational assets in the post-implementation stage. Hypothesis 5c was accepted.

Hypothesis 6a (H6a): The achievement of Organisational Readiness (i.e., success in ERP pre-implementation stage) has a significant effect on configuration and deployment of ERP implementation stage’s organisational assets.

The estimation of the structural path from Organisational Readiness to ERP implementation’s organisational assets (Imp-OA) [OR $\rightarrow$ Imp-OA] was statistically significant ($\beta = 0.56; \ t = 13.86; \ p < 0.001$). The R-square of 31.7 per cent suggested that the predictive power of this path relationship was only marginally weak. The Q-square values (communality = 0.618, redundancy = 0.086) were above zero, and so the structural path had good predictive relevance. The GoF was 0.442, denoting a large goodness of fit. The result suggested that ERP pre-implementation success, as proxied by Organisational Readiness to adopt ERP system, enabled configuration and deployment of the organisational assets for the purpose of ERP implementation.
Thus, hypothesis 6a was well accepted. The Organisational Readiness construct was operationalised as a reflective construct, thus no detailed complementarity effect analysis was applicable for this hypothesis.

**Hypothesis 6b: The achievement of Completion of Project Targets (i.e., success in ERP implementation stage) has a significant effect on configuration and deployment of ERP post-implementation stage’s organisational assets**

The estimation of hypothesis 6b revealed a statistically significant path from CPT → Post-OA ($\beta = 0.29; t = 4.22; p < 0.001$). The R-square was 28.5 per cent (weak) while Q-square was greater than zero (communality = 0.781, redundancy = 0.152). The GoF was 0.447, suggesting a large goodness of fit. This path relationship thus had good predictive relevance.

The completion of project targets such as completion of ERP project within budget, resources and others had positively infused the configurations and deployment of organisational assets to face ERP post-implementation stage. Hypothesis 6b was thus accepted.

### 5.2.2 Findings from qualitative research

The empirical findings presented in the previous sub-section paved the way for qualitative data collection using semi-structured interview questions. We selected 20 organisations and contacted potential respondents to seek agreement to participate in the interview. The primary aim of the interview process was to gather additional information to help understand and validate the empirical findings. The empirical findings assisted in formulating the key questions to be probed with the interviewees, which are discussed in this sub-section.
Flanking complementarity effects of organisational assets

The empirical results from the quantitative data led to the rejection of the null hypotheses. The configuration and deployment of organisational assets at the pre-implementation, implementation and post-implementation stages had a significant complementarity effect on achieving success in these three stages.

A detailed examination showed that certain assets had played a bigger role in the creation of the synergistic effects. The follow-up interviews focused on examining this phenomenon further by exploring two questions.

**Question 1: How did your company manage the configuration and deployment of organisational assets to foster flanking complementarity effects?**

First, the respondents were asked to share their experience on how they configured and deployed their organisational assets to foster complementarity effects in the three stages of adoption.

Analysis of participants’ responses identified two key themes: guidance from ERP vendors and consultants and the role of project champion. Note that [Org-x] denotes the coding given to each interviewee. Org-5, for example, refers to Organisation number 5.

**Theme I: Guidance from ERP vendors and consultants.** ERP vendors and project consultants seem to have played a significant role in ensuring that the ERP system that they install in their clients’ business structure does not fail or face significant challenges. Most organisations indicated that they relied substantially on their ERP vendors and consultants to guide them on how to leverage on their organisational assets for the purpose of the ERP project. This could be partly due to the sample organisations’ shallow experience in managing a complex and exhaustive technological project, such as ERP. While the sample organisations were in control of their assets, the allocation and utilisation of the assets were based on the expert guidance of the vendors and consultants:
The consultants taught us everything on how to use our assets throughout the project period…they are really experienced in this. (Org-5)

Our boss wanted us to rely extensively on the consultants. We can coordinate the assets for small projects, but this was quite a big project. (Org-9)

I made sure that the consultants played their role in guiding us on this matter. I discussed about asset utilisation strategy from day one with them. (Org-20)

Our ERP consultants helped us to manage the assets from beginning to the end of the project date. (Org-14)

Theme II: The role of project champions. Apart from guidance from ERP vendors and consultants, the role of project champions in facilitating smooth and successful adoption of ERP seemed to be paramount. Project champions were employees of the organisation or someone hired for the ERP project, responsible for coordinating and managing the project.

He or she led the ERP project team and became the central point of reference between the internal ERP team members and the external ERP consultants and vendors:

Our project manager, who is the project champion, is very good at his job. He drew a detailed asset management strategy for each stage of adoption and this has helped us in managing the assets properly. We had limited resource wastage. (Org-1)

The idea to have this system was mooted by the project champion. He worked hard in resource allocation and its associated activities to ensure no failure. His asset management skill is fantastic. (Org-12)

…..project champion has done his role well. He managed the assets thoroughly. (Org-9)
Question 2: Can you reflect on the importance of specific organisational asset(s) in facilitating the condition for flanking complementarity

The second question, related to configuration and deployment of organisational assets, went slightly deeper and explored whether the sample organisations emphasised particular assets to become the focal point to create flanking complementarity effects between the assets. Most respondents’ feedback coincided with the quantitative findings in the context of the importance of certain assets becoming the driving condition to foster flanking complementarity in a particular stage:

*Based on the project plan, we emphasised a lot on human capital and IT infrastructure during the pre-implementation stage. Management of these two assets were critical in ensuring that we have adequate technological hardware and software to support the advanced system, and to confirm that our employees are willing to accept the change and cooperate throughout the project period. These two assets had a major impact on the effectiveness of the other assets.* (Org-4)

*We placed equal amount of importance in all assets in all stages. But we realised as we progress from one stage to another, the role of few assets became critical. Training of our employees and adequate business process knowledge for instance are utmost important in the implementation stage. Lack of proper training complements possession of sound business process knowledge and vice versa.* (Org-10)

*We quickly realised that significant concentration on a set of assets would automatically reinforce other assets. Continuous top management support was perceived as important from the beginning to the end of ERP project. Without them, or a halt in their support would have meant discontinuation of the project at any stage. Top management support reinforced our knowledge transfer, exchange, gathering activities, post system implementation. These capabilities enhanced the role of our other assets.* (Org-16)
Configuration and deployment of organisational assets for different stages’ needs

*Question: Can you reflect on the configuration and deployment of your organisational assets for the different stages’ needs?*

The respondents were also asked to reflect on how they strategically managed (i.e., configured and deployed) the four organisational assets of Human resource, Knowledge, Relationship and IT infrastructure to cater to the needs of each stage of their ERP project.

This question was posed because the PLS estimations showed that the success achieved in one stage, say pre-implementation’s Organisational Readiness, had a significant impact in the configuration and deployment of the implementation’s organisational assets.

The general answers to this question again reflected the strong role played by external consultants in guiding the ERP adoption process. It seems that the organisations adopting the ERP system were dependent on the external ERP consultants’ expertise in successfully completing the project and using the system.

Since each stage of the adoption process (pre-implementation, implementation and post-implementation) entailed different but associated activities (Markus, 2000), the success achieved in each stage depended on the configuration and deployment of certain key assets that could push for completion of that particular stage. The need to refocus on a particular asset arose either in the midst of executing a particular stage, or at the completion of a stage:

*Yes, the assets that we own, especially the four assets you mentioned are critical for success. Preparing our company to be ready for ERP adoption [organisational readiness] for example required us to use human resource and IT infrastructure for the business blueprint design process. Our consultants gave*
us very good guidance on how to strategise and leverage on these assets in this stage. (Org-3)

By the time we reached the end of system implementation stage, we realised that business process knowledge and user involvement are key issues that can sustain post-implementation success. This fact was reinforced by our consultant and that’s what we did. (Org-17)

Our ERP consultants had a pretty good idea of which asset going to be important at which stage of adoption….we just followed their advice. (Org-2)

5.3 Summary of large-scale study’s findings

The primary aim of the full-scale study was to seek answers to two research questions and their associated hypotheses. The summary of the research findings is presented in Table 5.7. The testing of the hypotheses established for the large-scale study indicates non-rejection of all the hypotheses. Flanking complementarity effects are seen in all the three stages (pre-implementation, implementation and post-implementation) leading to achievement of each stage’s relative successes. We also found certain assets being the facilitating conditions for flanking complementarity effects to prevail in each stage.

The finding also imply that success experienced in one stage of the ERP project’s lifecycle does have a significant effect on the configuration and deployment of organisational assets in the next stage of the project’s lifecycle, denoting validation of the successive stage argument presented in the ERP-process theory. Figure 5.1 presents a final research model based on the large-scale study’s empirical findings. Note that as discussed in section 4.3 of Chapter 4, the governance asset was not included in the large-scale study’s final research model estimation based on the inferences made from the pilot study’s empirical findings. The bolded circle heads represent the critical assets driving the flanking complementarity effect in each stage.
Table 5.7: Summary of findings from large-scale study

<table>
<thead>
<tr>
<th>Research question</th>
<th>Hypothesis</th>
<th>Finding</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do organisational assets have flanking complementarity effects on the successes achieved in ERP pre-implementation, implementation and post-implementation stages, and under what condition does flanking complementarity prevail in each stage?</td>
<td>Hypothesis 5a: ERP pre-implementation stage’s organisational assets have flanking complementarity effect toward Organisational Readiness; with certain assets becoming the condition for flanking complementarity in this stage</td>
<td>ERP pre-implementation stage’s organisational assets does have flanking complementarity effect toward Organisational Readiness; with Human resource and IT infrastructure becoming the condition for flanking complementarity to emerge</td>
<td>Hypothesis accepted</td>
</tr>
<tr>
<td></td>
<td>Hypothesis 5b: ERP implementation stage’s organisational assets have flanking complementarity effect toward Completion of Project Targets; with certain assets becoming the condition for flanking complementarity in this stage</td>
<td>ERP implementation stage’s organisational assets does have flanking complementarity effect toward Organisational Readiness; with Human resource and Knowledge becoming the condition for flanking complementarity to emerge</td>
<td>Hypothesis accepted</td>
</tr>
<tr>
<td></td>
<td>Hypothesis 5c: ERP post-implementation stage’s organisational assets have flanking complementarity effect toward Business Process Outcomes; with certain assets becoming the condition for flanking complementarity in this stage</td>
<td>ERP post-implementation stage’s organisational assets does have flanking complementarity effect toward Organisational Readiness; with Knowledge and Relationship becoming the condition for flanking complementarity to emerge</td>
<td>Hypothesis accepted</td>
</tr>
<tr>
<td>Does the success experienced in one stage of ERP project have significant effect on configuration and deployment of organisational assets in the next stage?</td>
<td>Hypothesis 6a: The achievement of Organisational Readiness (i.e. success in ERP pre-implementation stage) has a significant effect on configuration and deployment of ERP implementation stage’s organisational assets</td>
<td>Organisational Readiness has a significant effect on configuration and deployment of ERP implementation stage’s organisational assets</td>
<td>Hypothesis accepted</td>
</tr>
<tr>
<td></td>
<td>Hypothesis 6b: The achievement of Completion of Project Targets (i.e. success in ERP implementation stage) has a significant effect on configuration and deployment of ERP post-implementation stage’s organisational assets</td>
<td>Completion of Project Targets has a significant effect on configuration and deployment of ERP post-implementation stage’s organisational assets</td>
<td>Hypothesis accepted</td>
</tr>
</tbody>
</table>
Figure 5.1: Large-scale study's final research model based on empirical findings

Notes:
TRA (Training); ITS (IT skills); HR (Human Resource); BPK (Business process knowledge); PMK (Project management knowledge); K (Knowledge); TMI (Top management involvement); UI (User involvement); R (Relationship); HAR (Hardware); NET (Networks); IT (IT infrastructure); Pre-OA (Organisational assets in Pre-implementation stage); Imp-OA (Organisational assets in Implementation stage); Post-OA (Organisational assets in post-implementation stage); OR (Organisational Readiness); CPT (Completion of Project Targets); BPO (Business Process Outcomes).
5.4 Chapter summary

This chapter has presented the results of the quantitative and qualitative data analyses from the large-scale study. The findings in the large-scale study led to acceptance of all the research hypotheses. The next chapter provides detailed interpretations of these findings.
CHAPTER 6: DISCUSSIONS AND CONCLUSION

6.1 Introduction

As discussed in the previous chapter, we undertook this research using two-pronged strategy that is by undertaking a pilot study with smaller sample size to test the research ideology, followed by an improved large-scale study with bigger sample size. Drawing on the ERP adoption success factor theory, the theory of complementarity (Milgrom & Roberts, 1995), and the process theory (Soh & Markus, 1995; Markus & Tanis, 2000) we sought answers for several research questions.

The first research question was designed for the pilot study and enquired if organisational assets (comprising of Governance, Knowledge and Relationship assets) have complementarity effect toward ERP post-implementation success. Detailed explanations on why we used Governance asset (apart from Knowledge and Relationship assets) and focused on the post-implementation success exclusively in the pilot study were given in Chapter 2. Four research hypotheses were established in relation to the first research question.

Hypothesis 1 (H1): Governance has a significant direct effect on ERP post-implementation success

Hypothesis 2 (H2): Knowledge has a significant direct effect on ERP post-implementation success

Hypothesis 3 (H3): Relationship has a significant direct effect on ERP post-implementation success

Hypothesis 4 (H4): Complementarity between organisational assets has a significant effect on ERP post-implementation success
As explained in Chapter 2 and 3 previously, pilot study was executed by testing two research models – direct individual effect and complementarity effect models. We employed this strategy to test the notion of complementarity between organisational assets before proceeding to the large-scale study.

In the large-scale study, we addressed the second and third research questions. The second question explored the existence of, and the conditions for, organisational assets to have flanking complementarity effects toward the successes achieved in three successive stages in an ERP project, namely the pre-implementation, implementation and post-implementation stages. This question was framed in the context of complementarity theory and process theory. Complementarity theory argues on the importance of synergistic/bundling effects of organisational assets in achieving organisational objectives. Horgan and Muhlau (2006) suggest that complementarity between organisational assets can occur in three ways: reinforcement, flanking and compensation.

In the large-scale study, we focused on flanking complementarity. To recap, flanking complementarity infers to an environment or situation in which different organisational assets supports the role of each other in a favourable way with potential outcome maximising effect (Horgan & Muhlau, 2006). The process theory, on the other hand, centres on the different phases or stages involved in technology adoption and the sequence of activities in each phase. This theory also postulates how certain assets inherent in an organisation play a significant role in achievement of the intended success. Three research hypotheses were established in relation to the second research question:

Hypothesis 5a (H5a): ERP pre-implementation stage’s organisational assets have flanking complementarity effect on Organisational Readiness; with certain assets becoming the condition for flanking complementarity in this stage

Hypothesis 5b (H5b): ERP implementation stage’s organisational assets have flanking complementarity effect on Completion of Project Targets; with certain assets becoming the condition for flanking complementarity in this stage
Hypothesis 5c (H5c): ERP post-implementation stage’s organisational assets have flanking complementarity effect on Business Process Outcomes; with certain assets becoming the condition for flanking complementarity in this stage

The third research question sought to identify whether the success experienced in one stage of the ERP project lifecycle leads to the configuration and deployment of organisational in the next stage of the project. This question was leveraged on the process theory and sought to validate the successive stages proposed in ERP project context. This research question was supported by two hypotheses:

Hypothesis 6a: The achievement of Organisational Readiness (i.e., success in ERP pre-implementation stage) has a significant effect on configuration and deployment of ERP implementation stage’s organisational assets

Hypothesis 6b: The achievement of Completion of Project Targets (i.e., success in ERP implementation stage) has a significant effect on configuration and deployment of ERP post-implementation stage’s organisational assets

Within this backdrop, the following section interprets the research findings obtained in the pilot and large-scale studies. The research and practical implications drawn from the large-scale study’s findings are given in Section 6.3, which is then followed by the limitations and future research direction in Section 6.4. Finally, Section 6.5 presents the conclusions drawn from the research.
6.2 Results discussion

The results outlined in Chapter 4 and 5 are interpreted in this section. Summary of the pilot and large-scale studies’ findings are presented in Tables 6.1 and 6.3. The results of the pilot study are discussed first, followed then by the large-scale study’s results. To recap, we used three organisational assets to test the pilot study’s research model.

6.2.1 Addressing the first research question and its associated hypotheses

**First research question:** Do organisational assets (comprising of Governance, Knowledge and Relationship) have complementarity effects toward ERP post-implementation success?

Table 6.1: Summary of findings from pilot study

<table>
<thead>
<tr>
<th>Research question</th>
<th>Hypothesis</th>
<th>Finding</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do organisational assets (comprising of Governance, Knowledge and Relationship) have complementarity effects toward ERP post-implementation success?</td>
<td>Hypothesis 1 (H1): Governance has a significant direct effect on ERP post-implementation success</td>
<td>Governance asset does not have a significant direct effect on ERP post-implementation success</td>
<td>Hypothesis rejected</td>
</tr>
<tr>
<td>Hypothesis 2 (H2): Knowledge has a significant direct effect on ERP post-implementation success</td>
<td>Knowledge asset does not have a significant direct effect on ERP post-implementation success</td>
<td>Hypothesis rejected</td>
<td></td>
</tr>
<tr>
<td>Hypothesis 3 (H3): Relationship has a significant direct effect on ERP post-implementation success</td>
<td>Relationship asset does have a significant direct effect on ERP post-implementation success</td>
<td>Hypothesis accepted</td>
<td></td>
</tr>
<tr>
<td>Hypothesis 4 (H4): Complementarity between organisational assets have a significant effect on ERP post-implementation success</td>
<td>Complementarity between organisational assets have a significant effect on ERP post-implementation success</td>
<td>Hypothesis accepted</td>
<td></td>
</tr>
</tbody>
</table>
The response obtained from 90 ERP users in Malaysia enabled a series of analyses on the dataset. As shown in Table 6.1 above, Governance and Knowledge did not have a significant direct effect on ERP post-implementation success. Relationship asset however had a significant direct effect on post-implementation success. The reinforcement effect test showed that Governance has had a reinforcing effect toward Knowledge and Relationship assets, thus suggesting the core importance of governance in establishing the conducive environment for effective employment of other assets for ERP project purpose. Due to the central thrust nature of Governance asset, we decided to remove Governance asset from the large-scale study as it is highly possible for Governance asset not to display different effects toward the completion of pre-implementation, implementation and post-implementation stages. As highlighted in Chapter 5 earlier, the final large-scale study’s research model differs than the pilot study’s model to represent several new dimensions. These dimensions are reproduced here for easy reference purpose.

The large-scale study’s model contains the following inclusions:

- Inclusion of three successive stages in ERP project’s lifecycle:
  - ERP pre-implementation stage
  - ERP implementation stage
  - ERP post-implementation stage

- Inclusion of three success outcomes in these three stages:
  - ERP pre-implementation stage’s success → organisational readiness (OR)
  - ERP implementation stage → completion of project targets (CPT)
  - ERP post-implementation stage → business process outcomes (BPO)
• Inclusion of two additional organisational asset dimensions:
  o IT infrastructure (network and hardware)
  o Human resource (IT skills and training)

• Inclusion of additional dimensions within some of the existing organisational assets:
  o Knowledge (business process knowledge and project management knowledge)
  o Relationship (user involvement and top management involvement)

• Exclusion of Governance asset from the large-scale study

6.2.2 Addressing the second research question and its associated hypotheses

**Second research question**: Do organisational assets have flanking complementarity effects on the successes achieved in ERP pre-implementation, implementation and post-implementation stages, and under what conditions does flanking complementarity prevail in each stage?

The analysis of data collected from 215 organisations in Malaysia using ERP supported all five research hypotheses, and provided a clear answer to the second research question.
The empirical analysis for H5a, H5b and H5c demonstrated the existence of flanking complementarity between the four organisational assets of concern: (1) Human resource (HR; composed of IT skills and training), (2) Knowledge (business process knowledge and project management knowledge), (3) Relationship (top management support and user involvement) and (4) IT infrastructure (hardware and software) in all three stages of an ERP project. Our finding suggests that flanking complementarities between a set of organisational assets foster an environment conducive to success across all stages of an ERP project.

Further probing into the conditions that infuse flanking complementarity between the organisational assets indicated the role different assets play in support of flanking complementarity in the three stages (refer to Table 6.2).

**Table 6.2: The conditions for flanking complementarity to emerge in the three stages**

<table>
<thead>
<tr>
<th>ERP project stage</th>
<th>Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>ERP pre-implementation stage</td>
<td>HR and IT infrastructure assets</td>
</tr>
<tr>
<td>ERP implementation stage</td>
<td>HR and Knowledge assets</td>
</tr>
<tr>
<td>ERP post-implementation stage</td>
<td>Knowledge and Relationship assets</td>
</tr>
</tbody>
</table>

The different conditions that infuse flanking complementarity in the three stages are shown diagrammatically in figures 6.1a, 6.1b and 6.1c. The following section provides a detailed discussion on the plausible reasons why such conditions exist in each stage.
Figure 6.1a: The conditions for flanking complementarity in the pre-implementation stage

- Human Resource (HR) and IT infrastructure (IT) assets being the conditions for flanking complementarity effects

Acceptance of Hypothesis 5a

Figure 6.1b: The conditions for flanking complementarity in implementation stage

- Human Resource (HR) and Knowledge (K) assets being the conditions for flanking complementarity effects

Acceptance of Hypothesis 5b
**Figure 6.1c: The conditions for flanking complementarity in post-implementation stage**

Knowledge (K) and Relationship (R) assets being the conditions for flanking complementarity effects

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**ERP pre-implementation stage (Hypothesis 5a)**

The ERP pre-implementation stage comprises activities for pre-planning the ERP system adoption process, resulting in Organisational Readiness to accept the system (Abdinour-Helm et al., 2003). The empirical results showed that the presence in the pre-implementation stage of HR assets (comprising IT skills and ERP training) and IT infrastructure (involving planning for technological hardware and software needed for ERP project) significantly supported the planning activities related to Knowledge and Relationship assets.
The importance of HR management in ERP projects has been discussed by previous scholars (e.g., Bancroft et al., 1998; Davenport, 1998; Stratman & Roth, 2002; Kwahk & Kim, 2007). The complexities inherent in most advanced technological systems, including an ERP system, can have a dramatic change on the HR management policy of the adopting firm (Siegel et al., 1997), especially in the pre-implementation stage. Once an organisation decides to adopt ERP, it needs to consider resource allocation, with a predominant emphasis on HR planning.

In the context of this study, HR policies related to the allocation, engagement and/or hiring of personnel skilled in IT represent an important dimension of HR assets in achieving success of pre-implementation stage. Wu (2007) has a similar perception, conceptualising IT skills as an important antecedent factor in pre-implementation stage success. Adoption of ERP requires employees skilled in IT who can learn the technical requirements of the new technology with few problems. A competent employee would have the ability to configure and maintain information systems in support of the business (Stratman & Roth, 2002). In the pre-implementation stage, skilled employees participate in the development of new business process blueprints, system mapping, software and hardware requirements and other technical issues. These activities require knowledgeable employees who can quickly become familiar with IT. Thus strategic pre-planning for IT skills to cater for adoption of the system is pertinent.

Apart from employees skilled in IT, training programs – another dimension of HR management – have also received widespread attention in the literature. Recent studies by Somers and Nelson (2004), Guang-hui et al. (2006) and Plant and Willcocks (2007) have found that establishing appropriate training programs can play a significant role in the successful pre-implementation of ERP. Training for ERP project team members or potential user groups is important to ensure effective implementation and use of the ERP system (Dowlatshahi, 2005).
**IT infrastructure asset**

The research findings also highlighted the importance of IT infrastructure as another key driving asset for the flanking complementarities effect in the pre-implementation stage. The result is consistent with arguments by Nah et al. (2001) and Wu (2007) on the importance of planning for adequate IT infrastructure prior to the implementation of ERP. At the project planning level, organisations will often emphasise the new technological infrastructure required to support their ERP systems, which will be undertaken in consultation with the ERP vendor and external consultants. New infrastructure planning often entails planning for acquisition of the appropriate hardware and network platforms.

The role of IT infrastructure in the pre-implementation stage becomes pivotal if the IT infrastructure cannot support the compatibilities between the various systems across the organisation (Holland & Light, 1999). The complexity in the organisation’s business processes would require a higher level of technical and organisational changes, and consequently advanced supporting IT infrastructure (Davenport, 1998). Therefore, it is imperative at the planning stage for the adopting organisation to carefully define and evaluate the extent of any problems, and how IT infrastructure should be structured to address the problem (Rao, 2000).

**Complementarity relationships in ERP pre-implementation stage**

Important elements in the ERP pre-implementation stage are the strategic planning for HR management related to IT skills and ERP training programs, and IT infrastructure. These assets offer substantial support for effective planning of other business practices, especially the acquisition and transfer of business process and project management knowledge (Knowledge asset), and securing the top management and internal users consistent support for ERP project (Relationship asset).
Strategic planning for IT skills, for instance, would assist in the management of business process knowledge, as knowing the extent of technical skills available in the organisation would lead to an understanding on how employees can be leveraged most efficiently in the acquisition and transfer of business process knowledge.

Planning for ERP training programs at the pre-implementation stage would enable the organisation to comprehend and plan the best way to involve ERP users in the project. ERP training imparts to users an understanding of how ERP system can be used, and its benefit to both users and the organisation as a whole. Such an understanding can reduce users’ resistance to change throughout the lifecycle of the project, enabling users to be thoroughly involved in their ERP project. The synergistic interactions between these assets would facilitate the achievement of organisational readiness to adopt ERP.

**ERP implementation stage (Hypothesis 5b)**

The testing of Hypothesis 5b (H5b) demonstrated the importance of HR and Knowledge (comprising business process and project management knowledge) assets in facilitating the complementarity effects in ERP implementation stage. While the other two assets (IT infrastructure and Relationship) played key roles in the implementation stage, the dominance of HR and Knowledge assets overshadowed the other two assets. Several other studies have made similar findings (Somers & Nelson, 2001, 2004; Al-Mashari et al., 2003; Guang-hui et al., 2006; Plant & Willcocks, 2007). The general agreement of these studies is that HR and knowledge assets are important drivers of ERP implementation stage.
**Human resource asset**

In the ERP implementation stage, the HR asset – that is, IT skills and training programs – plays a major role in the execution of several pertinent activities of this stage, such as business process re-engineering, prototype development, user training and the system go-live process. Skilled IT personnel are deployed throughout the implementation stage in support of the activities mentioned earlier. The system go-live process, for example, entails testing and validating the ERP system to ensure that the software works and the business process configurations are practical (Appelrath & Ritter, 2000; Al-Mashari et al., 2003). In another example, the implementation process entails migration of an extensive amount of data, and thus the skills of IT personnel will become an important bridge in ensuring accurate data migration to avoid adverse functioning of the ERP modules. Skilled IT personnel are used extensively in this process as their technical skills (and also ERP knowledge, *should it be applicable*) will be leveraged to test if the application system matches the organisation’s business processes.

In another context, training, another essential dimension of HR, has also played a key role in the ERP implementation stage success. This is consistent with the argument put forward in the literature about the importance of training programs for implementation success. Benchmarking Partners (1998), for example, reported that the go-live process in the ERP implementation stage is often blocked by users’ lack of understanding about what they are supposed to do after the go-live process. Nicolaou (2004) argues that ERP users with inadequate training in the implementation stage would have poor knowledge of the business process flows across the organisation. In another context, proper training of the targeted users in the implementation stage can assist the organisation in reducing resistance to change (Al-Mudimigh et al., 2001). A thorough training program would make the user comfortable with the new system. Training initiatives would also assist the users to become competent in business requirements and thus able to handle complex challenges, should they arise (Ramayah et al., 2007; Remus, 2007).
Knowledge asset

The knowledge asset, composed of business process and project management knowledge, represents the other important complementarity-driving element in the ERP implementation stage. In the ERP pre-implementation stage, an organisation will plan how to manage their business process knowledge, which is the knowledge of how the entire organisation is operating and how each department’s business process are interlinked (Li & Zhao, 2006). In the ERP implementation stage, effective management of this knowledge transfer, sharing and storage facilitates the creation of precise new system requirements, accurate data conversion and smooth data integration across the value-chain (Kapp, 1998). ERP project team members usually coordinate and deploy business process knowledge. The team members, often from different departments, will participate in mapping their own departments’ business process knowledge onto the new business process system, and will share such knowledge with external consultants and ERP installation teams in the implementation stage (Baskerville et al., 2000; Elliman & Eatock, 2005).

Another important dimension of the Knowledge asset is project management. Project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements. The importance of project management in ERP project success has been widely discussed (e.g., Bingi et al., 1999; Nah et al., 2001; Plant & Willcocks, 2007). The clearly defined project scope, plan, objectives and deliverables established in the pre-implementation stage will be managed in the implementation stage (Ngai et al., 2008). More specifically, project management in the implementation stage monitors the scope of the project, which includes the amount of the systems to be implemented, the extent of the business units involved, and the extent of change management required (Nah et al., 2001). New requirements or changes in the designed business process in the implementation stage will be strategically assessed against the impending benefits to the organisation by the ERP project team members (Wee, 2000).
Apart from the scope of the project, project management in the ERP implementation stage is also associated with managing the milestones to be achieved (Holland et al., 1999), which include project schedule, budget and credibility of the system (Wee, 2000).

Last but not least, project management initiatives in the implementation stage entail coordinating HR management activities (Falkowski et al., 1998).

Complementarity relationships in ERP implementation stage

Overall, the management of HR and Knowledge assets are important platforms for effective management of IT infrastructure and Relationship assets in the ERP implementation stage. For instance, execution of ERP training to its intended users would inculcate a greater comprehension of ERP knowledge. Better understanding of ERP would facilitate increased user involvement in the ERP implementation stage – for example, users would become proactive in defining the system’s functional and design requirements, thus ensuring that the delivered system meets users’ needs (Tait & Vessey, 1988). Project management activities with clearly defined goals and deliverables, communicated thoroughly would encourage users to support the ERP project, because they would understand the project’s scope, timeline and how it would affect their work (Jurison, 1999). Together, these assets exert a synergistic effect in the lead-up to the success of this stage, which is realised by completion of targets. Lack of complementarity in this stage could cause project delays and costs extending over budget or an ineffective project schedule (Grabski & Leech, 2007).

ERP post-implementation stage (Hypothesis 5c)

We found Knowledge and Relationship assets to be the primary drivers of flanking complementarity in the ERP post-implementation stage.
Other researchers, such as Karimi et al. (2007) and Zhu et al. (2010), have also found that knowledge and relationship are important assets that influence business process outcomes in the ERP post-implementation stage.

Continuous development and management of the knowledge asset in the post-implementation stage is critical for improving an ERP system’s capability (Karimi et al., 2007). The project management dimension in the post-implementation stage, for instance, can assist in automatic allocation of tasks by the ERP system.

Effective project management, in the form of project review activities, can also increase the likelihood of achieving the expected objectives. In terms of the relationship assets, both top management involvement and user involvement also foster flanking complementarity. Top management’s involvement in the post-implementation stage caters for continuous allocation of financial and non-financial resources for modifying or improving the implemented ERP system (Ross & Vitale, 2000). Apart from resource allocation support, the top management team is also responsible for change management activities (Liang et al., 2007), which could have a significant resistance to change. Top management often takes any action necessary to reduce resistance to change (Ross & Vitale, 2000) by exercising their authority to regulate users’ or employees’ behaviour toward the change (Purvis et al., 2001) and to reduce business risks (Young & Jordan, 2008).

These driving assets (i.e., knowledge and relationship), in collaboration with HR and IT infrastructure, can collectively influence the success of the post-implementation stage, in other words, the business process outcomes. For example, top management support complements the continuous engagement of IT-skilled employees in the post-implementation stage. Management of users’ involvement facilitates the smooth migration of the old work system to the new and improved work system. Such synergy between these four assets exerts positive energy to experience operational efficiency, operational effectiveness and business flexibility after implementation of the ERP system.
Summary

The findings of hypotheses 5a, 5b and 5c are in line with the theory of complementarity line of argument – that is, the synergistic effect that a bundle of organisational activities and practices creates by mutual enhancement of each other’s role and contribution (Milgrom & Roberts, 1995a). This research has clearly demonstrated the flanking synergistic or complementarity effect which HR, Knowledge, Relationship and IT infrastructure possess in all the three stages of ERP project lifecycle. These organisational assets mutually enhance each other’s role and contribute toward the success of each stage.

The empirical findings also concur with the process theory (Markus & Tanis, 1995, 2000) promotion of the importance of certain assets in fostering or supporting achievement of each stage’s success. This research has demonstrated the exclusive roles that HR, IT infrastructure, Knowledge and Relationship assets have played in support of flanking complementarities, in each stage of ERP project.

6.2.3 Answering the third research question and its associated hypotheses

**Third research question:** Does the success experienced in one stage of an ERP project have significant effect on configuration and deployment of organisational assets in the next stage?

The examination of the third research question showed support for the two associated research hypotheses, 6a and 6b; that is, success in one stage has a significant effect on asset management strategy in the next stage of the ERP project. Specifically, the success achieved in the ERP pre-implementation stage (i.e., achievement of Organisational Readiness) has a significant effect on the configuration and deployment of organisational assets in the ERP implementation stage, thus supporting Hypothesis 6a.
Subsequently, the success achieved in the ERP implementation stage (i.e., Completion of Project Targets) has a significant impact on the configuration and deployment of the organisational assets in the ERP post-implementation stage, thus supporting Hypothesis 6b. As discussed before, this research question was based on process theory. Confirmation that an ERP project’s lifecycle is contingent upon a series of continual stages justifies the ERP process theory argument of ERP adoption, which is characterised by a linear process of activities (Markus & Tanis, 2000). Achieving the objective of one stage has a significant effect on asset management strategy in the next stage.

Each stage of an ERP project comprises different activities. Each activity is leveraged on the available organisational assets (in the context of this research, HR, Knowledge, Relationship and IT infrastructure).

Occasionally, unforeseen circumstances might mean that certain activities cannot be executed efficiently, resulting in changes in the execution of activities in the next stage of the project. Such dynamism could infuse the need to reconfigure and concentrate on the role of certain assets to achieve the success of the next stage. The complexity of an ERP project poses significant uncertainties and risks (Davenport, 1998), and so embracing a dynamic management approach that facilitates continuity of the project (regardless of the changes in the project environment) could be the perfect managerial ideology to achieve successful ERP adoption. Table 6.3 summarises the empirical findings in regards to the third research question and its related hypotheses.
Table 6.3: Summary of research findings for third research question

<table>
<thead>
<tr>
<th>Research question</th>
<th>Hypothesis</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the success experienced in one stage of an ERP project have significant effect on configuration and deployment of organisational assets in the next stage?</td>
<td>Hypothesis 6a: The achievement of Organisational Readiness (i.e. success in ERP pre-implementation stage) has a significant effect on configuration and deployment of ERP implementation stage’s organisational assets</td>
<td>Hypothesis supported. Success achieved in the ERP pre-implementation stage (i.e. achievement of Organisational Readiness) has had a significant effect on the configuration and deployment of organisational assets in the ERP implementation stage</td>
</tr>
<tr>
<td></td>
<td>Hypothesis 6b: The achievement of Completion of Project Targets (i.e. success in ERP implementation stage) has a significant effect on configuration and deployment of ERP post-implementation stage’s organisational assets</td>
<td>Hypothesis supported. Success achieved in the ERP implementation stage (i.e. Completion of Project Targets) has had a significant impact on the configuration and deployment of the organisational assets in the ERP post-implementation stage</td>
</tr>
</tbody>
</table>

6.3 Research and practical implications

The results obtained in this study have several research and practical implications, as discussed below.

6.3.1 Research implications

The findings highlighted in this study have three main research implications. First, we employed and validated the arguments put forward by three theoretical lenses: ERP adoption, the theory of complementarity (Millgrom & Roberts, 1990) and the process theory (Markus & Tanis, 1995, 2000). We leveraged on these theories to investigate the flanking complementarity relationships between Human resource (IT skills, training), Knowledge (business process knowledge, project management knowledge), Relationship (top management support, user involvement) and IT infrastructure (hardware, and software) in successful completion of the three stages in an ERP project’s lifecycle.
Our research has shown that achieving successful ERP adoption is contingent upon synergistic relationships between different organisational assets. Our research also addresses the void in the complementarity literature by exploring the conditions under which complementarity can emerge (Ennen & Richter, 2010). Our findings have led to the development of a new theoretical framework in support of ERP project success, and this theoretical framework is based on the three theoretical architectures mentioned earlier. This is possibly the first research study that has taken such initiative, thus opening up a new research direction.

Second, our research has explored the events that take place inside an ERP project’s black-box. We have showed the explicit conditions that could hinder ERP project failure. Many studies have identified the critical issues that could lead to successful ERP adoption (e.g., Nah et al., 2001; Grabski & Leech, 2007), but insights into the critical organisational assets that facilitate the success of different stages could assist in diagnosing the problem areas across the entire ERP project lifecycle.

Third, we undertook this research in the context of a developing nation, Malaysia. Our findings do not support the argument that ERP adoption failure is more predominant in developing countries rather than in developed countries (e.g., Walsham, 2001; Soh et al., 2001; Xue et al., 2005). The literature often cites mismatch of local culture, economic and regulatory conditions as the major contributor to ERP adoption failure in developing countries. As explained by Recht and Wilderom (1998, p.8), “this is because ... tools transferred from one country to a specific enterprise abroad suffer a double-layered acculturation: the technology is confronted with a foreign national and alien corporate culture”.

Our research indicates otherwise – ERP adoption was successful in a cohort of sample organisations operating in Malaysia, demonstrating that the continuous strategic initiatives in promoting technology-led business development undertaken by Malaysian Government since the 1990s have paid off (Kuppusamy & Santhapparaj, 2005). It is plausible that the adoption of a complex technology such as ERP has become a strategic necessity in most industries in Malaysia.
Unlike some other developing countries, Malaysia’s ‘marriage’ with advanced technologies goes back to the early 1990s (Nair and Kuppusamy, 2004). The continuous experience gained from the adoption of various technologies seems to have given some organisations an edge when it comes to ERP adoption. However, we remain cautious in advocating this phenomenon and stress the need for more research to validate this notion.

6.3.2 Practical implications

Our research findings also have several practical implications for potential adopters of ERP system. First, we have highlighted the importance of four organisational assets as the primary facilitator for successful ERP adoption. Future ERP adopters should assess the strength and weaknesses of these organisational assets in their own organisation, and evaluate potential areas of improvement and establish plans for effective management of these assets.

Given the complex nature of an ERP project, steps taken to evaluate and effectively manage these assets could possibly determine the success or failure of ERP adoption.

Second, we believe that practitioners should not look at the ERP adoption process as a single input-output phenomenon. This infers that ERP adoption is not only about how much an organisation is willing to invest to get the best-practice business operations and reap the intended business returns. It is also about experiencing the ERP project stage by stage, and achieving smaller successes before reaching the final objectives. This is perceived as an important element of organisation behaviour, leading to great success.

Third, organisations operating in developing countries should pursue their ERP adoption ideology with an understanding of the importance of fostering complementary relationships between organisational assets across the ERP project’s lifecycle. The ERP management team should also understand the importance of Human resource in supporting complementarity relationships between all other assets in the pre-implementation and implementation stages.
Strategic planning for IT skills and ERP training in both of these stages should take into consideration on how these assets will support the management and deployment of other assets effectively.

Further, practitioners should note that the role of knowledge and relationship assets does not diminish at the end of the ERP implementation stage, but rather this role increases in the post-implementation stage. More specifically, business process and project management capabilities remain important in the post-implementation stage. Top management should be involved in the entire lifecycle of the ERP project (Somers & Nelson, 2004). Our findings, however, suggest that top management’s role is significantly accentuated in the post-implementation stage. The decisive power held by the top management team, especially in the context of organisations in developing countries, can ensure ERP post-implementation success, that is, the achievement of positive business process outcomes.

6.4 Limitations and future research

Although our research opens new avenues for explaining the success of ERP projects, the findings need to be interpreted with some limitations in mind. First, the research did not focus on any specific industry classification, and so it may not present an accurate representation of whether complementarity relationships among heterogeneous organisational assets are bounded by an industry effect. This is because a preliminary analysis on the data collected in the large-scale study suggests the participation of organisations from four main industries: engineering, manufacturing, ICT services and trading. The number of respondents in each industry cluster is less than 100 organisations in each cohort. Thus, a detailed comparison between different industries using the PLS may not yield a robust outcome to gauge industry effect. Future research should use the current research framework and compare if industry characteristics have significant effect on the complementarity relationships between organisational assets. We also suggest that the data size in different industry cohort should be more than 100 respondents to achieve a satisfactory comparative analysis.
Second, the assessment of complementarity relationship and asset management dynamics was made using self-reported data from a single respondent. These measures are vulnerable to subjective assessment of their organisations and to single respondent bias (Aral & Weill, 2007). Future research could concentrate on obtaining objective measures of complementarity and the success achieved in each stage of ERP project.

Third, our research was based on reflections of completed ERP project and its activities, thus we were not able to capture real-time events as they occurred in each stage of the ERP project. Future undertakings should try to identify the existence of complementarity relationships amongst organisational assets in real time, using longitudinal research. Such research could be undertaken in different time periods, based on the execution and completion of each stage in ERP project, which would provide a deeper understanding of the effects of the assets toward each stage’s success.

Fourth, we measured business process knowledge from the perspective of the staff of the sample organisations. We did not measure the business process knowledge of ERP consultants who ought to have played an important role in these organisations’ ERP projects, an argument notably made in most critical success factor studies (e.g., Nah et al., 2001; Somers & Nelson, 2004). While we acknowledge that the absence of ERP consultants’ perceptions is a crucial limitation of the research, we decided to focus on internal staff members for two main reasons:

- The sample organisations were already users of ERP who had completed their project in the last two or three years ago. These organisations refused to reveal their consultants’ background information, although naming their ERP vendor was not seen as an issue. A possible reason for this could be because revealing of their firm’s information may have been perceived as sensitive information that could affect their competitiveness level. Thus, we thought it would be futile to seek the consultants’ participation. Future research undertakings should use improved confidentiality statement that clearly spells out privacy issue.
• Internal members of staffs would normally have greater understanding of the internal business process knowledge than external consultants, and hence we believed internal staff would be able to provide quality answers regarding their business process knowledge.

Fifth, we chose to use only four organisational assets as the independent factors. This could influence the weak R-square values, implying the possibility of other important factors not being included in the research model. As this was exploratory and theory-building research, we wanted to investigate the role of some of the key factors that have been explored in the literature. Future research should integrate more independent factors into the research model in order to capture wider dimensions of the R-square.

Finally, the data collection focused on the opinions and perceptions of respondents in a senior management position. The opinions and perceptions of respondents at lower operational levels may be slightly different.

However, we believe that such opinions would not have significant implications for the results, as the ERP implementation should be well planned throughout the organisation and each employee should be fully aware of the project. A person working in a senior managerial position would normally have an eagle-eye view of the entire project lifecycle, and thus should be to provide quality information about the entire project.

6.5 Conclusion

The continuous evolution in technology leads to the development of various forms of advanced information system applications. Organisations engage and deploy such advanced applications for various reasons -- be it as a matter of strategic, managerial or operational purposes (Kamhawi, 2008). Adoption of these applications often comes with a heavy price, in the context of allocation of big financial budget, time and man-hours.
Limited or no payoffs from such investment could result in adverse outcomes to the adopting organisations. Such a negative phenomenon has been repeatedly highlighted in the context of ERP system adoption.

Heeding the ERP literatures constant call for finding other reasons for ERP adoption failure, we undertook this research on a sample of ERP using organisation in Malaysia to identify alternate avenues to achieve successful ERP adoption. The literature review highlighted several voids that have not been explored extensively in the past, and we believed that dissecting an ERP project into several stages and looking at the complementary relationships between a set of heterogeneous organisational assets in each stage would indicate the key enablers for successful ERP adoption.

The research provides empirical evidence that flanking complementary relationships between a set of heterogeneous organisational assets can lead to the success of ERP pre-implementation, implementation and post-implementation stages.

We also found that the emergence of flanking complementarity in each stage is infused by specific assets, that is, Human resource and IT infrastructure in the pre-implementation stage; Human resource and Knowledge in the implementation stage; and Knowledge and Relationship assets in the post-implementation stage. Finally, the empirical finding confirms the notion that an ERP project does undergo a series of continuous and interdependent activities and processes, with potential dependence on a dynamic asset management capability.

These findings leads to the conclusion that before engaging in an ERP project, an organisation should build and strengthen their human resource, knowledge, relationship and IT infrastructure assets, and be ready to proliferate a dynamic asset management capability across the different stages of an ERP project’s lifecycle. The empirical evidence found in this research leads to pertinent theoretical contributions.
First, we present a new dimension on how three independent theoretical platforms, namely ERP adoption, the process theory and the theory of complementarity can be integratively used to explore alternative avenues to achieve successful ERP adoption. Using an integrated theoretical lens in the context of ERP in rather novel and it gives a wider perspective on how successful ERP project can be achieved effectively.

Second, we investigated ERP adoption success by opening ERP project’s black-box and observing the different stage’s contributing antecedents. We are in the opinion that this is a significant contribution as we dissected and identified the different factors (i.e. organisational assets) that impacts the completion of each stage involved in an ERP project’s lifecycle. We have essentially validated the process theory-ERP project lifecycle frameworks introduced by authors such Krupp (1998), Markus and Tanis (2000a) and Ross and Vitale (2000).

Third, we contribute to the body of knowledge by identifying the importance of organisational assets engaging in a complementary relationship to augment/magnify the individual effect of each organisational asset in the completion of each stage involved in an ERP project. The findings obtained in this research seem to comply with Milgrom and Roberts (1995b) point of argument of management of incompatible assets could lead to undesirable outcomes.

Strategic management of several cohorts of compatible organisational assets such as IT infrastructure and Human resource in the pre-implementation stage, seem to have magnify the achievement of this stage’s success. The complementary relationships between different organisational assets have been tested in the context of ERP project, thus providing an interesting new theoretical perspective that can be used in future research.

Fourth, we employed a mixed research methods, both quantitative and qualitative, and conducted this research in two stages. The preliminary pilot study provided insights into the notion of complementarity and the stages of ERP projects, and the improved large-scale study employed a larger sample size that resulted in an increased response rate.
The findings from both phases complemented each other and provided a strong platform upon which to base a rigorous conclusion.

In summary, we contribute to the theory in the following contexts:

(iv) We found evidence for existence of complementarity relationships between a set of heterogeneous organisational assets with significant effects on the successes achieved in all the three stages in an ERP project.

(v) The conditions that facilitate emergence of complementary relationships in each stage are different.

(vi) An empirical confirmation that an ERP project does undergo several successive and interrelated stages.

Following the theoretical contributions, several research and practical implications drawn serve both as reference points for future research and as guidelines for the successful undertaking of ERP projects have been highlighted.
REFERENCES


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Jesitus, J. (1997). Broken promises? Foxmeyer’s project was a disaster. Was the company too aggressive or was it misled? *Industry Week, 31-37.*


Marion, L. (2000). Mastering ERP’s ‘Dirty Dozen’: how to identify and overcome ERP’s Top 12 obstacles. *ERP News*


191


192


Appendix A

17th December 2008

Notification of Approval

Dear Mudiarasan Kuppusamy

I'm writing to advise you that the Human Research Ethics Committee has agreed to approve the project.

TITLE: Strategic management of ERP project lifecycle

PhD Candidate: Mudiarasan Kuppusamy

The Protocol Number for this project is H6627. Please ensure that this number is quoted in all relevant correspondence and on all information sheets, consent forms and other project documentation. Please note the following:

1) The approval will expire on 14 August 2010. If you require an extension of approval beyond this period, please ensure that you notify the Human Ethics Officer (humanethics@uws.edu.au) prior to this date.

2) Please ensure that you notify the Human Ethics Officer of any future change to the research methodology, recruitment procedure, and set of participants or research team.

3) If anything unexpected should occur while carrying out the research, please submit an Adverse Event Form to the Human Ethics Officer. This can be found at http://www.uws.edu.au/research/ors/ethics/human_ethics

4) Once the project has been completed, a report on its ethical aspects must be submitted to the Human Ethics Officer. This can also be found at http://www.uws.edu.au/research/ors/ethics/human_ethics

Finally, please contact the Human Ethics Officer, Kay Buckley on (02) 4736 0883 or at k.buckley@uws.edu.au if you require any further information. The Committee wishes you well with your research.

Yours sincerely

Dr Janette Perz,
Chair, Human Research Ethics Committee

Kay Buckley
Human Ethics Officer, University of Western Sydney
Locked Bag 1797, Penrith Sth DC NSW 1797,
Tel: 02 47 360 883
Appendix B

PARTICIPANT INFORMATION SHEET

Survey Project Title: Strategic management of ERP project lifecycle

Who is carrying out the study?
This research is being conducted by Mr. Mudiarasan Kuppusamy, a doctoral student (ID No: 98784569) of the University of Western Sydney, Australia. He is pursuing his degree under the supervision of Dr. Yi Chen Lan and Dr. Geoff Lee, both from the College of Business.

What does the study involve?
The enclosed questionnaire is a core component of the doctoral study and seeks to obtain reliable data from your firm on the coordination and deployment of firm resources for the purpose of ERP implementation in your firm. The survey ideally needs to be answered by a person with reasonable involvement and experience in your firm’s ERP implementation phases and the outcomes achieved during the implementation and after using the ERP system. Answering the survey should not take more than 20 minutes of your time. Please complete the questionnaire by 20th October 2009, and send it back to us using the self-addressed stamped envelope.

Will the study benefit me?
This study can enlighten on the role of your firm’s capabilities in ERP system implementation project success. The findings could further reflect on how your firm can improve and position internal resources for future technology implementation success.

Will the study involve any discomfort for me?
No foreseeable risk of harm or discomfort is anticipated as your participation is on a voluntary basis. You are not obliged to be involved and if you do participate, you can withdraw from the research at any time without giving any reason and without any consequences. The information sought in this survey entails general questions pertaining to your firm and the information will be represented in Mr. Mudiarasan’s doctoral thesis report in an aggregated format without revealing the responding person(s) or the firm’s details. The data collected in this survey will remain confined to the doctoral student’s access only.

What if I require further information?
If you have any questions related to the study, please feel free to contact Mr. Mudiarasan through his e-mail: m.kuppusamy@uws.edu.au

What if I have a complaint?
This study has been approved by the University of Western Sydney Human Research Ethics Committee with Approval number H6627. If you have any complaints or reservations about the ethical conduct of this research, you may contact the Ethics Committee through the Office of Research Services on Tel +612-4736 0083 Fax +612-4736 0013 or email humanethics@uws.edu.au. Any issues you raise will be treated in confidence and investigated fully, and you will be informed of the outcome.
Appendix C

To the participants,
Please take time to answer this questionnaire if you have been reasonably involved in your firm’s Enterprise Resource Planning (ERP) system implementation project, with good knowledge of the utilisation of firm resources for the purpose of ERP project as well as the outcomes achieved in different levels of implementation phase. IF YOU THINK YOU DO NOT MATCH THESE CRITERIA, BUT HAVE RECEIVED THIS QUESTIONNAIRE, kindly forward it to the appropriate person within your firm. PLEASE READ THE KEY TERM DEFINITIONS CAREFULLY, BEFORE ANSWERING THE QUESTIONS. Please circle only one number for each statement.

Key terms

ERP pre-implementation phase
In this phase of ERP project, firms would normally be involved in activities such as planning for the technology introduction, deciding on the role of the vendor and in-house resources in managing the introduction, providing preliminary training, planning the logistics of the change, deciding whether a pilot study will be used, and deciding whether everything will be changed at once or whether a gradual phase-in will be used.

ERP pre-implementation phase
Implementation phase involves activities such as detailed gap analysis, business reengineering process, identification of complementary solutions, construction of prototype, data conversion, clarity of work procedures, full implementation, user training, and acceptance tests.

Post-implementation phase
Post-implementation phase involves activities such as fixing bugs, performance tuning, adding hardware capacity, technology migration, retraining of users, and continuous business improvement.

Section 1: Demographics

1.1 Please indicate your current role in the firm ______________________________

1.2 Please indicate the number of years you are working in this firm
   □ < 3 □ 3 - 5 □ 5 – 7 □ 7 - 10 □ >10

1.3 Please indicate your highest educational level completed
   □ Certificate □ Diploma □ Bachelor □ Masters degree □ Doctorate

1.4 Please indicate the years your firm have been operating
   □ < 3 □ 3 – 5 □ 5 – 7 □ 7 - 10 □ > 10

1.5 Please indicate the total full-time equivalent employees working in your firm
   □ 20 – 49 □ 50 – 99 □ 100 - 249 □ 250 – 499 □ > 500

1.6 Please describe your firm’s ownership structure
   □ Private Ltd □ Public Ltd

1.7 Please estimate your firm’s average gross revenue per year (in million $RM)
   □ < $10m □ $10m - $49m □ $50m - $99m □ $100 – $499m □ > $500m

1.8 Please describe your industry (e.g. Finance & Insurance, medical): __________________

1.9 In which year was the ERP project commenced _________ and completed? ___________

1.10 What is the total investment made on your ERP project (in million $RM)?
    □ < $10m □ $10m - $49m □ $50m - $99m □ $100 – $499m □ > $500m
## Section 2.1 Please tell us the extent to which coordination and deployment of the following Human Resources were considered important in different phases of your ERP project

<table>
<thead>
<tr>
<th>Human Resources</th>
<th>Pre-implementation</th>
<th>Implementation</th>
<th>Post-implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Identification of specific ERP users’ training needs</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>A formal training programs to meet the requirements of users</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>Customised training materials to suit each job functionalities</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>Updated ERP training materials to reflect system changes</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>ERP training materials targeting the entire business tasks, not just screens &amp; reports</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>Evaluation of employees’ ability to absorb ERP knowledge</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>Basic ERP skills training for all users</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>Scheduled ERP training review sessions</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>High degree of ERP related technical expertise IT staff(s)</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>Expert ERP database management system administrator</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>IT staff(s) with ERP system technical background</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>IT staff(s) with ability to implement ERP system upgrades</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>IT staff(s) with ability to conduct validation of changes</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>IT staff(s) with ability to analyse the impact of changes</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>IT staff(s) who actively builds relationships with business units</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>IT staff(s) who offer ideas on effective usage of IT</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>IT staff(s) who often communicates with ERP users</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>IT department that provides effective service</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>
Section 2.2 Please tell us the extent to which coordination and deployment of the following Knowledge Resources were considered important in different phases of your ERP project.

<table>
<thead>
<tr>
<th>Knowledge Resources</th>
<th>Pre-implementation</th>
<th>Implementation</th>
<th>Post-implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>very important</td>
<td>Not at all</td>
</tr>
<tr>
<td>2.2.1 Engagement of experienced consultants to guide in project implementation</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.2.2 Engagement of external consultants with considerable ERP expertise and experience</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.2.3 Engagement of external consultants with good experience in our business processes</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.2.4 Use of a formal project management tools and techniques</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.2.5 Estimation of ERP project's scope, size and efforts required</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.2.6 Evaluation, classification and prioritisation of the ERP implementation risks</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.2.7 Use of realistic project implementation schedules</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.2.8 Use of highly capable and experienced project manager(s)</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>

Section 2.3 Please tell us the extent to which coordination and deployment of the following Relationship Resources were considered important in different phases of your ERP project.

<table>
<thead>
<tr>
<th>Relationship Resources</th>
<th>Pre-implementation</th>
<th>Implementation</th>
<th>Post-implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Not at all</td>
<td>very important</td>
<td>Not at all</td>
</tr>
<tr>
<td>2.3.1 User communities involvement in the ERP project</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.3.2 Users involvement in determining the ERP system capabilities</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.3.3 Users involvement in identifying input and output requirements</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.3.4 Senior executives with consistent interest in the ERP project</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.3.5 Top level managers’ personal involvement in ERP project</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.3.6 Top management’s consistent support for ERP project</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>
Section 2.4 Please tell us the extent to which coordination and deployment of the following Information Technology Resources were considered important in different phases of your ERP project.

<table>
<thead>
<tr>
<th>Resource</th>
<th>Pre-implementation</th>
<th>Implementation</th>
<th>Post-implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4.1 Technology infrastructure that supports electronic linkage of business units</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.4.2 Technology infrastructure that supports electronic linkage of firm with external business partners</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.4.3 Technology infrastructure that supports business operations</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.4.4 High capacity network infrastructure that supports business needs</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.4.5 High speed network infrastructure that supports business needs</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.4.6 Sharable corporate data across business units and organizational boundaries</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
<tr>
<td>2.4.7 Standard components of technology infrastructure (i.e. hardware, operating system)</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
<td>1 2 3 4 5 6 7</td>
</tr>
</tbody>
</table>

Section 3.1 Please respond to the following statements on the outcomes experienced at the end of ERP pre-implementation phase.

At the end of the ERP pre-implementation phase, .......

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1.1 our general expectations toward the ERP system was positive</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.2 we believed that the data from ERP system will be always on time</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.3 we believed that the data from the ERP system will be very accurate</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.4 we believed that the ERP system will be very easy to use</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.5 we believed that the ERP system will be very easy to customise</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.6 we believed switching from legacy system to ERP is absolutely essential</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.7 we believed that the benefits of ERP will outweigh the costs</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.8 we saw the value in having an ERP system</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.9 we believed that ERP will help to coordinate our work activities</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>
### Section 3.1 Please respond to the following statements on the outcomes experienced at the end of ERP pre-implementation phase.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1.10 we believed that supporting or working on the ERP system can enhance career development</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.11 we believed that the ERP project was proceeding according to plan</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.12 we believed that the progress of the ERP project is too fast</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.13 we believed that given all the factors beyond our control, the time frame for ERP implementation was outstanding</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.14 we believed that the progress towards having the ERP system not at all frustrating</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.15 we were very satisfied with the progress of ERP system</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.16 we believed that it wouldn’t bother us if ERP project were discontinued</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.17 we became familiar with the functionality of the ERP system</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.18 we believed that the ERP system was important to us</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.19 we believed that the ERP project was very well run</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.20 we liked the way ERP system was designed</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.21 we believed that a lot of improvement should be made in the way the ERP system was run</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.22 we believed that our immediate superiors supported ERP implementation idea</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.23 we believed that ERP had little importance to us</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.24 we believed that communication on the ERP was good</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.1.25 we believed that the ERP is a great program and should be implemented in our firm</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

### Section 3.2 Please respond to the following statements on the outcomes experienced at the end of ERP implementation phase.

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2.1 we believed that it took us less efforts than others to complete ERP implementation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.2.2 we believed that our implementation was completed within budget</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.2.3 we believed that our implementation was completed within schedule</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.2.4 we believed that all users have had a complete training of the ERP system for effective usage</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.2.5 we believed that all ERP functions can meet the expected objectives</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>
Section 3.3 Please respond to the following statements on the outcomes experienced at post-implementation phase of ERP

<table>
<thead>
<tr>
<th>Statement</th>
<th>Strongly disagree</th>
<th>Strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.3.1 ERP usage has improved our efficiency of operations</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.2 ERP usage has lowered our costs of operation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.3 ERP usage has reduced the amount of rework needed for data entry errors</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.4 Data provided by ERP adds value to our operation</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.5 ERP usage has improved timely access to corporate date</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.6 ERP system provides a high level of enterprise wide data integration</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.7 ERP usage helps us to make better sales forecasts</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.8 The functionalities of ERP adequately meet the requirement of our jobs</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.9 ERP usage has improved our quality of operations</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.10 ERP usage has given us more ways to customise our processes</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.11 ERP usage has made our company more responsive</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.12 ERP usage has made us more adaptive to changing business environment</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
<tr>
<td>3.3.13 ERP usage has improved the flexibility of our operations</td>
<td>1 2 3 4 5 6 7</td>
<td></td>
</tr>
</tbody>
</table>

Thank you for your participation.