A Knowledge Management Based Cloud Computing Adoption Decision Making Framework

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Abstract

Cloud computing represents a paradigm shift in the way that IT services are delivered within enterprises. There are numerous challenges for enterprises planning to migrate to cloud computing environment as cloud computing impacts multiple different aspects of an organisation and cloud computing adoption issues vary between organisations. A literature review identified that a number of models and frameworks have been developed to support cloud adoption. However, existing models and frameworks have been devised for technologically developed environments and there has been very little examination to determine whether the factors that affect cloud adoption in technologically developing countries are different. The primary research carried out for this thesis included an investigation of the factors that influence cloud adoption in Saudi Arabia, which is regarded as a technologically developing country.

This thesis presents an holistic Knowledge Management Based Cloud Adoption Decision Making Framework which has been developed to support decision makers at all stages of the cloud adoption decision making process. The theoretical underpinnings for the research come from Knowledge Management, including the literature on decision making, organisational learning and technology adoption and technology diffusion theories. The framework includes supporting models and tools, combining the Analytical Hierarchical Process and Case Based Reasoning to support decision making at Strategic and Tactical levels and the Pugh Decision Matrix at the Operational level. The Framework was developed based on secondary and primary research and was validated with expert users. The Framework is customisable, allowing decision makers to set their own weightings and add or remove decision making criteria. The results of validation show that the framework enhances Cloud Adoption decision making and provides support for decision makers at all levels of the decision making process.

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I would like to express my deep thanks to my father and Mother for their prayers, support. I also would like to express my deep thanks to my beloved wife Abeer for her prayers, patience, understanding and supporting me throughout the period of this research. I would like to thanks my daughters Norah and Diala for their patience. They always give the source of inspiration and motivation for me. I would like to thank my brothers and sisters for their prayers, support and motivations.

Finally, I would like to thank all my friends for their prayers, support and encouragements.

Dedication

This thesis is dedicated to

To My Father, Mother

To my Wife Abeer

To my Daughters Norah and Dial

To my Brothers and Sisters

Publications

Conference Papers

Alhammadi, A., Stanier, C., & Eardley, A. (2015). A Knowledge based Decision Making Tool to Support Cloud Migration Decision Making. In *Proceedings of the 17th International Conference on Enterprise Information Systems* (pp. 637–643). SCITEPRESS - Science and and Technology Publications. http://doi.org/10.5220/0005464006370643

Alhammadi, A., Stanier, C., & Eardley, A. (2015). The Determinants of Cloud Computing Adoption in Saudi Arabia. In *Computer Science & Information Technology (CS & IT)* (Vol. 70, pp. 55–67). Academy & Industry Research Collaboration Center (AIRCC). http://doi.org/10.5121/csit.2015.51406

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Chapter 1: Introduction

1.1 Introduction

This chapter introduces the investigation into cloud adoption decision making and gives the background and motivation for the research. The aims and objectives are explained and the research philosophy, research design, methods of investigation and ethical issues are discussed. The chapter discusses the contribution and outcomes of the research and gives an outline of the structure of the thesis.

1.2 Background and Motivation

Businesses are currently coming to terms with the paradigm shift in computing resources known as cloud computing, which has been classified by Gartner as one of the ten most important technologies of the 21st century (Hashizume et al., 2013). It has been estimated that the value of the cloud computing market will increase from $40.7 billion in 2010 to $240 billion in 2020 (Chen et al., 2015). A characteristic of cloud computing is the promise to deliver IT services as a utility analogous to water, electricity and traditional telecommunications (Buyya et al., 2009; Lee et al., 2013). Cloud computing is also an enabling technology, providing computing resources to support other technologies and applications such as mobile computing, the Internet of Things and Big Data (Hassanalieragh et al., 2015).

Adopting cloud computing changes not only the technology used by an enterprise but also the way in which business operations are managed (Raj & Periasamy, 2011). In addition, migrating enterprise resources to a cloud solution involves decision making at the strategic, tactical and operational levels, and potentially impacts all aspects of the organisation (Andrikopoulos et al., 2014). A review of the related literature reveals that although there is a body of research dealing with cloud computing adoption, the discussion is fragmentary and sometimes lacks theoretical underpinning, focusing on specific technical aspects of the adoption process and not providing guidance on managing the whole process of cloud adoption decision making and migration implementations. A further issue is that the literature focuses on organisations in technologically developed economies and environments and does not consider whether the same concerns apply to enterprises working in technologically developing environments. To address the research gap, this research had two main motivations:

- To develop a theoretically sound framework that supports decision makers at every level of decision making when considering whether to adopt a cloud computing solution and to allow decision makers to tailor the framework to their individual requirements.
- To examine the process of cloud computing adoption in a technologically developing environment to identify whether the drivers and barriers to cloud adoption are the same as those faced in technologically developed environments.

Saudi Arabia is considered to be a technologically developing country (Saleh et al., 2014). Cloud computing adoption in Saudi Arabia is presumed to be slow compared to the adoption rates in technologically developed countries (Alkhater et al., 2014), although there is very little data about the nature and process of cloud computing adoption in Saudi Arabia or similar environments, and no study which investigates cloud computing adoption in Saudi Arabia from an enterprise perspective. This research was designed to fill this gap in the literature and to provide support for cloud computing adoption in technologically developing as well as technologically developed contexts.

The Knowledge Management Based Cloud Computing Adoption Decision Making Framework (KCADF) developed in this research provides an holistic approach to support cloud adoption decision making at all levels of decision making. At the strategic level, the approach takes into account five factors which were identified from the primary and secondary research as covering all aspects of cloud adoption decision making; these factors are technology, organisational, economic, security and regulatory factors. The tactical level supports the selection of a cloud deployment model. The models used at the strategic and tactical levels use a hybrid approach to support decision making, combining the analytical hierarchical approach (AHP) with case based reasoning (CBR) to provide a knowledge based decision support model. Operational level decision making is supported through the use of a Pugh Decision Matrix for the selection of cloud service model.

1.3 Aim and Objectives

The main aim of this research is to support the decision making process for cloud computing adoption by developing an holistic knowledge management based cloud adoption decision making framework, and supporting models to support cloud adoption decision at the strategic, tactical and operational levels. An additional aim is to contribute to the body of knowledge by conducting a field study to investigate the issues and benefits related to cloud adoption in a technologically developing environment.

The following objectives were developed to achieve these aims:

1. To critically review of the literature of cloud adoption approaches and frameworks and identify issues related to cloud computing adoption.

2. To investigate knowledge management and decision making theories to provide the theoretical underpinning for the research.
3. To investigate the theoretical basis of technology adoption models, frameworks and approaches.
4. To investigate the challenges and issues and benefits involved in cloud adoption in a technologically developing environment through a field study.
5. To develop a knowledge management based cloud adoption decision making framework based on secondary and primary research.
6. To develop, as part of the framework, decision making models to support the strategic decision on cloud adoption, the tactical decision on the selection of cloud deployment models and the operational decision on the selection of cloud service models.
7. To validate the cloud adoption framework and supporting models through primary research.
8. To evaluate the research and suggest directions for future research.

1.4 Research Philosophy

There are a number of different paradigms which provide support for researchers. In information systems (IS) research, paradigms are usually classified into positivism, critical research and interpretivism (Oates, 2005; Klein & Myers, 2011). The approach most widely used in IS research is interpretivism (Walsham, 1995; Klein & Myers, 1999; Mingers, 2003; Goldkuhl, 2011), partly because it supports researchers in developing deep insights into IS phenomena (Klein & Myers, 1999). In IS and computing research, interpretivism is seen as "understanding the social context of an IS: the social processes by which it is developed and construed by people and through which it influences, and is influenced by, its social setting" (Oates, 2005, p. 292), with the aim of finding new meanings of multiple realities (de Villiers, 2005). Interpretivism tries to investigate the social context of IS and to determine what factors influence users. These are elements which are difficult to investigate within the positivist paradigm (Myers & Avison, 2002; Goldkuhl, 2011). Silverman (1998) argued that the interpretivist approach could support understanding the process of organisational change. The current research is built on a study of the factors including technical, security, organisational, economic and regulatory which influence and/or must be taken into account when decisions are made on the adoption of cloud computing, for which reason this research is regarded as falling within the interpretivist paradigm.

1.5 Research Approach

Research methods can be classified into three main categories: quantitative, qualitative and mixed method research (Bryman, 2012). Quantitative research is defined as "a research strategy that emphasises quantification in the collection and analysis of data" (Bryman, 2012, p. 35), and is associated with the positivist paradigm, while qualitative research uses an explorative approach to improve the understanding of social or human problems (Creswell, 2009, 2007) and to understand phenomena (Green & Browne, 2005). There is a long-standing history of using qualitative approaches in IS research (Myers, 1997; Goldkuhl, 2011) and within the knowledge management (KM) discipline (Nicolas, 2004). Data collection methods for qualitative research are designed to explore issues and elicit opinions and explore the ambiguity of the phenomena and are appropriate for an interpretivist approach.

Bryman (2012) noted that quantitative approaches are used to test theory (deductive) while qualitative approaches are used to generate theory (inductive). This research adopts the inductive approach to investigate the main themes identified from the secondary research to support the development of the cloud adoption framework and the supporting models. As this investigation will make use of both qualitative and quantitative data, this research will adopt a mixed method approach combining qualitative and quantitative aspects within a single project (Bryman, 2012).

As noted in 1.2, there is currently little data about cloud adoption in Saudi Arabia, so quantitative data will also be collected to give the context of cloud computing adoption in a technologically developing environment and this research uses a questionnaire to test the hypothesis.

The mixed method approach supports researchers in collecting different types of data by different methods using different sources (Kaplan & Duchon, 1988). Finally, it is argued that using a mixed method approach could increase the robustness of the findings by supporting both richness of the analysis and generalisability of the findings (Kaplan & Duchon, 1988).

1.6 Research Design

Based on the discussion above, this research adopted both qualitative and quantitative approaches. An exploratory study focuses on examining a problem which has not been clearly defined (Tharenou et al., 2007). The exploratory study begins with the collection and analysis of qualitative data, and then this is used as a platform to develop the instrument to quantitatively assess and validate the qualitative results (Creswell et al., 2007).

The first stage of the research was a literature review undertaken to explore the issues and define the problem. The literature review identified that an holistic approach to support cloud computing adoption did not exist, and also identified the lack of research into cloud computing adoption in technologically developing environments. The literature review was followed by the primary research. The primary research was carried out in two phases: the first phase involved interviews with cloud service providers (CSPs) and users in Saudi Arabia. This stage of the research examined concerns related to cloud computing adoption primarily from CSPs point of view and the issues and benefits of cloud computing adoption in the context of a technologically developing county. From the literature review and the first stage of the primary research, hypotheses were developed about the drivers and barriers to cloud computing adoption. In the second stage of the primary research, a questionnaire was used to test these hypotheses from the client perspective. The purpose of the questionnaire was both to determine which elements should be included in the Cloud Computing Adoption Framework, and also to investigate whether the factors identified by users in a technologically developing environment were different from factors identified from theories of technology adoption and studies based primarily on users in technologically developed environments. Based on the results of the literature review, the interviews and the questionnaire analysis, the knowledge based Cloud Computing Adoption Decision Framework and the supporting models and tools were developed. The Framework was validated through workshops conducted with CSPs and cloud users and was revised and amended based on the feedback received. The Research as a whole was evaluated and directions for future work were identified. The research design is shown in **Error! Reference source not found.**

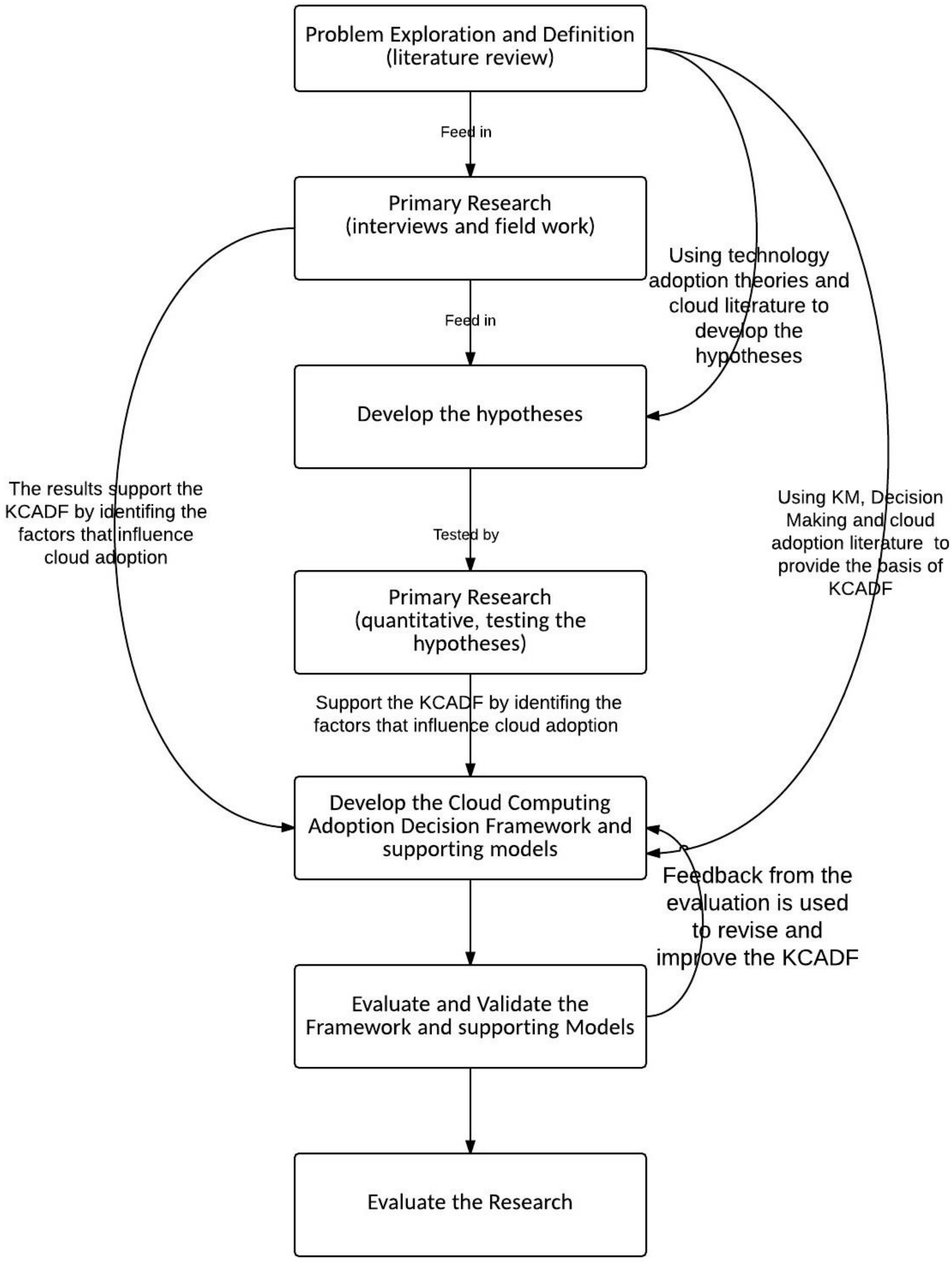


Figure 1-1: Research approach

1.7 Data Collection Tools

1.7.1 Secondary research

A literature review was conducted to examine cloud adoption issues and benefits in order to identify the main theme for this research. The literature review covered existing cloud migration/adoption frameworks and models and information system outsourcing. In addition, the literature review covered the area of knowledge management (KM), learning organisation (LO), and organisation learning (OL) and decision making approaches as the theoretical underpinning for this research. Moreover, the secondary research reviewed the literature on technology adoption theory to provide the foundation to develop the interview and questionnaire approach.

The data in the secondary research was collected through different sources including books, journals, conference papers and government and industry documents. Two different portals were used to collect data, Staffordshire University Library resources and the Saudi Digital Library. A comprehensive literature survey was conducted using among other sources the following academic databases: ACM Digital Library, Emerald Insight, the Institute of Electrical and Electronic Engineers (IEEE), SAGE Journals, ScienceDirect (Elsevier) and Springer. The literature review was conducted to established the context of this research, identify the knowledge gap, support the development of interview and questionnaire design and to support the development of the framework and supporting models.

1.7.2 Primary Research: Interview

Interviews, defined as a research conversation with participants (Creswell, 2014), are regarded as the main data sources for qualitative approach (Myers & Avison, 2002).

Interviews can be carried out in a range of formats (Green & Browne, 2005) and are seen as appropriate for collecting detailed information and for dealing with complex issues (Oates, 2005). A semi-structured interview format provides flexibility in changing or adding themes to allow the interviewee to raise new issues which have not been addressed (Oates, 2005). This research adopted the semi-structured interview format for the first phase of the primary research for a number of reasons:

1. The context of information systems varies between developing and developed countries due to different IT maturity levels including social, managerial, economic and legal factors which play an important role in the success of the adoption of new technology. Some of these factors are difficult to measure using quantitative techniques and are most appropriately studied using a qualitative approach.
2. Numerous studies have attempted to investigate cloud adoption issues; however, there is a lack of empirical study of cloud adoption issues (Chebrolu, 2012), as the majority of the existing studies are based on secondary research, as discussed further in chapter two. This is particularly the case for Saudi Arabia, where few field studies have been carried out on cloud computing adoption in general.
3. The nature of the problem investigated in this research requires rich and in-depth data. The interview approach supports the use of context sensitive data and different user perspectives (Oates, 2005).
4. Due to the limited number of CSPs in Saudi Arabia, the sample size will be small. The number of the participants and the need for in depth data made the semi-structured approach appropriate.

One of the criticisms of the qualitative approach is the difficulty of analysing data, as the researcher will deal with text rather than meaning. Russell (2015) observed that there is no one standard way to analyse qualitative data. However, the common theme of qualitative data analysis is to divide raw data into smaller units of analysis (Elo & Kyngäs, 2008).

This research adopted the framework analysis (FA) approach to conduct the qualitative interview analysis. The FA is defined as an analysis approach to analyse qualitative data thematically (Ram et al., 2008). the FA consists of five distinct but interconnected stages: familiarisation, identifying a thematic framework, indexing, charting and mapping and interpretation (Ritchie & Spencer, 2002; Srivastava & Thomson, 2009). In addition, The FA could be adopted during and after the data collection process (Ward et al., 2013).

During the first process of FA, which is familiarisation, the researcher must understand the data gathered (Ritchie & Spencer, 2002). This is carried out before and after the data collection process. The researcher needs to understand and know the issue under investigation and must prepare questions for the investigation. After the interview, the audio materials were transcribed. The transcriptions were read and reread to identify the main themes.

The second step is highly related to the pervious stage in that when researchers become familiar with the data they have a primary conceptualisation of the thematic framework (Ritchie & Spencer, 2002). After identifying the main themes the data can be classified and filtered (Srivastava & Thomson, 2009). Indexing is the third step in the FA, which involves labelling text to classify it into identified themes (Ward et al., 2013). After indexing the textual data, the main themes and sub-themes could be summarised in a chart. Charting refers to the presented textual data indexed in the previous step into a chart of themes (Srivastava & Thomson, 2009). The final stage of the FA is mapping and interpretation. This stage is concerned with interpreting the data set as whole and explaining the relationships between the themes and subthemes.

1.7.3 Primary Research: Questionnaire

A questionnaire is defined as a quantitative data collection tool that uses a set of predefined questions (Oates, 2005). Questionnaires can be used to reach a large population (Harris et al., 2010) and produce generalisable findings (Bryman, 2012). In addition, using questionnaires is a cost and time efficient method, which is easy to complete by respondents (Oates, 2005).

Questionnaires can be divided into two main types, open-ended and closed-questions (Bryman, 2012). In open questions the respondents have liberty to answer as they choose, while in closed questions participants are confined to selecting responses from a range of options provided by the researcher (Oates, 2005). One of the criticisms of closed questions is that they may miss deeper contextual information that participants could have to offer, which is relevant to the research area but which cannot be illustrated from pre-formulated structured questions; however, the great advantage of closed questions is that the elicited data is supports efficient analysis (Oates, 2005). Due to the large size of the population of cloud consumers in comparison with CSPs, the questionnaire is an efficient way to investigate the benefits and issues of cloud adoption from cloud perspectives. This is because the questionnaire could reach large numbers with low cost and in a short time.

1.7.4 Validation approach

A workshop approach was used to validate the framework. The workshops were held in Saudi Arabia and each workshop involved cloud computing users and representatives from cloud service providers. In the workshops, participants applied the framework to a scenario or a real life problem context to evaluate the contribution and usability of the framework and to provide feedback. The template of the validation workshops is attached in appendix E.

1.7.5 Ethical implications

The ethical implications of this research were considered in all phases of the study. Firstly, the ethics form was submitted and approved by the Research Degree Sub-Committee of Staffordshire University prior to conducting fieldwork, and all aspects of the research were conducted in full compliance with the ethical regulations of the University:

- Autonomy: all participants in this research were made aware of the aim and objectives of this research and were informed that their participation was voluntary, and they could withdraw from any time without giving a reason and this would not affect their livelihood or statutory rights.

- Confidentiality: all personal was anonymised and kept secure. Participants were aware that the interviews were recorded (with their permission) and a consent letter was signed by them to highlight the issues related to confidentiality. The consent letter is attached in Appendix F. Commercial confidentiality was an important ethical element as CSPs in Saudi Arabia participated in the research and circulated the questionnaire to their clients. In order to respect confidentiality, data was anonymised to ensure that CSP clients could not be identified and that comments made by CSP respondents could not be linked back to the specific CSP.

1.8 Contribution to Knowledge

This research makes several contributions to academic knowledge and practice. The principal contribution was to meet the main aim of this research by developing a knowledge management based cloud adoption framework to support cloud adoption decision making. An important secondary contribution is that this research added to the body of knowledge on cloud adoption in technologically developing countries by examining the factors that influence cloud adoption decision in a technologically developing context.

More specifically, the contributions to knowledge of this research can be summarised as:

- A knowledge management based cloud adoption decision making framework, with supporting models and tools, to support cloud adoption decision making at the strategic, tactical and operational levels.
- An investigation into the factors which influence organisational decision making for cloud adoption in technologically developing environments
- A critical review of the issues and benefits related to the adoption of cloud computing
- A critical review of existing frameworks and models which support cloud computing adoption.

1.9 Thesis Structure

This thesis has been divided into eight chapters, as illustrated in figure 1.2. The content of the chapters is summarised as follows:

Chapter one: discusses the background and the motivation of the research; based on the discussion of the background and motivation the aim and objectives are developed. The research approach and ethical considerations are discussed and an outline of the research is given.

Chapter two: provides a comprehensive background and critical review of cloud computing, cloud computing definitions, cloud deployment models and cloud service models. The discussion of issues and benefits of cloud adoption are discussed and the chapter discusses the existing models/frameworks that support cloud computing adoption.

Chapter three: provides the theoretical underpinning for this research. This chapter provides a discussion of KM, Organisational Learning (OL) and Learning Organisational (LO) concepts, and how they relate to cloud adoption. In addition, this chapter discusses knowledge based decision making theory and the concept of case based reasoning (CBR), which are the foundations of the cloud adoption framework and the supporting models. The chapter critically reviews the literature relating to technology adoption theories and develops the hypotheses used to examine the factors that influence the cloud adoption decision.

Chapter four: presents the findings of the interview conducted in Saudi Arabia. The findings of the interviews in this chapter reflect the views of CSPs as well as a enterprise that adopted a private cloud. The findings of this study supported the building of questionnaire.

Chapter five: presents the findings of the questionnaire administered in Saudi Arabia. The questionnaire was carried out to find out the issues and benefits of cloud adoption from cloud consumer point of view. In addition, it was used to test the hypotheses were built in chapter three.

Chapter six: presents the development of the Knowledge Management Based Cloud Computing Adoption Decision Making Framework (KCADF). The chapter discusses the framework and the models which cover the strategic decision as to whether to adopt a cloud solution, the tactical decision on the selection of cloud deployment model, and the operational decision on the selection of cloud service model. The chapter also presents the supporting tools such as the CBR tool and the checklists used to support the models.

Chapter seven: discusses the process of the validation and evaluation for cloud adoption framework and the supporting models.

Chapter eight: brings together the outcomes of this research and draws conclusions for this thesis. It also presents the implications of this research and identifies areas for future work.

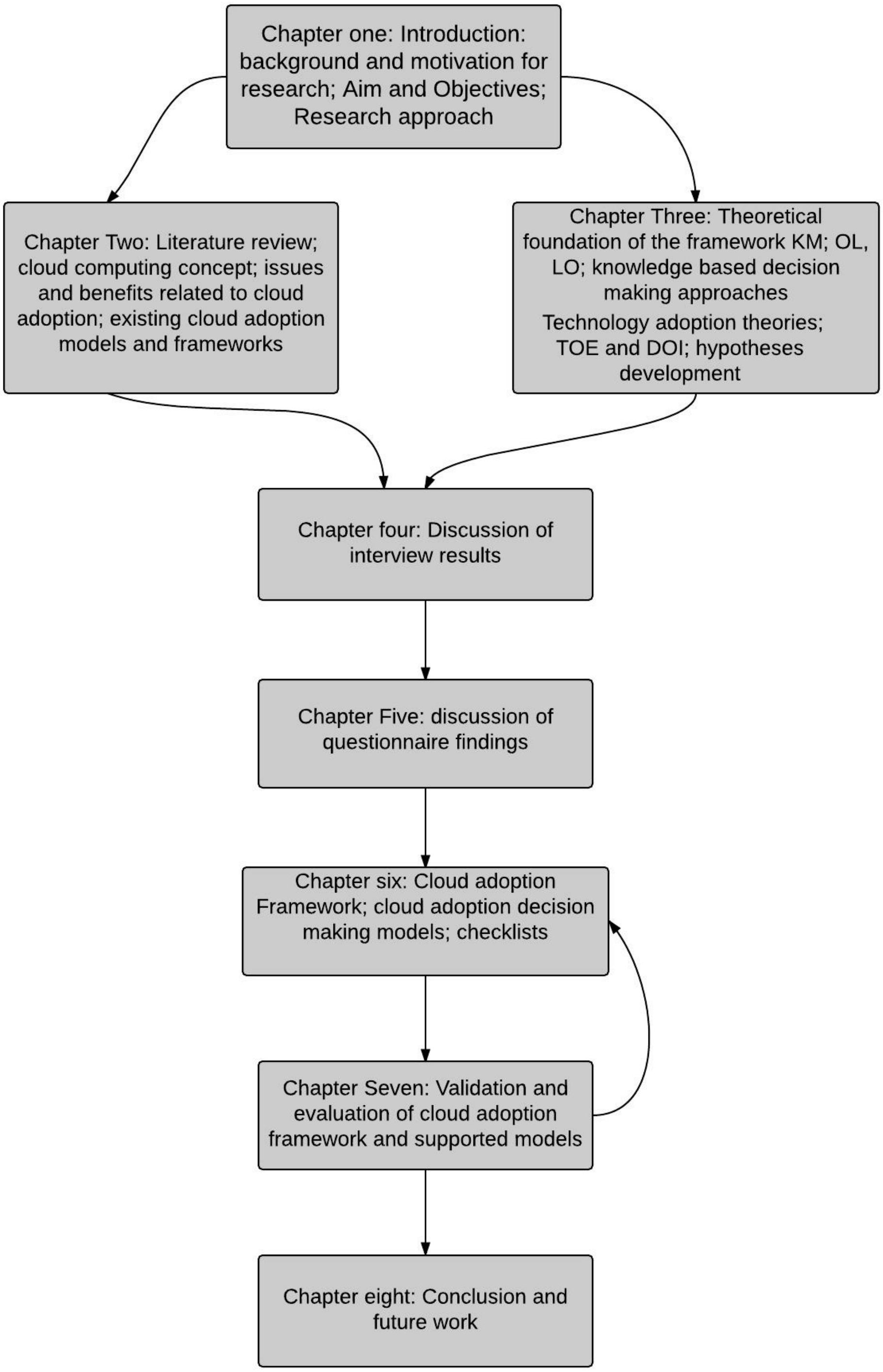


Figure 1-2: Thesis structure

Chapter 2: Literature Review

2.1 Introduction

The previous chapter discussed the aims and objectives of this thesis. The purpose of this chapter is to review the literature on cloud computing to provide the technical background to the investigation. We begin by defining cloud computing and critically discussing cloud deployment and cloud service models and identifying the main differences between them. We then discuss the benefits and risks of cloud computing, and the risks associated with migrating enterprise IT services to the cloud. Having identified the issues to be considered, we then review existing approaches and frameworks for cloud migration and argue that none of the existing approaches sufficiently consider all aspects of the cloud migration problem. We propose that a holistic solution is needed to support cloud computing migration.

2.2 Cloud Computing Definitions

Cloud computing has been described as the next generation model of computing (Rajan & Jairath, 2011). Enterprise spending on cloud computing is increasing at five times the rate of that spent on traditional IT systems (Praveena & Rangarajan, 2014), and according to Gartner, 80% of enterprise will ultimately adopt cloud computing in some of their services (Srinivasan, 2014). Cloud computing is defined in a number of different ways, depending on the user perspective. A widely used definition is that developed by the National Institute of Standards and Technology (NIST): "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources… that can be rapidly provisioned and released with minimal management effort or service provider interaction" (NIST, 2011, p. 2). This definition focuses on the technical characteristics of cloud computing while ignoring the business perspective. Cloud computing has also been defined as the provision of virtual computing resources that provide an on-demand service, dynamically scalable, shared services, which require minimal management effort using the Opex paying model (Marston et al., 2011). The second definition extends the NIST understanding to include business aspects, which is the sense in which cloud computing is understood in this research, although we follow the NIST definition for discussion of the technical elements and in the course of this chapter identify the issues involved in different payment models. The key characteristics of cloud computing as identified by NIST (2011) are:

- On-demand self-service: provisioning and release of cloud computing resources independently and without any human interaction (Hidayanto et al., 2015; Marston et al., 2011; Mell & Grance, 2011).
- Broad network access: cloud computing resources are available over a network, mainly the internet, and can be accessed via different devices (Borgman et al., 2013; Mell & Grance, 2011).
- Resource pooling: benefits from virtualisation and multi-tenant computing resources are pooled to serve multi users (Borgman et al., 2013; Mell & Grance, 2011).
- Rapid elasticity: computing resources can be easily provisioned (scale out) and released (scale in) in response to consumer demand (Mell & Grance, 2011).
- Measured service: usage of computing resources is self-measured, self-monitored, and self-reported with high transparency (Mell & Grance, 2011; Borgman et al., 2013; Hidayanto et al., 2015).

2.3 Cloud Computing vs. Outsourcing

This section considers cloud computing and traditional information system outsourcing to identify similarities and differences. Cloud computing is sometimes seen as a form of outsourcing (Dhar, 2012) but while there are similarities between cloud computing and Information Systems (IS) outsourcing, there are also a number of differences. IS outsourcing aims to outsource physical resources and also staff, while cloud computing only outsources computing resources. Consequently, in traditional IS outsourcing expertise will move to the outsourcers (Kremic et al., 2006; Gonzalez et al., 2009), but this risk is reduced in cloud migration (Adel et al., 2013), meaning that migration to cloud computing presents additional issues.

In traditional IT outsourcing data could be stored in or outside the company, but it is handled by a third party; in cloud migration data is stored by the cloud service provider but it is handled by the company (Dhar, 2012). In traditional outsourcing, a contract is a one to one relationship, while in cloud it is one to many (Schwarz & Jayatilaka, 2009). This has the consequence that in outsourcing, the relationships between the service provider and the client are individually negotiated, while in a cloud computing environment they are more standardised (Martens & Teuteberg, 2012). Reducing cost is one of the motivations behind both outsourcing and cloud migration, but the cost models are different. In cloud computing there is no up-front cost and pricing model is pay-per-use (Dhar, 2012; Martens & Teuteberg, 2012). In contrast, traditional outsourcing involves initial up-front costs (Dhar, 2012), while it may include hidden costs (Gonzalez et al., 2009; Dhar, 2012). In cloud computing, costs are more transparent (Dhar, 2012). The outsourcing literature provides some guidance for cloud migration decision making, but the fields are sufficiently different for cloud migration to be seen as a separate research topic.

Although there is an extensive literature on cloud computing, there is a lack of critical evaluation of service and deployment models and much of the discussion does not differentiate between the different models and services (Himmel & Grossman, 2014; Latif et al., 2014; Hidayanto et al., 2015). We review service models and deployment models in terms of degree of control of data, control of resources, cost of the service, pricing schemes, security and the IT skills needed to manage cloud services. Figure 2-1 presents the NIST view of cloud computing, showing service and deployment models.

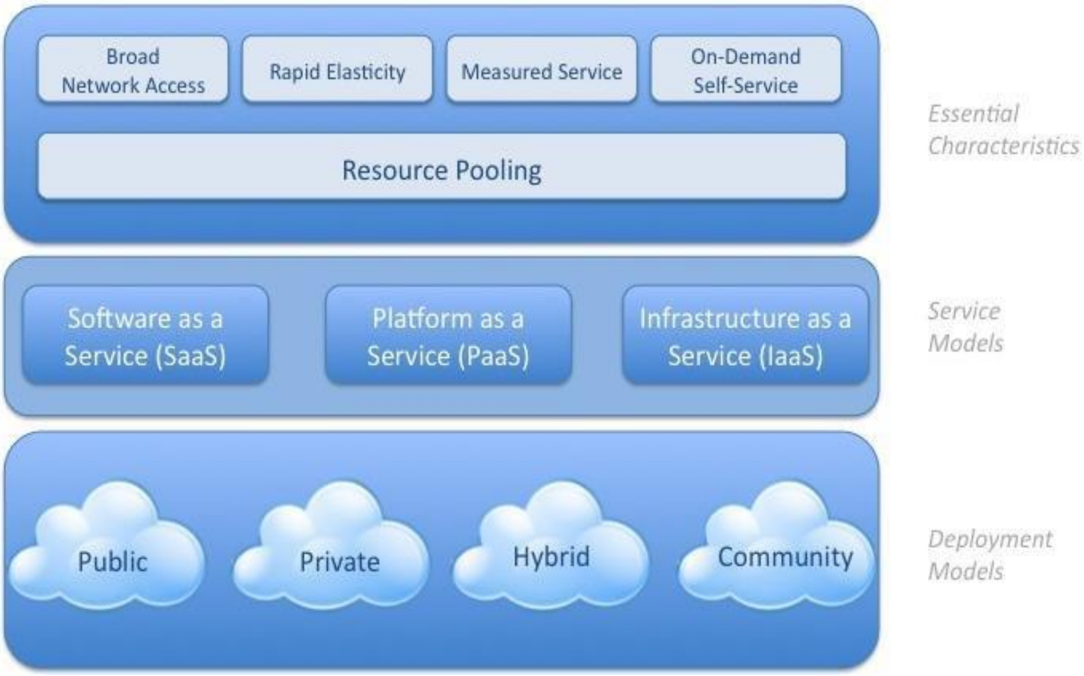


Figure 2-1: The NIST definition model of cloud computing (Mell & Grance, 2011)

2.4 Cloud Computing Service Models

Cloud computing services are provided by three different service models: software as a service (SaaS), platform as a service (PaaS) and infrastructure as a service (IaaS).

2.4.1 Software as a Service (SaaS)

SaaS is a software delivery model in which software is hosted on the service provider's cloud infrastructure and can be accessed by the end user through a web browser (Gonzenbach et al., 2014). The cloud user will use the software without the need to take responsibility for installation, management and licensing (Carroll et al., 2011). In the SaaS model users do not have control over data and infrastructure, which is managed by the cloud service provider (Dillon et al., 2010; Zissis & Lekkas, 2012). Adopting SaaS could help enterprises by reducing operation costs, as there is no up-front cost investment (Seethamraju, 2015). Moreover, it is argued that using SaaS could free enterprises from managing IT services to focus on their core business (Seethamraju, 2015), because the CSP takes on the responsibility of maintaining, upgrading, backing up, and security. SaaS could also shorten the time taken to acquire cloud computing services (Narwal & Sangwan, 2013; Avram, 2014), as many processes will be eliminated, including managerial processes such as approval for purchasing hardware and software as well as technical aspects such as development, deployment and testing.

However, security represents the main concern for many enterprises to adopt SaaS, which includes data location, segregation, access and integrity (Subashini & Kavitha, 2011), as discussed further in section 2.8. The SaaS model provides simple pricing schemes comparing with PaaS and IaaS whereby the cloud consumer only pays per month and/or per user (Al-Roomi et al., 2013). In addition, in some SaaS services cloud consumers could use limited free storage then pay for any extra storage required. In contrast, in the IaaS and PaaS model, cloud consumers are charged for every unit, such as storage, RAM and data transferred (Kansal et al., 2014).

Compared to IaaS and PaaS solutions, adopting SaaS does not require high-level IT skills, but the enterprise has to have security policies and procedures (Subashini & Kavitha, 2011; Seethamraju, 2015), including those related to: classified data, based on its sensitivity (Carroll et al., 2011); identifying employees who have access to the data and who have the privilege to alter, update and delete it (Cloud Security Alliance, 2011); and service level agreements (SLAs) covering elements such as the security policies and procedures that are used to secure client data.

Adopting a SaaS solution requires the user to consider a number of issues. Firstly, due to the lack of a standardized Application Programming Interfaces (API) for SaaS (Baudoin et al., 2014; Di Martino, 2014), it is believed that there are challenges when integrating SaaS applications with cloud based applications or on premise applications (Kolluru & Mantha, 2013), although solutions have been suggested for this (Di Martino et al., 2015). In adopting a SaaS, or in fact any cloud computing solution, the client needs to understand what is involved in accepting and monitoring SLAs. For example, a widely used approach to represent service availability is the concept of the '9s'. A 'three 9s' approach represents guaranteed availability 99.9% of the time, while the 'four 9s' approach provides a different level of availability, as shown in Table 2-1 (Srinivasan, 2014). A cloud computing solution requires users to work with and understand SLAs.

System uptime level (%)	Downtime per day	Downtime per month	Downtime per year
99.999	00:00:00.4	00:00:26	00:05:15
99.99	00:00:08	00:04:22	00:52:35
99.9	00:01:26	00:43:49	08:45:56
99	00:14:23	07:18:17	87:39:29

Table 2-1: Interpretation of system uptime metric(Srinivasan, 2014)

2.4.2 Platform as a Service (PaaS)

PaaS is a development and deployment environment paradigm offered by cloud service providers to allow users to develop and deploy their own applications. In the PaaS model the underlying cloud infrastructure, including operating system, storage and network are managed by a cloud service provider, but the user has control over applications and data (Carroll et al., 2011; Goyal, 2014). PaaS enables the user to follow a full software development life cycle, from planning to deploying the software (Subashini & Kavitha, 2011).

In contrast to SaaS, a PaaS solution needs staff with the IT capabilities to manage the platform that is used to develop and deploy their applications (Srinivasan, 2014). Moving to a PaaS solution requires the client to investigate provider technical capabilities, such as the ability to support multi-tenancy and scalability (Srinivasan, 2014). The client also needs to examine software management issues such as the types of application lifecycle management applications and Application Programming Interfaces supported, and data and application management issues such as programming languages supported and availability of log data (Srinivasan, 2014) . As with SaaS, SLA issues apply with a PaaS solution.

2.4.3 Infrastructure as a Service (IaaS)

IaaS is a computing resources paradigm delivered by a cloud service provider over networks. In this layer users can access computing infrastructure resources such as virtual machine (VM), storage and CPU (Srinivasan et al., 2012). The key advantage of IaaS is that the VM plays the role of server, so the VM actually has the same capability of the server in-house (Erek et al., 2014). As with PaaS and SaaS, users have no control over the physical infrastructure, but with IaaS the user does have control over operating system and storage (Goyal, 2014), which gives it an advantage over SaaS and PaaS in terms of security and control over resources. CSP owns the physical infrastructure and has the responsibility of housing and maintenance (Low et al., 2011).

However, unlike SaaS and PaaS, users of an IaaS solution have to undertake all security aspects, except physical security. IaaS is also a higher cost solution than the other two models (Srinivasan, 2014). Due to the characteristics of VMs, IaaS has a lower risk in terms of vendor lock-in, as discussed further in section 2.8. Therefore, IaaS has more reliability than the PaaS and SaaS in terms of availability and business continuity (Sadiku et al., 2014), although the technical demands are greater. Compared to PaaS, an IaaS solution requires high expertise in IT. This model is therefore more suited to enterprises wishing to keep control of their IT resources (Srinivasan, 2014).

Table 2-2 summarises the differences between the cloud service models discussed in this section from the four perspectives of control of resources security, cost and IT capability to manage them.

	Control of resources	**Responsibility for Security**	**Cost**	**Level of IT skills**
SaaS	No control over resources, but user control of own data	Limited user security choices such as access management	No upfront cost, low cost as long as there is no need to hire IT staff to manage services	Minimal IT skills required
PaaS	User control over data and application	Limited cloud consumer security over data and application	No upfront cost, operational costs include developers.	Need for good IT skills, because PaaS is oriented to developers
IaaS	Full user control over all resources except physical	User responsibility for system security, such as operating system and application	Some upfront cost regarding purchasing VMs and operation costs include hiring staff to manage VMs, and developers	Need for high level IT skills, because IaaS involves managing OS, virtual machine and networks

Table 2-2: Summary of differences between cloud service models

2.5 Cloud Computing Deployment Models

Cloud service models describe the management options for cloud computing services, while cloud deployment models discuss the way in which services are hosted. Although other deployment models such as hybrid cloud and community cloud have also been developed, the two major types of deployment model are public and private cloud (Mell & Grance, 2011).

2.5.1 Public cloud

A public cloud is a cloud computing infrastructure offered by service providers and made available to any organisation or individual, mainly offered over the internet (Balasubramanian & Aramudhan, 2012). These resources are controlled and managed by the service provider located off-site as far as the user is concerned (Carroll et al., 2011). A public cloud offer services at a low cost, with service on demand and high scalability (Carroll et al., 2011).

However, there are several concerns associated with public cloud. Data location represents one of the main issues in the public cloud, as data is stored beyond the enterprise firewall. In addition, to provide high availability and business continuity, the CSP stores data in multiple sites, possibly in different countries, while many countries have established regulations on some types of data or industries that cannot store data outside the country. For instance, the Saudi Arabia Monetary Agency (SAMA) sets rules for the insurance sectors, rule 17 of which emphasises that the company must keep customer’s personal data within the company boundary inside the country (SAMA, 2008). In addition, storing data in locations within different jurisdictions could cause problems for cloud consumers (Cheng & Lai, 2012), and raises questions about which state has jurisdiction over the stored data (Subashini & Kavitha, 2011). Moreover, it is argued that the risk of breach data and unauthorized access concerns many enterprises considering moving to public cloud (Nandgaonkar & Raut, 2014). Public clouds use a multi-tenant approach which could lead to data breaches. In terms of sensitive data, enterprises can use IaaS or PaaS, which offer some control over data and application.

CSPs promise high availability, however the availability on public cloud could be affected by numerous factors. The availability of cloud services depends on the high speed of internet connectivity (Nandgaonkar & Raut, 2014) as well as the internet bandwidth (Carroll et al., 2011; Cloud Industry Forum, 2015). In addition, cloud services could be unavailable due to resources failure (Keahey et al., 2012). One cause of resource failure is limited hardware capacity (Chuob et al., 2011; Chao et al., 2014), especially with local cloud service providers. Another cause of unavailability of the service is external attacks, such as denial of service attacks (DoS) (Cloud Security Alliance, 2011).

Use of a public cloud is regarded as suitable for small and medium enterprises who have limited resources to manage IT resources and are not handling sensitive data (Erek et al., 2014). In addition, a public cloud could be used by large organisations to process or store non-sensitive data (Srinivasan, 2014) or for temporary tasks, as with the New York Times, which used Amazon EC2 to archive 4 TB of data in 36 hours (Street & Chen, 2010; Marston et al., 2011).

2.5.2 Private cloud

A private cloud is a cloud computing infrastructure provided to one organisation; it can exist on or off premises and it may managed by a third party or the organisation itself (Mell & Grance, 2011; Rajan & Jairath, 2011; Goyal, 2014). The major advantage of a private cloud over the traditional in-house system is that the private cloud has a better utilisation of resources (Missbach et al., 2013) and provides elasticity, which enables resources to be made available as required. A private cloud has advantages over a public cloud in terms of security and control over resources (Mell & Grance, 2011; Rajan & Jairath, 2011; Goyal, 2014). However, unlike with public cloud, the private cloud may require substantial capital as well as operational expenditure (Carroll et al., 2011).

It has been claimed that adopting a private cloud inherently cedes some of the advantages of cloud computing (Srinivasan, 2014), especially the economic and organisational benefits discussed in section 2.7. However, private clouds still have the NIST five characteristics of cloud computing discussed in 2.2.Srinivasan (2014) identified four types of private cloud: a private cloud hosted and managed by the enterprise itself; a private cloud hosted within the enterprise but managed by a third party; a private cloud and infrastructure hosted and managed by a CSP whereby the servers are not shared; and a virtual private cloud, which is similar to the hosted private cloud, but the infrastructure is provided in a shared environment. Table 2-3 shows the differences between the types of private cloud from the four dimensions of location, management, security and scalability.

Type	Location	Management	Security	Scalability
Classic private cloud	On-site	Cloud infrastructure managed by enterprise	Provides a high level of security because all resources are managed by enterprise itself	Limited to enterprise IT infrastructure
Managed private cloud	On-site	Cloud infrastructure managed by third party	Provides a high level of security because all resources located on-site, but some security and privacy issues similar to traditional outsourcing	Limited to enterprise IT infrastructure
Hosted private cloud	Off-site	Cloud infrastructure managed by CSP	Privacy issues when data stored off-site	High scalability
Virtual private cloud	Off-site	Cloud infrastructure managed by CSP	Privacy issues when data stored off-site in a multi-tenant environment	Virtual high scalability

Table 2-3: The differences between private cloud types

2.5.3 Hybrid cloud

A hybrid cloud is combination of two or more types of cloud (public, private and community) (Mell & Grance, 2011; Goyal, 2014). The hybrid cloud combines the advantages of cost effectiveness and high scalability of a public cloud with the security advantages of private clouds (Goyal, 2014). There are different scenarios in which the hybrid cloud be used; organisations can benefit from hybrid cloud by keeping critical applications in its own private cloud while moving non-critical applications to a public cloud (Leavitt, 2013). In addition, large enterprise may use hybrid clouds for testing new applications. Hybrid clouds can also be used to manage workload when high demand is predicted, moving work between their private cloud and the public cloud (Leavitt, 2013; Srinivasan, 2014). In this scenario, enterprises need to ensure mobility between the private and public cloud. In this context, mobility has been defined as "the ability to move a live computer workload from one host to another without losing client connections or in-flight state" (Dowell et al., 2011, p. 259).

However, because hybrid cloud integrates different types of cloud, this may lead to security risks (Sturrus & Kulikova, 2014), including security issues concerning how to manage different platforms together (Balasubramanian & Aramudhan, 2012). In addition, portability and interoperability are considered to be major issues in hybrid clouds. Srinivasan, (2014) suggested that enterprises should use IaaS in hybrid cloud to keep the control over infrastructure, to ensure portability between the private and public cloud and to obtain the freedom to move applications between the two different types of cloud.

2.5.4 Community cloud

A community cloud is a cloud computing infrastructure offered to several organisations that have similar interests and requirements (Dillon et al., 2010; Mell & Grance, 2011; Goyal, 2014). A community cloud is suitable for enterprises working in the same sector, such as education and healthcare, which have common regulations and similar requirements and applications (Sangavarapu et al., 2014; Srinivasan, 2014). A community cloud combines the advantages of public clouds in terms of sharing resources between members and the security of a private cloud where the members of the community can focus on their core issue. Community clouds can be managed and controlled by one of these organisations, some of them or a third party (Carroll et al., 2011). This type of cloud provides cloud based services with low cost and provides security and privacy for these organisations (Goyal, 2014). Thus, community cloud may be a good choice for government agencies such as hospitals and universities.

A community cloud can be offered in two models: federated and brokered cloud (Srinivasan, 2014). Federated cloud refers to a network of an aggregated cloud infrastructures are owned by different organisations, which are interconnected and use open standards to provide a shared computing environment (Kertesz et al., 2013; Toosi et al., 2014).

In a community cloud, a federated cloud means that there are private clouds for each member of the community, and they share the resources. Thus, hybrid cloud should ensure the portability and interoperability between clouds. On the other hand, in a broker community cloud, members of community cloud trust cloud service providers to provide IT services to their members.

2.6 Advantages and Issues with Cloud Computing Adoption

The previous sections discussed the technical background to cloud computing, reviewing the definition of cloud computing and cloud service and deployment models. This section discusses the benefits of cloud computing and the issues experienced by enterprises when migrating to the cloud. The complexity of cloud migration is part of the rationale for developing a framework to support the adoption process. Another factor, as discussed in the following sections, is that cloud migration has strategic implications for the entire organisation and is typically a one-off decision which affects the whole of an organisation's IT infrastructure and service delivery.

2.7 Advantages of Cloud Computing

Cloud computing has been described as a new IT delivery model (Gangwar et al., 2015) and as a paradigm shift (Vaquero et al., 2008; Zhang et al., 2013; Srinivasan, 2014). This description of cloud computing as a new paradigm is sometimes questioned on the grounds that some of its characteristics (e.g. virtualisation) date back to the early age of computers (Marston et al., 2011; Zissis & Lekkas, 2012). However, in the early days of computing, these features were available only to large organisations or in mainframes, but cloud computing makes IT resources available for everyone. Therefore, it is argued that cloud computing offers many benefits for both individual and enterprise from different aspects, namely technical, economic, security and organisational. The decision as to whether to move to the cloud has implications for IT services throughout the organisation.

2.7.1 Technical benefits

Cloud computing has been considered as revolution in the way of delivering IT services to enterprises with new and emerging technology (Dillon et al., 2010; Avram, 2014). Cloud computing reshapes existing technology to support business in the following dimensions:

- Improved IT efficiency: scalability represents one of the main features of cloud computing that allows computing resources provisioning and released based on user demand (Carroll et al., 2011; Low et al., 2011; Rajan & Jairath, 2011; Zissis & Lekkas, 2012; Avram, 2014). Scalability can support enterprises which to expand their IT capacity rapidly with a very short lead time. A well-known example of scalability is Instagram, a start-up company that reached 100 million users in just two years (Kavis, 2014), which would be very difficult to achieve without using cloud based technology.
- Better IT utilisation: Marston et al. (2011) pointed out that only 10-30% of data centres' computer power is used in off-peak, while features of cloud computing such as virtualisation and pool resources could provide a better utilisation of IT resources. This is because the cloud environment provides a shared space in which resources are provisioned and released in respect to consumer needs.
- Accessibility: cloud computing is location independent (Mell & Grance, 2011), allowing users access anywhere, anytime, subject to an internet connection. In addition, in a cloud environment all computation operations will be performed in cloud, so the user can access from any device through web browser or other thin client interfaces (Cheng & Lai, 2012; Zissis & Lekkas, 2012). Thus, cloud computing offers more mobility to users, enabling them to access computing resources anytime, anywhere and on any devices.

- Faster access to IT resources: cloud environments could offer faster access to a variety of hardware and software with no or minimum upfront cost in public clouds (Dillon et al., 2010), while in the private cloud enterprise incur an upfront cost.
- Innovation: cloud computing represents a change in the way IT services are provisioned. It has been argued that as a consequences of this, rather than focusing on the management of physical resources, IT staff will be freed up to focus on application and service development, encouraging greater innovation (Praveena & Rangarajan, 2014).
- Green IT: many countries set regulations to make data centres more sustainable, such as the Carbon Reduction commitment in the UK and the EU Energy Using Products Directive (Sultan, 2014). Cloud computing environments can provide a greener environment (Sultan & van de Bunt-Kokhuis, 2012) because they enable multiple users to share common resources, provided according to users' needs, and many data centres can be consolidated into one, reducing the energy required for computing power and cooling (Nandgaonkar & Raut, 2014).

2.7.2 Economic benefits

One of the main reasons for enterprises to move to cloud computing is the associated economic benefits. While the cost of getting reliable IT services is a barrier to many small and medium enterprises in traditional IT environments (Avram, 2014), cloud computing may offer IT services at a reasonable cost. There are several economic benefits that can be obtained when adopting cloud computing.

Moving to cloud could reduces the costs of using IT services because the operating and maintenance costs of underlying infrastructure might be moved to CSP in public clouds

(Amini et al., 2013), while some operational costs remain in enterprise in PaaS and SaaS (as discussed previously). Secondly, enterprises using a private cloud could benefit from cloud computing by consolidating servers or data centres (Hung et al., 2011; Himmel & Grossman, 2014), which will be reflected in saving on the costs of energy consumption, cooling and floor space (Carroll et al., 2011). Thirdly, it is argued that public and hybrid cloud offer opportunities to transfer capital expenses (Capex) to operating expenses (Opex) (Andrikopoulos et al., 2013). As a consequence of transferring Capex to Opex, enterprise will pay the cost of IT services in the same manner as they pay for utility services such as water and electricity (Cheng & Lai, 2012; Avram, 2014) this reduces financial costs and limitations. IT departments in many firms are considered to be cost centres rather than profit ones (Avison et al., 2004). Cloud computing can add value to enterprises by using cloud based services at lower cost, allowing enterprise to increase return on investment (ROI) in a short period (Gong et al., 2010; Avram, 2014). In addition, there is scope for large enterprises which have migrated their traditional IT systems to a private cloud to optimise existing IT infrastructure (Mithani et al., 2010) and sell the extra capacity (Goiri et al., 2010).

2.7.3 Security benefits

Security has been identified as a key consideration when moving to a cloud solution (Carroll et al., 2011; Zissis & Lekkas, 2012 Hashizume et al., 2013; Avram, 2014; Gonzenbach et al., 2014). However, it has been argued that moving to cloud computing may in fact improve enterprise security (Carroll et al., 2011; Zissis & Lekkas, 2012), as CSPs can offer:

- Better IT capability: it is believed that building a secure IT environment for some small and medium enterprises could be beyond their budgetary capabilities due to the prohibitive cost of IT expertise as well as computing resources (Kshetri, 2010). In contrast, larger scale cloud computing services make security implementation cheaper in terms of IT resources (hardware and software) and employment of expert staff to manage cloud infrastructure security comparing with single entity (Khajeh-Hosseini et al., 2010b).

- Backup and disaster recovery: data in a cloud environment is typically in multiple sites, which minimises the risk of lost data (Khajeh-Hosseini et al., 2011; Zissis & Lekkas, 2012; Gupta et al., 2013). Therefore, cloud can offer better backup and disaster recovery services.

2.7.4 Organisational benefits

Public cloud and outsourcing share the same concept of contracting IT services to third parties to focus on other areas of operation, but they are different in some features (Dhar, 2012). One advantage shared by both outsourcing and cloud computing is that, depending on the service model chosen, moving to the cloud allows the organisation to focus on core competency. In terms of public cloud, cloud consumers may move managing physical infrastructure to CSP with PaaS and SaaS model, whereas in SaaS managing all IT operations will be moved to CSP. Similarly, in hybrid cloud, cloud consumer will move part of IT operations to CSP.

In addition, cloud computing architecture supports the autonomic provisioning and releasing of computing resources without human interactions (Zhang et al., 2010; Jajodia et al., 2014). This could lead to allocating computing resources in a short time to provide developed applications and services (Yang, 2011). Finally, it is argued that adopting public or hybrid cloud could minimise the risks of managing IT resources by moving the risk of managing IT resources (e.g. in upgrading, updating, backup and uptime) to the cloud service providers and making resource available rabidly

2.8 Issues with Cloud Computing Adoption

Cloud computing represents a paradigm shift in how to manage information technology services within enterprises. The degree of risk associated with this shift depends on the nature of the change and the cloud computing model adopted, which varies between enterprises (Madria & Sen, 2015). Thus, the risks of adopting cloud computing vary between low risk with the incremental change, and high with radical change (Baker, 2012). We discuss the risks of cloud computing under five areas identified from previous literature: technical, economic, security, organisational (strategy) and regulatory risks.

2.8.1 Technical risks

There are several technologies which underpin cloud computing, such as virtualisation and multi-tenancy. Virtualisation is defined as an abstraction of computing resources to be made available as multiple isolated virtual machines (Takabi et al., 2010). The computing resources include hardware, OS, network and storage. Multi-tenant refers to the ability of multiple users in a cloud environment to use the same IT resources (Mahmood & Hill, 2011). Thus, as virtualisation and multi-tenant provide a shared environment, this includes sharing CPU, network, storage and memory. Risks which have been identified in this include possible data breaches and unauthorised access (Lombardi & Di Pietro, 2011; Mouratidis et al., 2013; Himmel & Grossman, 2014) although it should be noted that strategies such as separate data pipes are widely used to reduce the risk.

2.8.1.1 *Integration of existing IT infrastructure*

Existing IT infrastructure, particularly in large enterprises, could represent a barrier to adopting cloud computing, as legacy architectures and the complexity of existing systems can make migration to cloud more difficult and costly (Parakala & Udhas, 2011). Cloud computing adoption is typically a decision which will impact on the entire IT structure of an organisation. In addition, migrating existing IT infrastructure to cloud environment brings with it associated uncertainty and risks (Phaphoom et al., 2015). The migration complexity of existing IT infrastructure centres around legacy hardware that cannot be integrated with cloud technology or which is otherwise incompatible with the cloud requirements (Alkhater et al., 2014). Complex and legacy applications may need to be redesigned for a cloud environment to take advantage of cloud computing features such as scalability and multi-tenancy.

2.8.1.2 *Portability and interoperability*

Portability refers to the ability to move data/application from desktop to cloud or from cloud to cloud (Dowell et al., 2011; Chang et al., 2013b; Rafique et al., 2014). In this context, interoperability has been defined as the ability of a program to work with more than one CSP simultaneously (Avram, 2014). However, Di Martino et al. (2015) argue that cloud portability and interoperability cannot be summed up in a single definition. They identify three categories of portability, data portability, system portability and application portability, and also identify three categories of interoperability, service interoperability, application interoperability and platform interoperability.

Data portability refers to the ability of cloud users to move or copy data to/from different cloud platforms. System portability refers to possibility of moving VMs, applications or cloud services and their dependent components from one CSP to another (Di Martino et al., 2015). However, da Silva et al. (2013) distinguished between the portability of virtual machines and the portability of applications in the context of IaaS, as they have different issues. Application portability refers to the ability of migrating or reusing applications, or some of their classes between cloud platforms or between cloud and on-site.

Service interoperability refers to the ability of cloud users to use cloud services among different cloud platforms. Application interoperability refers to the scope for collaboration between different applications across different cloud platforms. Platform interoperability refers to the ability of platform components to interoperate (Di Martino et al., 2015).

Therefore, the issues of portability and interoperability vary depending on the cloud computing layer. In SaaS, where the application code and data format are managed by CSP and the user has no control over resources, which could lead to vendor lock-in, this would have long-term implications for the organisation. Therefore, the cloud user should take into account data portability when considering adopting SaaS. In the PaaS level, the service provider may support specific APIs which make migration to another CSP difficult and costly if the CSP does not support the same APIs (da Silva et al., 2013). In the IaaS level, there are two cases; in the first instance, cloud users have control over the virtual machine and can migrate VM from CSP to another CSP, but they should support the same format. In the second, the user has no control over the VM, but CSP provides a hosting plan that users can build and deploy.

2.8.1.3 *Reliability and performance*

Cloud computing characteristics such as elasticity and accessibility promise to provide a reliable service with high performance. However, according to a recent study, reliability and performance were considered the third major risk of adopting cloud computing (55%) after security and integration with existing infrastructure, 63% and 57% respectively (Phaphoom et al., 2015). The main critical issue for reliability is how to deliver the XaaS (IaaS, PaaS and SaaS) to clients in the case of network disconnection (Avram, 2014). Therefore, high reliability is understood as the ability of the system to be available under any conditions (Rahimli, 2013). In addition, cloud computing promises to provide better performance (Carroll et al., 2011), but this is affected by some external factors such as network connectivity and internal factors within the CSP, such as hardware capacity, memory CPU cycle and database size (Chao et al., 2014; Das et al., 2015) .

2.8.2 Economic risks

The perceived cost efficiency of cloud computing is the fundamental rationale for moving to the cloud environment for most enterprises who do so (Carroll et al., 2011; Srinivasan, 2014). However, there are many factors that need to be taken into account when deciding to migrate to cloud, and some associated risks.

2.8.2.1 *Hidden costs*

According to Research in Action (2013), 79% of companies have concerns about hidden costs when they migrate their applications to a cloud environment. However, among the three types of cloud computing, the SaaS model is regarded as having fewer hidden costs. This is because CSP takes the responsibility of associated costs and risks such as those pertaining to data backup, recovery and upgrading. SaaS costs are identified upfront, and the only risk factor is that the CSP could change prices after subscribers or users need to change providers, or actual usage exceeds predicted consumption, resulting in higher charges. For example, the CSP may set a fixed storage limit and the client then has to pay for extra storage. The cloud provider SalesForce.com, for instance, gives 2 GB for file storage for each user in the enterprise edition, then applies extra charges for additional data usage. As a further example, Microsoft Dynamics CRM provides 5 GB for each subscription (Microsoft, 2016). The amount of storage and the charges for additional data usage vary between providers and contract types, and are one of the issues to be considered as part of service level agreements. In PaaS and IaaS, the user needs to consider additional costs including backup, disaster recovery (Srinivasan, 2014), security control and the costs related to controlling resources. In addition, the cloud user needs to estimate the expected cost of transferred inbound/outbound data in terms of IaaS and PaaS. There are a number of different pricing models, as discussed previously. For IaaS and PaaS, some CSPs charge for every unit such as storage, CPU and network.

Consequently, to mitigate the risk of uncontrolled costs the CSP should provide a clear and transparent SLA that shows all anticipated expenses. In addition, cloud consumers should estimate the actual costs of using cloud services by using cost estimation tools (Khajeh-Hosseini et al., 2011). The estimation of hidden costs could help enterprises to allocate resources, including budgetary ones, when deciding to use cloud services.

2.8.2.2 *Migration costs*

Although cloud computing is usually associated with no or minimal upfront costs, enterprises with a large IT infrastructure could face some challenges when migrating their IT services to the cloud environment, although this risk is lower with an SaaS or PaaS solution. One of these challenges is the lack of financial resources to adopt new innovation (Phaphoom et al., 2015). The migration costs include replacing the existing hardware that is incompatible with cloud technology, recoding the legacy applications to work with the cloud and providing training for IT staff to enable them to deal with cloud technology (Akande et al., 2013).

Moreover, the integration of complex systems with cloud computing services could lead to high costs (Khajeh-Hosseini et al., 2011). Consequently, cloud consumers need to assess the existing IT infrastructure before moving to cloud. This assessment includes the extent to which the existing hardware is compatible with the cloud solution, the effort required for the code modification and the cost needed (Minkiewicz, 2014). In addition, budgeting for the assessment of staff knowledge and experiments to work with the cloud environment are required, along with training costs if needed.

2.8.3 Security risks

Security represents the highest risk in the cloud computing environment, and the main barrier to cloud adoption, as identified by surveys (Carroll et al., 2011; Chao et al., 2014). We discuss security issues using the confidentiality, integrity and availability (CIA) triad model (Peltier, 2013).

2.8.3.1 *Confidentiality*

Confidentiality is defined as the ability to keep data available for authorised access only (Cheung, 2014). In the cloud computing environment, data stored beyond the company firewall is threated by unauthorised access, thus data privacy in cloud computing is a big issue (Takabi et al., 2010; Wei et al., 2014). Data breaches could lead to loss of reputation, brand damage and loss of customers etc. This brings a dual responsibility in that enterprises should set policies and procedures that ensure the privacy of their data, while the CSP should maintain the safety of data, and convince users that their data is secure and protected. Himmel & Grossman (2014) interviewed 68 cloud and security experts, all of whom claimed that the human factors are the most significant issues affecting confidentiality of data in the cloud computing environment. However, human factors or insider attacks threaten the traditional IT environment, and are not particular to cloud computing.

2.8.3.2 *Integrity*

Integrity refers to the protection of data from unauthorised change and alteration. There are two issues related to storing data in cloud in terms of integrity: the unauthorised access to and alteration of data in the storage cloud; and alterations to data through what is known as a Man in the Middle attack when data is intercepted when it travels between the users and the CSP. This is a risk for any network traffic and is not exclusive to cloud computing.

2.8.3.3 *Availability*

Due to the nature of cloud where data/services accessed via the internet/network. The availability in cloud computing relates to ubiquitous access to data and applications for authorised users anytime, anywhere, on any devices. Availability is a major concern due to the nature of cloud computing, whereby all services are made available mainly over the internet (Akande et al., 2013), which renders connectivity a major issue particularly with public and hybrid cloud (Avram, 2014). In addition, enterprises rely on CSPs to store their data, backup and restore, which exposes them to high risk of losing data if the CSP goes out of business or is affected by natural disasters . (Carroll et al., 2011). Moreover, because cloud computing is a shared resource environment where huge data and applications are hosted in a cloud, it is prone to attacks such as denial of service (DoS) attack.

2.8.4 Organisational risks

Migrating to the cloud also presents organisational risks. Dahbur et al. (2011) identified possible threats to business reputation because the CSP could provide a low level of service, data could be breached to competitors or the CSP could be terminated or acquired. In addition, as cloud computing changes the way of provisioning IT services, enterprises have to expect a major change in their IT strategy, including IT architecture, data strategy, IT management and IT/ business alignment (Palvia, 2013). Consequently, the IT roles and responsibilities will change, requiring a new skills set and training, which has resource implications for organisational strategy.

Changes to IT strategy and IT roles impact on IT staff in different aspects. Adopting cloud computing changes the IT roles from resources management to cloud provisioning (Adel et al., 2013). Therefore, many roles will be cancelled and replaced with a new roles and responsibilities. Adopting cloud computing could downsize IT departments, which could lead to a lack of job security and reduce staff morale throughout the organisation (Khajeh-Hosseini et al., 2011; Morgan & Conboy, 2012; Akande et al., 2013).

2.8.5 Regulatory risks

Regulatory risks are understood as the legal problems related to data that has been stored or processed across multiple countries that have different jurisdictions (Dahbur et al., 2011). As discussed previously, one of the advantages of cloud computing is that it provides affordable access to computing resources, partly by using computing resources in countries that provide IT services at low cost. However, this advantage is inconsistent with regulation in some countries and sectors. For example, as a consequence of the USA Patriot Act, the Canadian government has been asked not to use computing resources located within the US (Avram, 2014). Another key issue is that some industry sectors emphasise that enterprises working within their environment should comply with their regulations, such as the Health Insurance Portability and Accountability Act (HIPAA) in US for health care and the Payment card Industry Data Security Standard (PCI-DSS) for the financial sector (Himmel & Grossman, 2014).

The following table summarises the likelihood of the risks in terms of cloud deployment models and cloud service models. Scalability in the public cloud is very high compared with the private and hybrid cloud, while in the cloud service model, the scalability is very high in IaaS in public cloud environment, whereas in the private cloud it is limited to the enterprises resources. Scalability in the virtual private cloud depends on the service contract.

	Public cloud			**Private cloud**			**Hybrid cloud**		
	IaaS	**PaaS**	**SaaS**	**IaaS**	**PaaS**	**SaaS**	**IaaS**	**PaaS**	**SaaS**
Data privacy	M	M	L	VH	VH	H	H	M	M
Control over resources	H	M	L	VH	VH	H	H	H	M
Capability to manage the services	VH	H	L	VH	VH	H	VH	H	M
short lead time	H	H	VH	M	M	H	H	H	H
Cost	M	M	L	VH	H	H	H	H	M
Scalability	VH	VH	H	M	M	M	H	H	M
Performance	H	H	M	H	H	M	VH	VH	M
Availability	H	H	H	H	H	H	VH	VH	H
Interoperability and portability	VH	H	M	H	M	M	H	H	M
Risk: VH is very high, H is high, M is medium, L is low.									

Table 2-4: Summary of issues related to cloud deployment models and cloud service models

2.9 Existing Cloud Computing Adoption Frameworks and Models

The previous sections discussed the technical context of cloud computing and the advantages and issues presented by cloud computing adoption. The complexity of the problem and the fact that this is a strategic issue which has far reaching implications for organisations means that there have been a number of attempts to develop cloud computing migration/adoption framework and models. This section discusses these existing cloud migration/adoption frameworks and models and the strengths and limitations of the different approaches under the headings of risk and benefit analysis, decision support, application migration, factors which affect cloud adoption and assessment of organisational readiness.

One general limitation of existing approaches is that while there are a number of studies of cloud computing adoption in developed countries, there are very few studies on cloud adoption in technologically developing countries such as Saudi Arabia. Yates et al (2011) distinguish between technologically developing and developed countries by measuring the diffusion of broadband internet in the country. However, this study will consider technology diffusion in general as a criteria to classify the developed and developing countries in terms of technology. Alharbi (2012) studied user acceptance of cloud computing based on the user acceptance model in Saudi Arabia. One of the limitations of this study is that it is focused on the acceptance of cloud computing at the level of the individual, rather than the organisation, and only one group of users is considered. We view the Alharbi study more as an examination of technology acceptance than as a study of examine cloud adoption issues.

A more recent study examined the factors that affect cloud adoption in higher education institutions in Saudi Arabia (Tashkandi & Al-Jabri, 2015). This study concluded that relative advantage is the main reason to move to cloud computing. In contrast, security and technical issues, including internet connection, concerns the higher education institutions in Saudi Arabia. This study was limited to the higher education sector in Saudi Arabia. Another study conducted in Malaysia by Abolfazli et al. (2015) found that data security and privacy, regulation and lack of competence and knowledge about cloud computing were the main challenges to cloud adoption in Malaysia. We have established that the migration frameworks discussed in this section of the literature review do not address the issue of whether the factors which affect cloud migration may differ between technologically developed and technologically developing countries. Lian, Yen & Wang (2014) investigated the factors that affect adoption cloud migration in hospital industry in Taiwan. They found that the most important factors in the adoption of cloud computing are technological, followed by human and organisational. This study was limited to the hospital sector in Taiwan, which makes it difficult to generalise to other industries.

2.9.1 Risk and Benefit Analysis

Migrating services and systems to the cloud has business as well as technological implications (Raj & Periasamy, 2011; Gonzenbach et al., 2014a). One of the factors restricting the growth of cloud computing is the issue involved in migrating existing systems to the cloud model (Chao et al., 2014). Research on adoption to cloud provision has tended to be based in four main areas: the decision making stage, including analysis of benefits and risks; identification of factors that affect cloud adoption processes; solutions for specific cloud infrastructure and/or applications; and evaluations of the migration process and assessment of cloud computing maturity based on case studies, although as noted above, these case studies are usually limited to technologically developed environments.

Cost, benefits and risk analysis of cloud adoption for a single service model were discussed by numerous studies, but they only focused on cost and risk analysis, and did not discuss how deployment and service models should be selected and how to do the actual migration (Khajeh-Hosseini et al., 2011; Yam et al., 2011; Johnson & Qu, 2012; Khajeh-Hosseini et al., 2012; Martens & Teuteberg, 2012; Azeemi et al., 2013; Madria & Sen, 2015). Khajeh-Hosseini et al. (2012b) proposed a cloud adoption toolkit which supported cloud adoption decision by analysing the cost and risks against a number of categories which included stakeholder impact analysis and technology suitability analysis.

2.9.2 Decision Support

Decision making for cloud computing migration was investigated by a number of studies (Song, 2013; Alkhalil et al., 2014; Andrikopoulos et al., 2014; Rehman et al., 2015). However, these studies share a limitation in that they focus on developing decision making tools to support application migration and consider technical and cost aspects only, and they did not discuss organisational and strategic issues. Latif et al. (2014) presented a systematic review of cloud computing risks from a cloud service perspective as well as client perspective, and in the same context Hashizume et al. (2013) highlighted the main issues related to cloud security, although neither study considers all aspects of the cloud migration problem.

There has been a limited evaluation of cloud migration. Some empirical studies identified cloud adoption factors (Khajeh-Hosseini et al., 2010; Alshamaila et al., 2013; Carcary et al., 2013; Chang et al., 2013; Lian et al., 2014) . There have also been a number of industry and vendor studies, however these tend to be vendor specific, as with the Amazon migration strategy, which is built around the Amazon Web Services (AWS) platform (Varia, 2010), or else consider only a subset of issues (Parakala & Udhas, 2011).

2.9.3 Application Migration

In addition to models focused on business issues, there are approaches that consider cloud adoption from an application perspective. The literature shows that several studies propose a migration framework (Binz et al., 2011; Meng et al., 2011; Tran et al., 2011a, 2011b; Menzel & Ranjan, 2012; Alonso et al., 2013; Wang et al., 2013). The key problem with these studies is they focus only on migrating applications without taking into account other factors such as organisational issues. In addition, Feuerlicht & Thai Tran (2015) and Mehfuz & Sahoo (2012) developed approaches to manage migrating applications to cloud environment. These approaches involved five phases, based on the software development life cycle (SDLC). Likewise, Márquez et al. (2015) developed a framework to migrate corporate legacy systems to cloud environments via four phases: analysis, design, deployment and evaluation. The limitation of this framework is that it considered legacy systems only.

Cloud migration has also been studied from the perspective of choice of deployment model perspective and CSPs. Nussbaumer & Liu (2013) proposed a cloud migration framework to analyse business requirements and select cloud service providers. Similarly, Junior et al. (2015) and Kaisler et al. (2012) developed a framework to support cloud migration decision making to find out which cloud solution can match business requirements. In the same context, Hao et al., (2009) developed a cost based framework to facilitate service selection and migration. These frameworks tend to focus on only some of the relevant issues, which are technical and economic, and they do not provide objective criteria for strategic decision makers.

2.9.4 Factors in Cloud Migration

A number of studies have attempted to identify factors affecting cloud migration. Gonzenbach, Russ & Brocke (2014) identified a set of criteria which should be considered when organisations are deciding whether to move data to a cloud environment, but their study was limited to data only and did not consider other aspects of the system. Rong, Nguyen & Jaatun (2013) highlighted the security challenges that restrict cloud computing adoption, but focused only on security and did not consider other inhibiting factors.

2.9.5 Assessment of Organisational Readiness

Evaluating organisational readiness to move to the cloud is an active research area. Kauffman et al. (2014) developed a metric to assess enterprise readiness to adopt cloud computing that considers four dimensions: technology and performance, regulation and environment, organisation and strategy, economic and valuation. However, their metric does not address migration approaches and strategies. In the same context, maturity models based on the Capability Maturity Model have been developed to assess organisational readiness to move to the cloud (Alonso et al., 2013; Sheet et al., 2013; Soni et al., 2014), but again these models did not consider migration approaches and strategies. From an industry aspect, Oracle developed a cloud maturity model based on two dimensions, technology and organisational (Mattoon et al., 2011). Similarly, the International Data Corporation (IDC) proposed a cloud maturity model based on five stages: ad hoc, opportunistic, repeatable, managed and optimised (Knickle et al., 2013). In the context of migrating applications to the cloud, Corradini et al., (2015) developed a metric to assess legacy applications before migration. However, there is no such model to assess the maturity of CSPs, which is an important factor for cloud migration decision makers.

At the strategic level, Brandis, Dzombeta, & Haufe (2014) designed a framework to address the challenges of cloud governance. Palvia (2013) reviewed the impact of e-cloud computing on organisational IT strategy, while Adel, Reza & David (2013) identified the impact on IT management roles and data security.

The studies discussed in this literature review have a number of limitations. The models and frameworks tend to focus on only one or two aspects of cloud migration which are cost and risks, and do not consider all the issues. Approaches that support the migration of applications to the cloud provide guidance on some aspects but do not consider some or all of the organisational, security and economic factors. The factors which influence cloud computing adoption have been investigated in a number of studies but these studies do not provide a systematic strategy for translating these factors into decision making and/or the factors considered are not complete. The variety of cloud adoption frameworks and models pertaining to different decision making levels emphasises the need for an integrated, strategic approach to manage the cloud migration process from the different point of views of all decision making levels.

The review has identified that although there are numerous studies which consider different aspects of the cloud migration process in detail, a comprehensive, holistic framework to support decision making for cloud adoption has not been identified from the literature.

2.10 Conclusion

This chapter reviewed the literature related to cloud computing. We considered the technical context of cloud computing, the benefits and issues of cloud computing migration and critically reviewed existing cloud adoption frameworks and approaches. Existing cloud migration approaches were discussed under the headings of risk and benefit analysis, decision support, application migration, factors which affect cloud migration and assessment of organisational readiness. The discussion showed that although there is an extensive literature on cloud computing migration, a comprehensive, holistic decision support framework for cloud computing adoption does not currently exist. The following chapter discusses knowledge management, learning organisations, organisational learning and decision making as the theoretical underpinning of this research.

Chapter 3: Theoretical Foundations of the Framework

3.1 Introduction

In the previous chapter we discussed the technical background of cloud computing, identified the related risks and advantages of use cloud computing, and existing approaches and frameworks to manage cloud adoption. This chapter discusses concepts from the field of knowledge management (KM), including theories on technology adoption, which inform the KM based framework developed as part of this research. We discuss what is meant by knowledge in this context, the ways in which knowledge can be used to improve decision making, the different types and levels of decision making and the importance of organisational factors in decision making. We discuss techniques used to support decision making such as the use of models and frameworks and explain how the elements discussed in this chapter are relevant to support for decision making about cloud. We provide a visual summary of the elements which influence cloud computing adoption decision making.

As part of the theoretical underpinnings for this research we also discuss the Technology-Organisation-Environment (TOE) and Diffusion of Innovation (DOI) theories and from these theories and the literature review discussed in chapter 2, we develop a number of hypotheses about the factors that influence cloud computing adoption that provide the underpinning for primary research discussed in chapter five.

3.2 Knowledge Management Background

Decision making in management literature prior to 1988 does not take into account the approach now known as knowledge management, although decision making was later seen as a knowledge-intensive activity (Holsapple, 1995; Zhong, 2008). Holsapple (1995) defined decision making as a process of selecting one of different alternatives, and Yim et al. (2004) proposed that decision making can be improved through the use of KM. The efficiency and effectiveness of decision making are affected by the availability of knowledge (Holsapple, 1995; Giebels et al., 2015), and it has been argued that without input from knowledge, decisions are sub-optimal (Yim et al., 2004). Rowley & Gibbs (2008) argue that knowledge and learning are required to support organisations making decisions in uncertain environments. Thus, this study takes into account KM and related concepts, including organisational learning and the learning organisation to support the cloud adoption decision process.

KM is a developing discipline and current KM research builds on the work done in the last two decades to define key concepts. Knowledge is increasingly regarded as a strategic resource (Bollinger & Smith, 2001), meaning that many enterprises have become more knowledge-focused in managerial practices such as decision making and strategic planning. It has been argued that organisations need to develop mechanisms to exploit knowledge in order to remain competitive and meet business challenges (Bollinger & Smith, 2001; Alhawari et al., 2012). The KM literature shows that most authors distinguish between knowledge and information, and we clarify these concepts here.

Information is defined as data processed to give meaningful content (Zack, 1999; Kakabadse et al., 2003). In contrast, knowledge is defined as an interpretation of information (Karadsheh, 2009). Bollinger & Smith (2001) extended Karadsheh's definition, to include experiences, skills and competencies as well as information. It has been argued that knowledge can be defined as the result of merging information with experience, practice, perspective and interpretation (Tippins & Sohi, 2003; Alhawari et al., 2012).

Although KM is viewed as having a significant role in competitiveness and innovation within organisations (Hsu & Sabherwal, 2012), there is no consensus on its precise definition. One definition is that KM is an organised and systematic process for capturing, organising, and delivering staff's knowledge so that enterprise can share this knowledge to make staff more productive and effective in their work (Alavi & Leidner, 1999). This definition dates back to the first phase of research in the KM field and focuses on knowledge that is being used for day-to-day work, whereas knowledge is now understood to be used for different purposes such as planning, enhanced performance and decision-making.

A later definition defines KM as a systematic approach to capture, document and apply knowledge to add value to enterprises in order to achieve their goals and objectives (Holsapple & Joshi, 2004). This definition understands KM in terms of the overall organisational goals. In the same context, Dalkir (2005) defined KM as a process of collecting, organising, managing and disseminating knowledge within an enterprise to.

The definitions of Holsapple & Joshi (2004) and Dalkir (2005) concur in that KM can be used to help organisations to achieve their objectives, however the former emphasises the way in which knowledge adds value to an organisation, while the latter extends this to describe the knowledge life cycle. Moreover, the Dalkir definition understands KM in terms of enhancing organisational enhance quality of work and reduce the time taken, utilise best practices and reduce costs by apply the lessons learnt from project to project performance, organisational learning and project management. The aim of the thesis is to support decision making for cloud adoption, and for this reason we explore what is meant by knowledge in the context of an organisation and organisational decision making.

3.3 Categories of Knowledge

3.3.1 Tacit and explicit knowledge

Knowledge may be classified as explicit or tacit; this classification is so well understood that the terms are sometimes used without definition (Spulber, 2012), although an understanding of the concepts is necessary to support a KM based approach. This thesis uses the accepted definitions of explicit and tacit knowledge developed by Hahn & Subramani (2000), thus tacit knowledge is defined as knowledge that resides in the personal mind, such as skills and experience, which makes it hard to articulate, document and transfer; and explicit knowledge is that which can be extracted and documented and shared with enterprise staff (Hahn & Subramani, 1999).

Tacit knowledge can be captured from individuals through their expertise, beliefs, values and behaviours. In contrast, explicit knowledge can be extracted from codified sources, such as documents, databases and other media such as video. Tsoukas (2005) argues that tacit knowledge cannot be captured, converted or translated, but it can be displayed and learnt through social interaction or via media. In contrast, Nonaka (2007) suggested that tacit knowledge can be articulated and made explicit through a process of knowledge conversion. Nonaka (2007) identifies four modes of knowledge conversion, as shown in Figure 3-1.

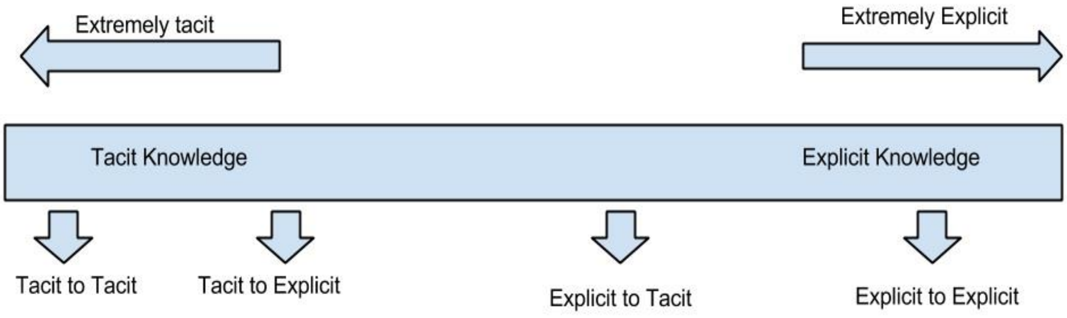


Figure 3-1: Knowledge types model

The four modes of knowledge conversion are: socialisation, which converts tacit knowledge to new tacit knowledge; combination, which refers to creating new explicit knowledge from explicit knowledge; externalisation, which refers to converting tacit knowledge to explicit knowledge; and internalisation, which converts explicit knowledge to tacit knowledge. Therefore, tacit knowledge can be classified into two classes: knowledge that can be captured and converted to explicit knowledge, and knowledge that cannot be articulated, which only can be converted from tacit to tacit.

The importance of tacit and explicit knowledge is recognised in a wide range of organisations (Ferlie et al., 2012; Hau et al., 2012; Nonaka et al., 2014). It is also acknowledged that there are particular difficulties working with and utilising tacit knowledge (Haldin-Herrgard & Tua, 2000; Ryan & O'Connor, 2013). One of the aims of KM is to bring together these two aspects of knowledge. Haldin-Herrgard & Tua (2000) claim that tacit knowledge is mostly stored in the human mind, so it is hard to manage and teach. To obtain the best utilisation of tacit knowledge it should be given in direct interaction, such as face to face, rendering it costly to manage in terms of time and resources. Perception and language are considered as the main difficulties of sharing tacit knowledge (Haldin-Herrgard & Tua, 2000). Tacit knowledge can present difficulties because the knowledge may be held in a non-verbal form (Haldin-Herrgard & Tua, 2000). Thus people are generally unaware even of their own tacit knowledge, because it becomes an instinctual and intuitive part of their way of thinking.

Nevertheless, a considerable amount of literature has proposed several approaches to capture and transfer tacit knowledge. Razmerita & Phillips-Wren (2016) argued that social networks such as enterprise social network (ESN) could help transfer tacit knowledge at low cost. Lu & Yang (2015) suggested a job rotation approach to transfer tacit knowledge within enterprises. Similarly, Noh et al. (2000) proposed a hybrid approach by using a cognitive map (CM) to represent tacit knowledge and the cased based reasoning (CBR) for the storage of knowledge represented by CM. In addition, Cheng & Jiang (2008) developed a knowledge interactive platform to share tacit knowledge to support decision making within enterprises. Moreover, artificial intelligence (AI) has been used to transfer tacit knowledge to explicit knowledge (Wieneke & Phlypo-Price, 2010). One of the challenges of this research is to work with tacit and explicit knowledge to support decision making for cloud adoption.

3.3.2 Descriptive, procedural and reasoning knowledge

Knowledge is also classified into categories and described as descriptive knowledge, procedural knowledge and reasoning knowledge (Holsapple & Joshi, 2000; Burstein & Holsapple, 2008).

Descriptive knowledge, also called declarative knowledge, characterizes the state of something (Zack, 1999; Burstein & Holsapple, 2008). Descriptive knowledge can provide an understanding of object, concept and state of a particular situation. Thus, it can be described by the term 'know-what'. Know-what can be acquired from both internal and external resources (Burstein & Hosapple, 2008). Kyoratungye et al. (2009)

argued that know-what is the explicit knowledge that can be captured and documented. Know-what can be understood as explicit knowledge used to help provide solutions.

Procedural knowledge is defined as how something occurred or was performed, or how to do something (Zack, 1999). Procedural knowledge consists of a series of steps to implement various tasks, such as strategies and action plans (Burstein & Holsapple, 2008). As shown in the conceptualising knowledge model presented in Figure 3-2, procedural knowledge can be expressed by know-how. Haldin-Herrgard & Tua (2000) suggested that 'know-how' can be understood as the tacit knowledge which uses the 'know-what'. It is also argued that 'know-how' is technical knowledge (Attewell, 1992; Kyoratungye et al., 2009), which is used to facilitate the implementation of new technology (Vandaie, 2008; Khajeh-Hosseini et al., 2012) but which can also be a potential barrier to the adoption of new technology. Attewell (1992) said that procedural knowledge/ know-how can be influenced by lessons learnt, organisational culture and experience.

The third element in the knowledge taxonomy is reasoning knowledge, which is defined as "what conclusion can be drawn when a certain situation exists" (Holsapple, 1995, p. 17). In contrast, Zack (1999) called reasoning knowledge causal knowledge, which he defined as knowledge of why something occurs. Causal knowledge can support organisations to coordinate strategy for achieving a goal (Zack, 1999). Reasoning knowledge is know-why, such as cause-and-effect principles, correlations and heuristics (Holsapple & Joshi, 2002). King, (2009) claimed that the know-why is the highest level of knowledge because it concerns the deep understanding of the relationship between the interrelated factors of the phenomenon.

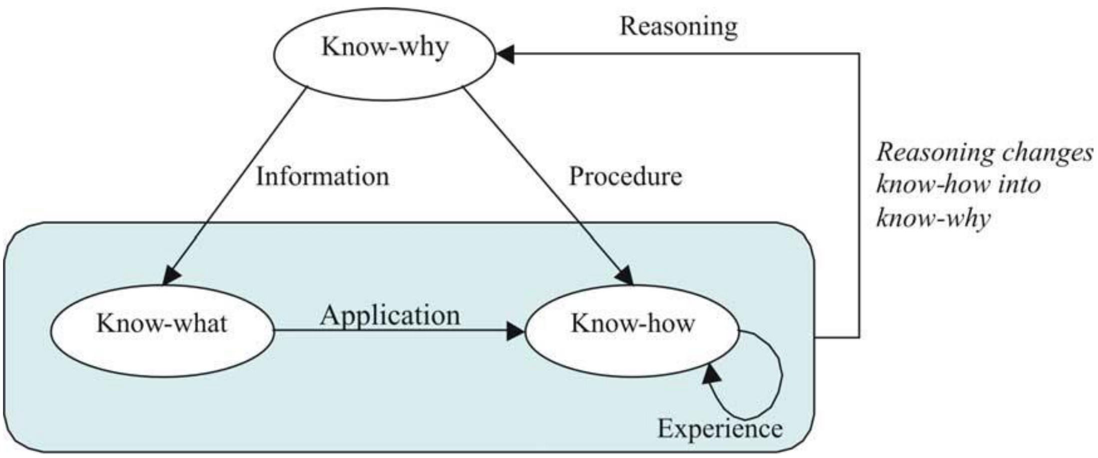


Figure 3-2: Conceptualising knowledge (Yim et al., 2004, p. 144)

It has been argued that enterprises need to develop a map of know-who and know-where to manage these type of knowledge (Fernandes & Saudubray, 2003). Know-who refers to the person who has the knowledge and skills related to specific action (Wu & Zhao, 2010). In addition, Park & Lee, (2014) argued that the sharing know-who and how-where information between the members how involved in information system development project is necessary to success the project. The cloud adoption process requires organisations to make use of descriptive (know-what), procedural (know-how) and reasoning knowledge.

3.4 Knowledge Management Strategies

Hahn & Subramani (2000) identified two broad classes of KM strategy used to manage knowledge in organisations: personalisation and codification. Personalisation strategy is related to tacit knowledge. In personalisation strategy knowledge is transferred through direct interpersonal communication. In the codification strategy, knowledge can be extracted and stored in a database. Nicolas (2004) argued that the KM strategy should be classified into three categories; technological, personalisation and socialisation strategies.

Technological strategy is a codification strategy using an information system to manage explicit knowledge. In contrast, socialisation strategy is a combination of technological strategy and personalisation strategy.

This thesis will adopt the socialisation strategy for the following reasons. Firstly, socialisation provides a flexible approach by combining personalisation and codification strategies. Secondly, a decision on cloud adoption involves different levels of decision making and will use both tacit and explicit knowledge. The socialisation approach can also be applied in organisations where knowledge has not been codified or where KM systems do not explicitly exist.

3.5 Organisational Learning and Learning Organisation

It is believed that enterprises that adopt the concepts of organisational learning (OL) and learning organisation (LO) are more amenable to change (Raymond & Blili, 2000), because such organisations have more commitment to learning and are more aware and understand their environment, which makes them seek to adopt new innovations (Zeng et al., 2015). In addition, technology adoption is defined as "process of organisational learning, which proceeds in a feedback loop from observing, interpreting, integrating to acting" (Running et al., 1999, p.1095). Thus, a culture of OL and LO might support cloud adoption decision making.

OL is a concept closely related to KM, and distinguishing between the two can be problematic (Mishra & Bhaskar, 2011). King (2009) distinguished between KM and OL in that the latter focuses on process while the former focuses on content. Mishra & Bhaskar (2011) went further by stating that OL is concerned with how to manage the process of learning in an organisation while the KM is concerned with how to build and use it. Decision making for cloud adoption involves both OL and KM.

The concepts of OL and the LO have been shown to be highly interrelated; the main difference between them is that the latter is a description of an organisation while the former is an activity or process of learning (Tsang, 1997; Örtenblad, 2001). OL is defined as the use of available knowledge and experience to improve the organisation's performance. (Nevis, 1995). However this definition limits the concept of OL to experience only, while King (2009) argues that OL is a significant approach in which an organisation can utilise its knowledge. Lyles (2014) stated that OL is a dynamic process of creating and transferring knowledge when and where it is needed. Sotirakou & Zeppou (2004) argued that OL is a combination of information and interactive perspectives. The information perspective is concerned with the procedures, structures and principles of an organisation, while the interactive perspectives are concerned with the members of the organisation and their interaction with the information perspective.

Mishra & Bhaskar (2011) claimed that all organisations conduct a process of learning but that this learning could be effective in high learning organisations or slow in low learning ones. OL plays an important role in improving the firm's capability and competitive advantage (Tsang, 1997; Tippins & Sohi, 2003; Wang & Ellinger, 2011). Moreover, OL improves the organisation's ability to respond to organisational change and improvement (King, 2001; Wang & Ellinger, 2011). OL also has a significant role in the adoption of adopting new IT systems (Raymond & Blili, 2000; Scott & Vessey, 2000).

Rowley & Gibbs (2008) emphasised that practicing OL could lead to innovation in different aspects in an enterprise, including infrastructure, new tangible activities and new methods and tools used by employees to carry out their jobs. A culture of OL can support enterprises when adopting innovation (Mavondo & Tsarenko, 2015; Zeng et al., 2015). Ratten (2015) claimed that OL supports cloud adoption due to the ability of OL to learn from experience and knowledge rather than manage knowledge only.

Cloud adoption involves different decision making levels, and a range of factors. This requires a systematic process to manage the interaction between the different levels of the organisation

OL has two major styles, single and double loop learning (Argyris, 1976; Rowley & Gibbs, 2008). Single loop learning is associated with responding to changes in the organisation's environment while maintaining organisational norms (Rowley & Gibbs, 2008); this is a low level learning that can foster incremental innovation (Scott & Vessey, 2000). Double loop learning responds to changes with changes in the organisation environment as well as organisational norms (Rowley & Gibbs, 2008). The double learning loop is a high level learning approach concerned with strategic change to bring discontinuous innovation (Scott & Vessey, 2000).

As discussed in section 2.8, adopting cloud computing could be considered as an incremental innovation when migrating some services to cloud, which requires single loop. In contrast, adopting cloud could be a discontinuous innovation when migrating existing IT infrastructure to cloud. Because of this, enterprises need to consider the types of changes in order to apply the appropriate learning style.

A learning organisation has been defined as an organisation that expands its capacity continually to retain its sustainability (Senge, 1990). Raymond & Blili (2000) extended Senge's definition and define a LO as one with a dynamic process of learning to produce new knowledge, including know-how, to develop a competitive advantage. Raymond &

Blili's (2000) definition links knowledge and LO. Similarly, Garvin (1993, p. 80) stated that a LO "is an organization skilled at creating, acquiring, and transferring knowledge, and modifying its behaviour to reflect new knowledge and insights". Sotirakou & Zeppou, (2004) argued that a LO is an organisation that involves its members in the learning process and transforms itself and its context continuously and consciously. The definitions above emphasise the need for continuous learning and change to retain enterprise sustainability and continuous improvement. This suggests that a LO culture supports enterprises when adopting innovation and responding to change.

Senge (1991) identifies five key disciplines of OL: system thinking, personal mastery, mental models, building shared vision and team learning.

3.6 Enterprise Knowledge Sharing

Knowledge sharing is considered a core element area of KM (Shaohua & Fan, 2008), which is defined as the process of transferring knowledge from one person or enterprise to another (Lee, 2001). Friesl et al. (2011) extended this to state that knowledge sharing could be person to person or enterprise to enterprise. Subsequently, the advantages of knowledge sharing might be related to the positive impacts of the transferred knowledge on the person or enterprise. As shown in Figure 3-3 knowledge sharing is a combination of internal, external and personal knowledge.

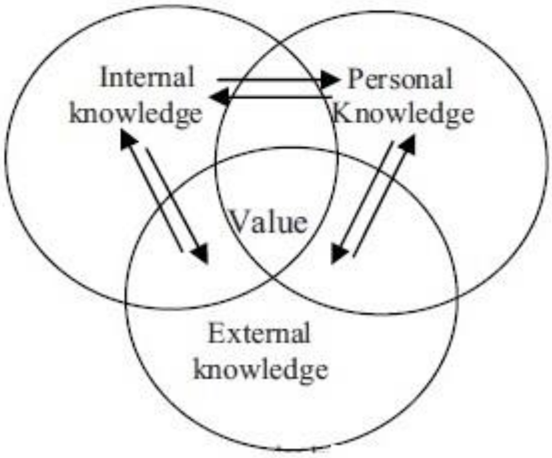


Figure 3-3: Knowledge sharing model (Song & Chu, 2012)

However, knowledge sharing is influenced by the collaboration of the knowledge holders, particularly in terms of tacit knowledge (Li et al., 2009). Technologies such Web 2.0 and enterprise social networks play an important role in sharing knowledge between individuals and enterprises (Hau et al., 2012; Zhao & Chen, 2013). It is argued that knowledge sharing is a critical factor for success IS outsourcing, software development and adopting new technology (Vandaie, 2008; Ryan & O'Connor, 2013; Yozgat et al., 2013).

3.7 Knowledge Management Based Decision Making

Knowledge used in decision making can be generated in different ways, including (but not limited to) feasibility studies, scenarios and organisational publications (Simonen et al., 2009; Giebels et al., 2015). McKenzie et al. (2011) argued that decision making today requires external as well as internal knowledge, as the challenges and changes surrounding organisations today are increasingly complex and rapid. As discussed above, decision making is influenced by KM, OL and LO. As shown inFigure 3-4, the three concepts of KM, OL and decision making show that there is interaction between these concepts and each of them is influenced by the others.

The decision making process consists of intelligence, design or conception and choice or selection phases (Courtney, 2001; Nicolas, 2004). The intelligence phase is concerned with investigation of the problem, while new solutions are designed in the conception phase. In the selection phase, different solutions and alternatives are evaluated to choose the optimum one for a particular context (Nicolas, 2004).

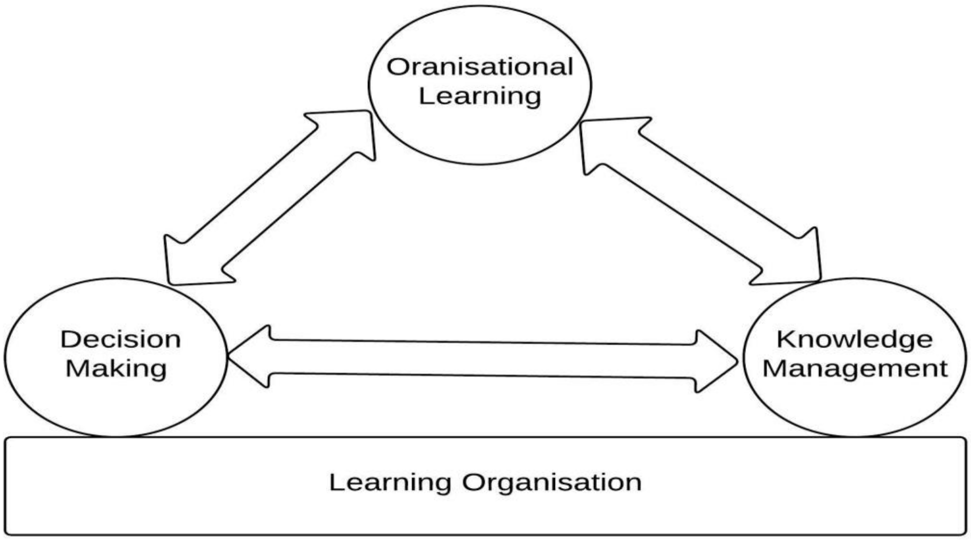


Figure 3-4: Learning organisation triangle model

Three levels of decision making were identified in the literature: strategic, management (tactical) and operational (Gorry & Morton, 1971; Courtney, 2001; Nicolas, 2004). Strategic decision making typically has a time focus of greater than 5 years, tactical decision making typically has a time focus of up to 3-5 years and operational decision making has a shorter time focus. Falkenberg et al., (1998) argued that the strategic level is concerned with high-level planning and organising, the tactical level focuses on more detailed planning while the operational level is concerned with operational decisions and directing and controlling of tasks. Decision making knowledge is defined as "the recognition, understanding of the world and facts, a set of rules, modes and approaches which can help an individual or an organization make decisions" (Zhong, 2008, p.516). Tacit and explicit knowledge were defined in 3.3.1 and different types of knowledge tend to be used at different levels of decision making (Nicolas, 2004). Tacit knowledge is mostly used at the strategic level, whereas both tacit and explicit knowledge are used equally in the tactical level, and the operational level is focused more on explicit knowledge (Yim et al., 2004), although processes differ between organisations.

Strategic decisions are those that affect the overall mission and goal of an enterprise, requiring a change in organisational objectives, resources used to achieve objectives, or changes on the policies that govern the obtaining, use and organising of these resources (Gorry & Morton, 1971; Schultz et al., 1987; Courtney, 2001). Casadesus-Masanell & Ricart (2010) argued that strategic decisions refer to decisions about the selection of the business model. One of the definitions of a business model is that it is the description of how an enterprise works (Casadesus-Masanell & Ricart, 2010). Parakala & Udhas (2011) argued that strategic decisions are decisions concerned with business transformation. In this context, it is believed that IT is the backbone for many enterprises, which makes the selection of IT provisioning model strategic. Dandache, M & Claude (2009) considered the decision about outsourcing which is similar decision to the cloud adoption decision as a strategic decision. In the context of cloud computing, we identify the decision as to whether to adopt cloud computing or not, as a strategic decision.

In contrast, tactical decisions are decisions which guide the enterprise to achieve the strategic goal (Courtney, 2001). Tactical planning is viewed as the "detailed deployment of resources to achieve strategic plans" (Schultz et al., 1987). Similarly, Casadesus-Masanell & Ricart, (2010) stated that tactical decision refer to the decisions about the selection of alternatives that belong to the selected business model. In addition, it is argued that financial and technical evaluation and adoption roadmaps might be considered at the tactical level (Parakala & Udhas, 2011). In the context of cloud computing, we identify the decision on choice of deployment model as a tactical decision.

The operational level is concerned with carrying out a specific task (Gorry & Morton, 1971; Courtney, 2001) typically, low level decisions such as product specification (Dandache, M & Claude, 2009). Tasks at the operational level require a well-defined knowledge and narrow scope, while at the tactical level the scope might broaden to cover the whole organisation. Operational level tasks may also include implementation plan, migration and development and maintenance (Parakala & Udhas, 2011). In the context of cloud computing, we identify the decision as to choice of service model as an operational decision because the selection of cloud service model is related to the requirements of the operational divisions. It might be argued that this is a tactical decision as the choice of service model might affect the whole organisation but it is also the case that different divisions within the same company might use different service models. Our motivation for regarding this as an operational level decision is that IT infrastructure is managed at this level (Cater-Steel, 2006), and operational level managers have the technical knowledge required to tailor the cloud solution according to the specifications of each division. Defining the choice of service model as an operational level decision provides for more input from the technical end users and offers more flexibility.

3.8 Knowledge Management and Cloud Computing Adoption

The discussion on Knowledge Management has identified that there are a number of different elements which make up the decision making environment. Figure 3-5 gives a diagrammatic representation of the environment for cloud computing adoption decision making. The outer circle of the diagram represents the factors that influence an enterprise when adopting cloud computing. The inner circle depicts the decision making levels, the decisions related to each level and the use of descriptive and procedural knowledge. A summary of the different elements in the diagram is given in the following sections and a more detailed discussion is given in Appendix A.

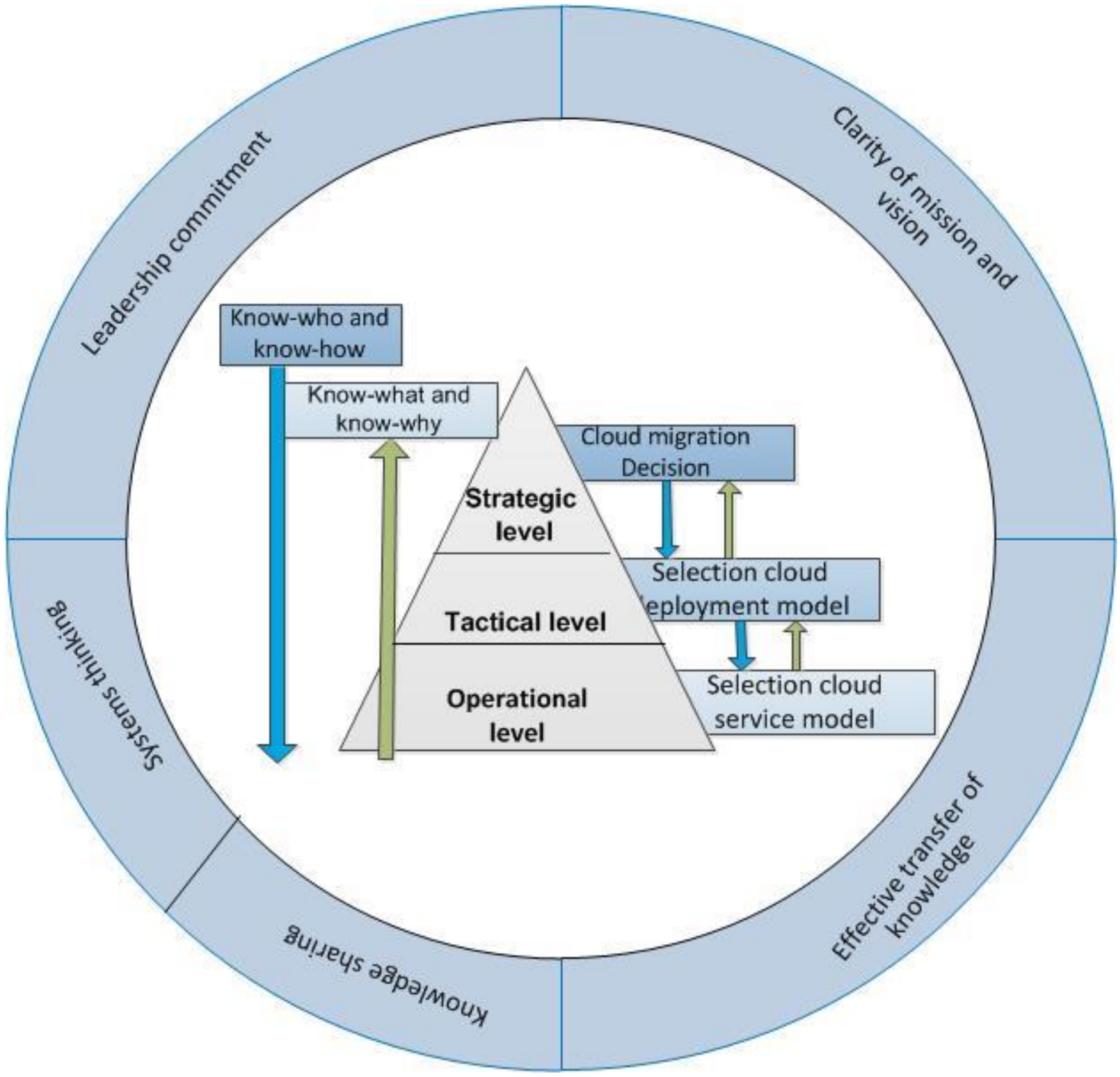


Figure 3-5: A structural framework to support cloud computing adoption

3.8.1 Enterprise environment

As discussed in 3.5, it is argued that the culture of a learning organisation plays an important role in the adoption of new technology, including cloud computing (Dove, 1999; Baramichai et al., 2007). Five factors which characterise a learning enterprise environment have been identified from the literature and applied to cloud computing adoption. These factors are shown in the outer circle of figure 3-4 and are clarity of mission and vision, leadership commitment, system thinking, knowledge sharing and effective transfer of knowledge. It has been claimed that clarity of mission and vision will create a shared vision (Senge, 1990; Goh, 2003), increase creativity and innovation (Martins and Terblanche 2003) and help to minimise the risks associated with change. Leadership has been identified as an important element in the learning organisation (Senge, 1990) and top management support is regarded as crucial to project success (Siguaw et al., 2006). As discussed further in 5.5, top management support was highlighted in the primary research as one of the main factors influencing cloud adoption. System thinking refers to the ability to see the problem from all perspectives (Rowley & Gibbs, 2008). It is argued that the holistic approach supported by system thinking supports the adoption of new technology, including cloud computing (Garrison et al. 2012; Azeemi et al. 2013). One of the findings from the literature review which was supported by the primary research, was that cloud computing adoption is influenced by multiple interconnected factors and is not a solely technical decision. Knowledge sharing plays a critical role in the adoption of new technology, including cloud computing (Vandaie, 2008) and can result in reduced time and costs as mitigating risks (Park & Lee, 2014). One of the characteristics of a LO is transferring knowledge when needed (Bloodgood & Salisbury, 2001; Lyles, 2014). The primary research established that decision makers in enterprises lack knowledge about cloud computing and this led to the inclusion of a Case Based Reasoning element in the Cloud Computing Adoption Framework.

3.8.2 Applying and Generating Knowledge

3.8.3 Knowledge Flow and Decision Making Levels

The central circle of Figure 3-5 shows the decision making hierarchy, the types of decisions made at each level and the knowledge flows that support decision making. Goh (2003) argued that knowledge should be transferred between the different levels in an organisation as well as between different units and as shown in the diagram, knowledge may flow down from the strategic to the operational level or conversely up. McKenzie et al. (2011) highlighted the importance of using the correct knowledge at each stage of the decision making process. In the cloud adoption context, know-why and know-who address the strategic elements of the decision; these top-down flows representing the flow from top management level to operational level. Know-how and know-what are at the tactical and operational level and represent the up-down approach, where the flow of knowledge is directed from the operational to the strategic level (Wu & Zhao 2010). This reflects the fact that cloud adoption involves multiple perspectives and requires input from different divisions within enterprises.

3.9 Framework and Model

Frameworks and models are widely used as KM tools to support decision marking in a number of fields and have been used in connection with outsourcing (Ho & Atkins, 2005; Sharp et al., 2011), a context where the issues encountered have a number of similarities to cloud computing. Frameworks provide guidance, communication and a clear description for decision making (Jung & Joo, 2011) and using frameworks can reduce the time and cost of a project (Fayad & Schmidt, 1997). KM research often uses the term model and framework interchangeably (Alexopoulos & Theodoulidis, 2003; Jung & Joo, 2011), but in this research we distinguish between them.

From the software development aspect, Johnson (1997, p.39) defined a framework as "A reusable design of all or part of a system that is represented by a set of abstract classes and the way their instances interact"; from the business perspective, frameworks are defined as "A systematic set of relationships or a conceptual scheme, structure of system" (Jung & Joo, 2011, p.126). The first definition covers most of the features of a framework but is limited to application development, whereas the second definition is more general. Silva et al (2014) argued that the framework could be viewed as a skeleton of an essential structure to application. In turn, a model is defined as “any simplified abstract of reality” (Lucey, 2005, p. 132), which can be physical or symbolic (conceptual). In this research, the term framework used to describe the overall decision support structure and within the framework we developed different models for use at each of the stages of decision making.

3.10 Technology adoption theory

The success or failure of any IT adoption project is determined by internal and external factors. A number of theories have been developed to examine these factors and to describe the conditions required for successful innovation. One of the features of cloud computing is that it changes the way in which IT services are managed within enterprises. It is also recognised that technology diffusion rates and processes vary between technologically developed and developing countries, including cloud computing (Kshetri, 2010; Parakala & Udhas, 2011). This section discusses the DOI, TAM and TOE approaches, and links concepts developed from these theories to the findings of the literature review. From this we develop a series of hypotheses about the factors which influence cloud computing adoption. The hypothesis were tested in the primary research and helped to determine the elements included in the Cloud Computing Adoption Decision Framework.

3.11 Theories relating to the adoption of innovation

This section discusses three key theories which influence understanding of the way in which organisations adopt technology

3.11.1 Diffusion of Innovation (DOI) theory

One of the first theories developed to examine technology adoption was DOI (Rogers, 1962,2003). DOI is defined as "a theory of how, why, and at what rate new ideas, technology, and process innovation spread through an organization, a society, or a country" (Cua, 2012, p. 307). The DOI theory provided the basis for other technology adoption theories such as TAM and TOE (Cua, 2012). DOI consists of two aspects, diffusion and innovation. Diffusion is the process by which an innovation is spread among the members of an enterprise over time, while innovation is defined as "an idea, practice, or object perceived as new by an individual or other unit of adoption" (Rogers, 2003). Rogers identified five stages of innovation adoption: knowledge, persuasion, decision, implementation and confirmation. In this process a decision-making unit goes from obtaining the necessary knowledge of an innovation, building the attitude toward the new idea, adopting or rejecting the decision toward the innovation, implementing it, and finally confirming the decision.

DOI is concerned with how new ideas are adopted within organisations over time and how they change the organisation. DOI adoption is affected by five influences: relative advantage, compatibility, complexity, trialability and observability, which are discussed further in section 3.13. One of the advantage of DOI theory is that it identifies factors which can be used to examine the success or failure of new technology in an organisational context.

The first factor of DOI is relative advantage, which examines whether the new technology could add advantages compared to the existing system. Some studies considered these factors in terms of purely technological aspects (Alshamaila et al., 2013; Ramdani et al., 2013), whereas other studies argued that these factors could be approached from different perspectives (Lin & Chen, 2012; Oliveira et al., 2014).

Numerous studies have used the DOI theory to support investigation into the adoption of new technologies at both the individual and organisational levels (Bharadwaj & Lal, 2012; Rahimli, 2013; Oliveira et al., 2014). These studies have attempted to identify factors which influenced the adoption of technology (Gangwar et al., 2014). Technology adoption theory plays an important role in investigations of the adoption of technology in different contexts such as RFID (Ramanathan et al., 2014), e-business (Lin & Lin, 2008) and e-commerce (Tan et al., 2007). In addition, several studies used technology adoption theories to investigate the adoption of cloud computing (Alshamaila et al., 2013; Lian et al., 2014; Oliveira et al., 2014).

3.11.2 Technology Acceptance Model

TAM is a model used to identify the factors that lead the user to accept or reject information technology (Davis et al., 1989; Gangwar et al., 2014). TAM involves two factors as the key determents of the use of technology: perceived usefulness (PU) and perceived ease of use (PEOU) (Venkatesh & Bala, 2008; Gangwar et al., 2014). PU is defined as “the degree to which a person believes that using a particular system would enhance his or her job performance” (Davis, 1989, p. 320). The definition shows that the PU is concerned with the perception of benefits that can be obtained and the value added. PEOU has been defined as “the degree to which an innovation is perceived as relatively difficult to understand and use” (Cua & Langefors, 2012, p. 24).

Venkatesh and Bala (2008) identified five attributes to measure PU, namely subjective norm, image, job relevance, output quality and result demonstrability; and six attributes to measure PEOU, identified as computer self-efficacy, perception of external control, computer anxiety, computer playfulness, perceived enjoyment and objective usability (Venkatesh & Bala, 2008).

TAM has been used in several studies on IS in general and in cloud computing adoption specifically (Alharbi, 2012; Ramanathan et al., 2014). However, the definitions of PU and PEOU and their determinants relate to benefits as perceived by the user and are not at organisational level. Therefore, one of the limitations of using TAM for this study is that the focus is on the individual not the organisational level (Nedbal et al., 2014; Oliveira et al., 2014). In addition, TAM fails to consider wider issues related to new technology, such as security and regulation (Gangwar et al., 2014; Nedbal et al., 2014). The focus in this study is on organisational issues and the wider factors that influence technology adoption.

3.11.3 Technology-Organisation-Environmental framework

The TOE framework was developed by Tornatzky and Fleischer (1990) to investigate innovation adoption from the organisational perspective (Ramdani et al., 2013; Gangwar et al., 2014). The framework examines three categories of factors influencing technology adoption, namely technological context, organisation context and environmental context (Baker, 2012). The TOE framework has been described as providing a holistic picture of the factors that influence the adoption of technology (Nkhoma & Dang, 2013; Gangwar et al., 2014). Gangwar et al. (2014) argued that the use of these three elements gives the TOE framework an advantage over other technology adoption theories in studying technology use, adoption and the value added from technology innovation.

We adopted the TOE approach in this investigation since our focus is on the adoption of cloud computing at the organisational level, with the caution that as Saudi Arabia is a technologically developing country, technical and organisational factors may present more of a challenge than would be the case in a technologically developed context.

3.12 TOE hypotheses

3.12.1 TOE: Technological context

This section describes the hypotheses developed in this research which are related to the technological context of cloud computing adoption. The technological context refers to individual and organisational factors influencing adoption of innovation (Gangwar et al., 2014). Baker (2012) stated that the adoption of an innovation can produce three types of changes: incremental, synthetic and discontinuous changes.

Incremental change happens when a new version of an existing technology is released or when adding new features to existing technology. Synthetic change is a result of combining existing technologies or ideas in a novel way. Discontinuous change is the change that happens when moving from current ideas or technologies to new ideas or technology. There are risks associated with each type of change and the level of risk varies, with incremental change seen as presenting the least risk and the discontinuous change the highest risk (Baker, 2012). Cloud computing is regarded as an example of discontinuous change, therefore it carries higher risk (Baker, 2012).

- *Technology readiness*

Cloud computing is a new model of IT service delivery. Thus, the technology context is a very important determinant to investigate when adopting cloud computing. Zhu et al. (2004) claimed that technological readiness is the main factor influencing the adoption of e-business, which fundamentally depends on internet technology (Zhu et al., 2004; Lin & Lin, 2008). Similarly, cloud computing requires high internet connectivity to benefit from cloud services. Technology readiness in a cloud computing context has been defined as having the necessary IT infrastructure available to an enterprise to obtain cloud services and human resources that can manage cloud services (Oliveira et al., 2014). Yeh et al. (2014) selected IT infrastructure and maturity within organisation as the key factors in the technological context which influence the adoption of e-business. IT maturity is understood here as an aspect of the organisational readiness dimension, since it relates to the level of knowledge and expertise available within the organisation.

Based on the factors identified in the literature, this research will take into account that technology readiness is one of the main factors influencing the adoption of cloud computing in a technology context. The framework developed for this research will consider the availability of IT infrastructure and IT support to companies who wish to use cloud services as well as the capability of CSPs to provide adequate cloud-based IT services to enterprises. The first hypothesis is developed as:

H1: Technology readiness positively influences cloud computing adoption.

- *Security*

As discussed in 2.8.3, security is seen as one of the highest risk elements in the adoption of cloud computing (Carroll et al., 2011; Chao et al., 2014; Gangwar et al., 2015), although it has also been argued that there is no relationship between security and cloud adoption (Oliveira et al., 2014). This study will examine whether the security concerns influence the adoption or rejection of cloud computing.

H2: Security concerns negatively influence cloud computing adoption.

- *Technology barriers*

Technical issues such as the complexity of existing IT systems, portability and interoperability and vendor lock-in have been identified as possible barriers to the adoption of cloud computing (Phaphoom et al., 2015). We therefore propose the following hypothesis:

H3: Technology barrier negatively influences cloud computing adoption.

3.12.2 TOE: Organisational context

The organisational context refers to the characteristics of the organisation and its internal resources (Baker, 2012; Oliveira et al., 2014). Organisation characteristics include organisation size, status, industry and scope. Internal resources include knowledge capability, top management support and organisation readiness (Gangwar et al., 2014). Cloud computing has organisational as well as technical implications and this makes the organisational context a key determinant of cloud adoption.

- *Enterprise size*

Enterprise size is considered to be one of the main factors affecting innovation (Zhu et al., 2004; Pan, Ming-Ju and Jang, 2008; Aboelmaged, 2014; Oliveira et al., 2014b). Large enterprises have been shown to be more likely to adopt innovation, such as ERP and e-commerce (Zhu et al., 2006; Pan et al., 2008). The main reason is considered to be that large enterprises have more organisation and financial resources to adopt ERP and e-business. However, the cost model of cloud computing makes it possible for SMEs to acquire IT services, which makes cloud computing a more attractive option for SMEs.

H4: Enterprise size has an impact on the adoption of cloud computing services.

- *Top management support*

Top management support refers to the decision makers who influence the adoption of innovation (Lai et al., 2014). This has been seen in many studies as a strong factor favouring the adoption of innovation (Jeyaraj et al., 2006; Ramdani et al., 2013; Yeh et al., 2014). Gangwar et al. (2014) argue that the impact of top management support varies depending on the context. According to Baker (2012), top management can encourage an enterprise to adopt innovation in two ways: by creating an organisational environment that supports change and innovation in order to develop the enterprise's core mission and vision; the leadership provided by top management can support innovation by emphasising the importance of innovation to staff. Thus, the role of top management leadership is key to the adoption of cloud computing.

H5: Top management support has a positive impact on cloud adoption.

- *Organisational readiness*

Organisational readiness is defined as "the degree to which an organization has the awareness, resources, commitment and governance to adopt IT" (Hameed et al., 2012, p. 226). In addition, organisational readiness can cover elements such as the availability of human, technology and financial resources to adopt cloud computing (Lin & Lin, 2008; Riyadh et al., 2009; Ramdani et al., 2013). Organisational readiness can be measured by establishing whether the organisation has the capability to adopt innovation (Ramdani et al., 2013); from the human factor point of view, this includes IT skills. Knowledge about cloud computing and the attitude toward using the technology is an important factor to adopt cloud computing. Aldraehim et al. (2012) argued that the low level of organisation readiness in Saudi Arabia is one of the main reasons for the failure to adopt e-services.

H6: Organisational readiness has a positive impact on cloud adoption.

- *Enterprise status*

Enterprise status is defined in this study in terms of whether the organisation is an established company or a start-up. A start-up company is defined as one which is in the early stage of the business (Gurel & Sari, 2015). The literature does not include any detailed empirical study which investigates the impact of enterprise status on technology adoption in general and cloud adoption specifically. However, a small number of studies have linked enterprise status and cloud computing adoption and concluded that start-up companies were more likely to adopt cloud computing than established ones (Gupta et al., 2013; Sadiku et al., 2014). However, these conclusions were based on literature studies, not empirical conclusions. Therefore, this study will examine the relationship between enterprise status and cloud adoption as part of the examination of the influence of organisational factors on cloud computing adoption.

H7: Enterprise status has a positive impact on cloud adoption.

3.12.3 TOE: Environmental context

The environmental context refers to the external factors that influence the adoption of technology, including government regulation and initiative, service providers and competitors (Gangwar et al., 2014).

- *Industry sector*

Industry sector is acknowledged to have a major impact on how enterprises manage their business but the role of IT is different in different sectors (Alshamaila et al., 2013; Son et al., 2011). Moreover, the adoption rates for new technology vary between sectors, and there may be specific factors which influence individual sectors. For example the largest user of technology is the financial sector (Zhu et al., 2004), but due to the sensitivity of the data used by the financial sectors, there may be greater caution in adopting cloud computing (Khajeh-Hosseini et al., 2010; Srinivasan, 2014).

H9: Industry sector is associated with cloud adoption.

- *Competitive pressure*

Competitive pressure refers to "the level of pressure felt by the firm from competitors within the industry" (Oliveira & Martins, 2010, p. 1341). Ramdani et al. (2013) stated that competitive pressure is very influential in the adoption of technology. In contrast, Alshamaila et al. (2013) argued that there is no relation between competitive pressure and the adoption of technology adopting technology, based on an empirical study of cloud computing adoption in Northeast England. Low et al. (2011) found that competitive pressure has influenced companies that work in high-tech industries to adopt cloud computing. Oliveira et al. (2014) reported similar findings in Vietnam. The business environment in Saudi Arabia is different to that of the UK and Vietnam, and as noted above, competitive pressure may be more or less significant depending on sector. This study will therefore investigate whether competitive pressure influences cloud computing adoption.

H9: The existence of competitive pressure has a positive impact on cloud adoption

- *External support*

External support in this research is defined as support from the CSP, which might influence clients to adopt cloud technology. There is a lack of understanding of cloud services, particularly as regards cloud architecture and pricing models (Misra & Mondal, 2011). This represents a possible barrier for companies, particularly SMEs, to adopt cloud computing. Support in this case may be the knowledge and expertise that a CSP offers to clients (Ifinedo, 2011). To date there has been little research investigating the role of CSP and cloud computing adoption within organisations (Alshamaila et al., 2013; Tehrani & Shirazi, 2014). External support in this study is understood in two ways; support from the CSP for business applications and support for the management of IT services, for example traditional IT help desk functions.

H10: The provision of external support has a positive impact on cloud adoption.

- *Government support*

Government support in this context is understood as government regulation, policies and initiatives that support enterprises in the adoption of adopt cloud computing. Government regulation can play an important role in supporting or inhibiting the adoption of technology innovation (Zhu et al., 2006; Baker, 2012; Oliveira et al., 2014). Many countries have restrictions on the use and storage of citizen data. However, the impact varies between industries, with the health and financial sector having more restrictions than other sectors (Borgman et al., 2013). On the other hand, governments can encourage enterprises by passing legislation which organises the relationship between CSPs and clients, creating laws to ensure security and privacy of data (Carroll et al., 2011).

Zhu et al. (2006) concluded that government regulation has more influence on e-business adoption in technologically developing countries. Alghamdi et al. (2011) pointed out that Saudi SMEs seek support from the government. Government initiatives can play an important role in encouraging the adoption of innovation, such as developing strategies, building reliable infrastructure, funding and provision of consultation and training. Examples of such initiatives include the Canadian Small

Business Internship Program (SBIP) to support SMEs adopting e-commerce (Ifinedo, 2011), the US government Cloud Computing Technology Roadmap and initiatives in China and Vietnam (Kshetri, 2011). Thus, this study will examine the following hypothesis:

H11: Government support has a positive impact on cloud adoption.

3.13 DOI hypotheses

This section describes the hypotheses developed in this research which are related to the DOI theory of innovation adoption.

3.13.1 DOI: Relative advantage

Relative advantage is defined as “the degree to which an innovation is perceived as being better than the idea it superseded” (Rogers, 2003). Al-Jabri and Sohail (2012) stated that relative advantage takes into account economic advantage, increased efficiency and improvement in status. As discussed in chapter two, it has been argued that cloud computing has technical as well as economic advantages compared to traditional IT environments and that the adoption of cloud computing will support enterprises in achieving their strategic goals. It is proposed here that, based on the literature, one of the factors taken into account when adopting cloud technology is the relative advantage provided by cloud computing, as examined through the following hypothesis:

H12: Relative advantage has a positive impact on cloud adoption.

3.13.2 DOI: Compatibility

Compatibility in the DOI approach is defined as the extent to which the innovation fits with the organisation's existing values, culture and practices (Rogers, 2003; Oliveira et al., 2014). Compatibility is an important factor in the adoption of cloud computing. From the technical perspective, the extent to which cloud solutions are compatible with existing systems is a key factor when considering adopting cloud computing. Staff resistance to change is an important factor from the organisational perspective. In addition, the extent to which cloud computing is compatible with an organisation's policies and regulatory obligations is crucial for an organisation when considering a move to cloud computing. Thus, this research will suppose the following hypothesis as a barrier to adopt cloud computing:

H13: Lack of compatibility has a negative impact on cloud adoption.

3.13.3 DOI: Complexity

The third factor of DOI is complexity, defined as "the degree to which an innovation is perceived as relatively difficult to understand and use" (Rogers 2003). This is a wider concept than the definition given by Al-Jabri and Sohail (2012, p. 381): "Complexity is the opposite of ease of use", as it covers issues that restrict the adoption of innovation, such as privacy and the availability of cloud computing knowledge and skills to manage cloud computing services. Cloud computing is an advanced technology and comes with some challenges, including security and privacy ones, and the adoption of cloud computing may require new skills and expertise (Oliveira et al., 2014). Difficulties in these areas will affect the adoption of a cloud solution.

H14: Complexity has a negative impact on cloud adoption.

The hypotheses were tested in the primary research through the use of questions linked to each hypothesis (Table 3-1). These questions were developed from the literature review and the results from the interviews conducted in the first stage of the primary research, as discussed in chapter four. For example, in Table 3-1, the hypothesis on technological readiness is explored by questions examining internet access and the level of knowledge about cloud computing. These questions are based on comments made by interviewees that lack of knowledge about cloud computing in Saudi Arabia is one of the main issues affecting its adoption (Table 4-3). Similarly, some participants identified internet connectivity as one of the main barriers to the adoption of adopt cloud computing. Therefore, we used these two elements measure the impact of technological readiness on cloud adoption in Saudi Arabia.

Hypothesis	Question
Technological readiness	The organisation's connectivity to the internet is adequate
	The level of knowledge about cloud computing within the organisation is low
Security concerns	Data security
	Availability of service
	Data location
Technology challenges	Vendor locked-in
	Difficulty of migrating existing system to cloud
	Lack of knowledge about cloud computing
Organisational readiness	The awareness of the implications on IT roles and organisational change when moving to cloud.
	Ensuring the sufficient financial resources to support the decision to adopt cloud computing
	The level of knowledge about cloud computing within the organisation is low.
Top Management Support	Top management believes that adopting cloud computing services can add value to the company.
Firm Size	How many people work in your organisation?
Firm Status	Is your company established for?

Industry Sector	Please select which sector is your organisation
	Please select the industry sectors is your company belong
Competitive pressure	Adopting cloud computing will give your company competitive advantages.
	Adopting cloud computing will increase the customer retention rate.
	Adopting cloud computing will reduce the time to manufacture products or provide services
External Support	Cloud service providers support your business line applications.
	Cloud computing services have more vendor support than traditional software.
	The quality of the service provided by local service provider is good.
Government Support	Government policies, support and initiatives have an impact on cloud adoption decisions.
	Existing regulations influence the adoption of cloud computing services.
Relative advantage	Adopting cloud computing will help the company increase its focus on its business
	Adopting cloud computing will reduce the time taken to manufacture products or provide services.
Compatibility	Regulation compliance
	Compatibility with existing IT services
Complexity	Incompatibility with existing systems impedes moving to cloud computing.
	Adopting cloud computing will require additional effort and training.
	Migrating the existing system to cloud computing is too complex.

Table 3-1: Hypothesis design

3.14 Conclusion

This chapter reviewed the literature related to KM and technology adoption. We considered different types of knowledge and the way in which knowledge is used in decision making. The LO and OL were discussed and we examined how these theories could be used to support the research. The DOI, TAM and TOE theories of technology adoption were discussed and we selected the DOI and TOE approach. Based on TOE and DOI, we developed a number of hypotheses to support the investigation of cloud computing adoption. The following chapter discusses primary research carried out in Saudi Arabia.

Chapter 4: Interview Analysis

4.1 Introduction

As discussed in chapter one, the primary research was carried out in two phases. The first phase included interviews with 14 experts in IT as well as cloud computing from five different CSPs and the second phase involved a survey of cloud computing users/possible adopters. This chapter discusses the first phase of the primary research, describing the fieldwork carried out in Saudi Arabia to determine the context of the research and, together with the hypotheses developed in the previous chapter, to provide the basis for the survey discussed in chapter five. The aim was to build on the data about cloud computing adoption decision making obtained from the literature review, and to collect primary data through in-depth interviews in order to identify factors which influence decision making about cloud computing adoption in Saudi Arabia.

Most of literature on cloud computing adoption is based on studies in technologically developed countries. Saudi Arabia is regarded as a technologically developing country, thus the research provided an opportunity to examine whether the factors which influence cloud computing adoption differ between technologically developed and developing countries. An important finding from the research was the comparative lack of maturity in the cloud computing market in Saudi Arabia. Framework analysis was used to support the analysis of results and the key factors influencing adoption were categorised into five main themes identified from the literature, based on the TOE framework as discussed in Chapter Three; the technology context was divided into technological and security, and the organisational context was divided into economic, organisational and environmental.

4.2 IT context in Saudi Arabia

According to the (Tan, 2011), the Kingdom of Saudi Arabia is a technologically developing country. KSA is the second largest country in the Middle East and North Africa (MENA) by land area (around 2,150,000 km^2). The economy is oil-based, which represents 90% of general income (Ministry of Finance, 2014). In the ICT context, according to the International Data Corporation (IDC, 2015), managed services, data centres and IT outsourcing in KSA reached $2,762.28 million in 2014 and was projected to increase by 16% by 2015, while the cloud market reached about $77.5 million. In addition, KSA has the largest and fastest growing ICT sector in MENA (AlGhamdi et al., 2012).

However, in 2010 KSA was ranked 52 out of 70 counties in an e-readiness report assessing ICT infrastructure and the usage of ICT by people, government and business (AlGhamdi et al., 2012). This is supported by a study carried out by a Saudi governmental organisation, the Communication and Information Technology Commission (CITC, 2010), which showed that only 14% of SMEs in the country have a website. 30% of government organisations and 13% from the private sector buy online, while only 8% of enterprises sell online. At the individual level, there are 3.5 million internet users in KSA , representing about 46% of the population (Eid, 2011; Alghamdi et al., 2013). This reflects the fact that there are about 2.92 million landlines, which cover only 46% of housing in Saudi Arabia (CITC, 2010).

The discussion above shows that there is a gap between the amount of expenditure on ICT in KSA and its usage by (intended) end users. The reasons for this disconnect include the lack of facilities on the ground. For example, in 2005 the government launched an e-government plan with the vision: “By the end of 2010, everyone in the

Kingdom will be able to enjoy from anywhere and at any time world class government services offered in a seamless user friendly and secure way by utilizing a variety of electronic means" (YESSER, 2006). This vision was not realised (Alghamdi et al., 2013). A major factor in this is the disparity of ICT infrastructure between the regions in KSA. The widespread absence of landlines in more than half of Saudi homes causes infrastructure difficulties with internet access. A second major factor is the shortage of IT skills in the country (Alshitri & Abanumy, 2014).

4.3 Study design

4.3.1 Selection of participants

The study was designed to obtain in-depth views from expert users who represented different sectors and different aspects of cloud computing that allowing us to access both the tacit and explicit knowledge of experts. For the purpose of this study, five enterprises were selected, drawn from three groups: three large CSPs who provide a public cloud service; a small start-up CSP which provides SaaS services; and a large general hospital which had migrated its infrastructure to a private cloud. Fourteen IT experts, with different organisational backgrounds, participated in the study. Participants were selected according to two criteria: relevant experience in cloud computing and in general IT, and managerial experience in cloud computing. The aim was to hold in-depth discussions about cloud computing adoption to inform the design of the questionnaire. Table 4-1 describes the individuals who took part in the study. To ensure confidentiality, identifying details have been removed so that the organisation to which the participant belonged cannot be identified. Participants included cloud computing managers, data centre and virtualization managers, cloud migration specialists and project managers.

Code	Position	IT expertise (years)
P1	Cloud Computing manager	10 years or over
P4	Business or Project Manager	10 years or over
P12	Business or Project Manager	5 years or over
P3	Business or Project Manager	5 years or over
P5	Business or Project Manager	10 years or over
P8	IT Manager	10 years or over
P13	Business or Project Manager	5 years or over
P6	IT Manager	10 years or over
P7	IT Manager	20 years or over
P9	Business or Project Manager	20 years or over
P10	IT Manager	10 years or over
P11	IT Manager	20 years or over
P2	Cloud Manager	20 years or over
P14	IT Manager	5 years or over

Table 4-1: Participants' information

Table 4-2 summarises the cloud computing context of the enterprises which took part in the study. All the enterprises in the study provide SaaS, while only three provide IaaS and only one provides PaaS.

enterprise	Description	Deployment model	Service model
1	A large enterprise that provides e-services, including cloud to government and private sectors	Private cloud for internal using, and public cloud for consumer	SaaS
2	A large enterprise that provides communication solutions and recently start providing cloud services	Private cloud for internal using, and public cloud for consumer	SaaS IaaS
3	A large enterprise that provides information communication technology and recently started provide cloud services	Private cloud for internal using, and public cloud for consumer	SaaS PaaS IaaS
4	A start-up enterprise that provides cloud solutions	Public cloud	SaaS
5	A hospital that migrated its infrastructure to cloud	Private cloud	SaaS IaaS

Table 4-2: Description of selected enterprises

We noted that the way in which cloud services are offered to customers in KSA differs from the experience elsewhere. The CSPs who took part in the study do not provide much detail about the services in their website concerning costs, availability and SLA. For example, with Amazon EC2 or salesforce.com, both of which companies serve the European and US markets, the cloud consumer could obtain services through the website without needing to contact any of the companies' staff. In contrast, with local CSPs in Saudi Arabia, the cloud consumer needs to fill in a form with contact details and is then contacted by the CSP. This means that cloud services are using the same sales model as non-cloud services, and the sales process loses aspects of service on-demand and automation. This suggests that, as discussed in section 2.9.5, cloud computing markets are at different levels of maturity and there is a need to develop a cloud maturity model for service providers.

4.3.2 Data collection approach

Preliminary agreement to participate in the field study was obtained before the study began. Before conducting the first interviews, an email was sent to the enterprises selected, explaining to them the aim of the study and arranging dates. The interviews were scheduled after receiving confirmation of participation. The interview format was semi-structured in that participants were asked the same questions and were then invited to give their own views and comments. Fourteen individual interviews were conducted, and each session took an average of one hour. With the interviewees' consent, all interviews were recorded and notes were taken during the interview. The interview questions were divided into four parts, as shown in Appendix B. The interviews were conducted in a mixture of English and Arabic, depending on the preference of the interviewee, but were transcribed into English for the purposes of analysis.

4.3.3 Limitations and constraints of the study

Due to the geographical distance between the major cities in Saudi Arabia, interviews took place in only one city, Riyadh, the capital of Saudi Arabia. Riyadh is, however, the most populous city in Saudi Arabia and is the commercial, economic and political centre of the kingdom. Approximately one-fifth of the total Saudi population live in Riyadh. As already noted, IT and internet access vary between regions, but IT and internet access is generally good in the capital making it a centre for cloud computing.

The interviewees were mainly drawn from CSPs. One reason for this is that during the period in which the study was conducted (March to June 2014), all the selected enterprises but one were still in the early stage of providing cloud services. This meant that it was difficult to arrange interviews with consumers of cloud computing services because the CSPs wished to maintain commercial confidentiality. This also reflects the fact that cloud computing services in Saudi Arabia have not yet reached maturity, and expertise is concentrated in the CSPs. The views obtained during this part of the study are balanced later with views obtained from cloud computing users through the survey and in the evaluation. Interviewing CSPs provided expert views on the cloud computing context in KSA and contributed to the design of the questionnaire.

4.3.4 The analysis approach

As discussed in chapter one, framework analysis was used to support analysis of the interview results. The key advantage of framework analysis is that data is organised according to the selected themes which supporting classification and organization of data. The data obtained from the interviews was classified into the categories of technological, security, economic, organisational and environmental factors, further refined into subcategories, based on factors identified from the literature review and supported by the analysis of the interviews.

4.4 Results of analysis

4.4.1 Drivers to provide cloud services

The participants were asked about the drivers of cloud services provision in Saudi Arabia. Participants identified three reasons for the use of cloud services, including the underlying presence of market demand. Clients need resources to be provided quickly, but existing resources are limited and expansion could take them over budget. This means that the elasticity and the OPEX payment model of cloud computing are attractive. There is a shortage of IT skills in Saudi Arabia from the client side. These factors were supported by three participants P4, P3 and P8. P5 cited the motivation for developing a private cloud as the desire to minimise operational operation costs, provisioning services quickly, automation and high support for disaster recovery. P9 and P10 suggested the CSPs are taking the lead in innovation building on their vision to become key innovative ICT players in the region. Discussing SaaS services, P11 claimed that some CSPs in KSA lack understanding of the SaaS model, and international CSPs cannot support local needs.

4.4.2 Cloud computing issues

As noted in section 4.1, analysis was based around the five themes of technological, security, economic, organisational and environmental factors, as shown in Table 4-3, which lists the issues identified by participants using the codes described in section 4.3.1.

Enterprises	**Technological**			**Security**			**Economic**		**Organisational**			**Environmental**	
	Connectivity	*Integrated with existing system*	*Complexity of migration existing system*	*Trust*	*Data security*	*Availability*	*High cost*	*Lack of funding*	*Lack of knowledge*	*Loss of control*	*Top management support*	*Lack of regulation*	*External support*
1	*P4* *P12*	P1 P4	P4 P12	P1	P1 P4		P1 P4		P1 P4 P12	P1 P4	P1 P4	P1 P4	
2	*P13*	P3 P8	P3 P8 P13	P5	P3 P5 P8 P13	P5 P13	P5 P13		P5 P8 P13	P3 P8	P8 P13	P3 P13	P8 P13
3		P6	P6 P9 P10	P7 P9	P6 P7 P9 P10				P6 P9 P10	P6 p7	P6 P9 P10	P6 P7 P9 P10	P10
4	*P11*		P11	P11	P11		P11		P11	P11	P11	P11	P11
5		P14 P2	P2		P2 P14				P2 P14			P2 P14	P2 P14

Table 4-3: Summary of issues related to cloud computing

4.4.2.1 Technical issues

The technical theme was sub-classified into three issues having the potential to restrict migration to cloud computing. Only four participants claimed that internet connectivity could affect cloud migration decision. However, all these participants acknowledged that Riyadh has a good IT infrastructure, and the problem here is the high cost of internet connectivity. It was accepted that the internet in rural areas is not as good as in the main cities. For example, one participant stated that "when we provide one of our services to customers in a rural city we need to request high internet services from internet service provider which take a long time to provide the service". This is one of the elements which may apply more to technologically developing countries than to technologically developed countries.

Integration with existing systems was seen as a challenge for cloud computing migration by half of the participants. Participants from two different CSPs claimed that integration between legacy systems and cloud computing is difficult and requires a lot of effort. Ten of the interviewees cited the complexity of existing systems as a technical issue when migrating to cloud computing. This was illustrated by one participant who quoted a migration project in KSA where the difficult of migrating some servers meant the client had to spend a lot of money to replace them.

4.4.2.2 Security issues

In terms of security, three factors have been identified from the interviews, which are trust, data security and privacy and availability. Five participants stated that trust in the CSP was still an issue when adopting cloud computing in Saudi Arabia, with one stating that "The relationship between the customer and service provider needs a long time to develop".

In terms of data security and privacy, all interviewees but one stated that security is one of the major issues in cloud. However, most of the interviewees pointed out that concerns about data security and privacy are related to a lack of understanding of security in cloud computing. One participant stated that the decision makers have no idea of how CSPs handle data security, and argued that cloud data security could be stronger than on-site security, as CSPs are able to hire highly skilled IT security consultants and data centres have very strict data security policies. Only two participants believed that availability issues could restrict cloud computing adoption.

4.4.2.3 Economic issues

With regard to economic factors, two issues were highlighted, one relating to cloud consumers and one relating to CSPs. In terms of cloud consumers, five interviewees stated that the costs of cloud based services and the internet connectivity is high, specifically for small enterprises. One participant commented that "because we do not have a huge set up within cloud service in Saudi Arabia, the local CSPs cannot beat cost of international CSPs such as Google and Amazon, so the cost element is still there". This was illustrated by the comment from one interviewee who said the cost of developing a data centre led him to change his plan to build a data centere for his company and instead developed a cloud data centere to provide SaaS. In the case of CSPs, lack of private sector and government funding represents an obstacle to providing cloud based services.

4.4.2.4 Organisational issues

From the organisational aspect, there are three factors which might inhibit cloud computing adoption. All interviewees but one stated that the lack of knowledge is one of the main issues that inhibits decisions to move to the cloud. Some participants pointed out that the client's decision makers do not have a deep understanding of cloud services, especially the financial aspect. In addition, over half of those who were interviewed indicated that the concerns over loss of control over resources was an issue for enterprises considering adopting cloud services. Two participants stated that one of the main differences between Saudi Arabia and technologically developed countries is that IT managers in the former want to keep full control over resources, as this will empower them within enterprises. One participant added that the high maturity of cloud computing in developed countries was because enterprises in these countries had long experience with outsourcing. This meant that these organisations have more experience of managing different types of provisioning IT services.

Lack of top management support was seen as an obstacle to cloud migration decision. One participant stated that decision makers do not recognize IT as a value-adding component of their enterprises, and they consider it purely as a cost. This means there is less willingness to innovate in IT, including in cloud services. Another participant stated that unless there was commitment from top management, cloud computing adoption would be slowed down. These views reflected the findings of the literature review, that the top management leadership influences the attitude toward cloud adoption (Ratten, 2015).

4.4.2.5 Environmental issues

All interviewees were asked to identify any issues related to the business environment. Two themes were highlighted, namely lack of regulation and external support. Almost two-thirds of participants stated that the lack of regulation has a negative impact on cloud migration in Saudi Arabia. One participant argued that standardizations and certification for CSP are important while another stated that applying the best practices of technologically developed countries such as the US and UK as a benchmark could solve the problem until specific government regulation was developed. It was noted that some company regulations are already in force; two participants pointed out that industries such as healthcare and banking have restrictions on moving data outside the organisation, which is related to the requirement that citizens' data must remain within KSA. The restrictions on moving data could restrict the benefit of using public cloud from outside Saudi Arabia, such as low-cost cloud services. However, most countries have some form of restriction on the movement of personal data.

External support has been divided into two elements, government and vendor support. On one hand, as we discussed with regard to the economic aspects, two participants identified a lack of funding for new innovation, including cloud computing as a barrier to increasing awareness of cloud computing. Two participants argued that the small number of local CSPs could reduce competition, which could affect CSPs innovation and limit the growth of a awareness among customers. One participant argued that the IT industry in Saudi Arabia was still in the early stages of development, and would benefit from government and private sector initiatives to support the fledgling industry.

Six interviewees stated that the local vendor clouds do not support certain types of industry sectors. The small number of CSPs who can support certain enterprises restricts user choice and could lead to vendor lock-in. Deciding on cloud computing migration in a technical environment where there are fewer CSPs and less choice means that the decision makers need to consider all possible alternatives before moving to the cloud. A more restricted market place means that although alternatives to cloud computing would be part of the decision making process in a technologically developed country with a mature cloud computing industry, this element is more significant in a technologically developing country where the industry remains immature.

4.4.3 Benefits of cloud computing

The results obtained from the analysis of interviews are summarised in Table 4-4. The benefits related to cloud computing were classified into four main themes: technological, security, economic and organisational. There are no environmental benefits identified from the findings. One of the benefits highlighted in the literature review that was not identified from the interviews is green IT. One of the possible explanations for this is the absence of any regulations to make data centres more sustainable and to reduce carbon emissions, such as in the UK and EU.

Enterprises	**Technological**			**Security**			**Economic**		**Organisational**	
	Scalability	*Fast access to new technology*	*Better IT capability*	*Availability*	*Disaster recovery and business continuity*	*Better IT security*	*Saving cost*	*Lower up-front cost*	*Focus on core competency*	*Competitive advantage*
1	P12	P1 P4	P1 P4 P12			P4	P1 P4 P12	P1 P4	P1 P4	P1 P4
2	P3 P5		P3 P5 P8 P13	P5			P3 P5 P8 P13	P5 P8 P13	P3 P8	P3 P8
3		P10	P9	P10	P9 P10	P9 P10	P6 P7 P9 P10	P6 P7 P9 P10	P6 P10	P6 P7 P10
4			P11	P11	P11	P11	P11	P10	P11	
5			P2 P14	P2	P2		P14			

Table 4-4: Summary of the benefits of cloud computing

4.4.3.1 Technological benefits

As discussed in chapter two, scalability has been seen as one of the benefits of cloud computing. However, only three participants identified scalability as one of the drivers to move to cloud computing. A possible explanation for this might be that the most of the businesses in Saudi Arabia do not need the high scalability of cloud computing because business growth is generally slow (Almakenzi et al., 2015) and most businesses are micro enterprises.

Fast access to technology is identified as a driver to move to cloud services for some enterprises. One participant stated that some enterprises need to provide IT services within a short timescale, but that using traditional IT provisioning approach will take a long time from planning, ordering, installation and configuration, while cloud services can be provided quickly. Most interviewees identified CSP provision of better IT capability as a benefit of migration to cloud computing, but interviewees from three different CSPs noted that the lack of IT staff in Saudi Arabia meant that enterprises could find it difficult to manage IT services in-house. They argued that CSPs, as large enterprises who have high IT expertise and high amounts of IT resources, could provide better IT capability for SMEs.

4.4.3.2 Security benefits

Discussion on this element emphasised the claim that CSP might offer better IT security than enterprises with their own data centres. This perhaps reflected the number of CSPs in the sample. Four interviewees stated that enterprises can benefit from the disaster recovery and business continuity provided by cloud computing. One participant pointed out that small businesses rely on individual people to build their own IT services, but that there might be difficulties contacting these individuals when maintenance or expansion was required.

Two participants argued that security should be seen as a driver to move to the cloud. The example given was that multiple sites were used in three different cities, offering high availability and disaster recovery. Two Interviewees who provide a public cloud, stated that CSPs can provide more security than large enterprises that work in non-IT industry sector and justified this statement by saying that while enterprises focus on their core business and give less attention to IT issues, CSPs builds expertise over the years and has the capability, both in human and IT resources, to implement strong security.

4.4.3.3 Economic benefits

As discussed in chapter two, there is a considerable body of literature claiming that cloud computing offers cost-effective IT resources. All interviewees but one claimed that cost saving is one of the biggest factors that attract enterprises to move to cloud. Three participants stated that small enterprises could benefit from cloud computing, giving as an example that the cost of one employee could equal to the cost of a cloud service. Ten interviewees considered cloud computing benefits start-up enterprise by lowering the up-front cost. Most of those who participated in the field study agreed that transferring expenditure from the Capex to the Opex model was attractive to customers.

A different view was expressed by an interviewee who had been involved in a project to migrate the IT infrastructure to a private cloud. He said that the project was expensive to migrate, but in the long term it would save operational costs. This reflects the fact that establishing a private cloud has a different up-front payment model to using a hosted service.

4.4.3.4 Organisational benefits

The organisational benefits, cited by almost half the participants, were seen as enabling enterprises to focus on their core business. In addition, one participant claimed that using a cloud solution would enable the enterprise to retain its IT staff while changing the way in which they manage IT infrastructure, freeing up IT staff to focus on adding business value by providing solutions to support operations. It is accepted that most of the interviewees were from CSPs, but this result matches those reported from the literature in chapter two (Oliveira et al., 2014).

Half of the interviewees argued that cloud computing could support enterprises in becoming more competitive in their markets, because cloud computing would free up IT expertise from provisioning physical resources to support business goal by providing the solutions. Secondly, the short lead time in provisioning resources could support enterprises in producing their applications and services in a short time.

4.4.4 Impact of organisational characteristics on cloud adoption

As discussed in chapter two, cloud migration decisions are influenced by organisational characteristics such as size, status and industry sector. Figure 4-1 shows factors impacting on cloud migration decision. Six factors which could affect the decision on cloud computing adoption were identified from the literature review and technology adoption theories; enterprise size, industry sector, enterprise status, organisation readiness, technology diffusion and competitive pressure.

Figure 4-1 shows that enterprise readiness and technology diffusion were identified in the interviews to have the most impact on cloud computing adoption decision. The interviewees claimed that start-up enterprises find it easier to adopt cloud computing. Enterprise readiness, enterprise size and industry sector were found to have less impact on cloud adoption decisions. One participant stated that because cloud adoption in Saudi Arabia is slower, it is difficult to say if these factors influenced the cloud migration decision. However, in general, the SMEs are more likely to adopt cloud computing.

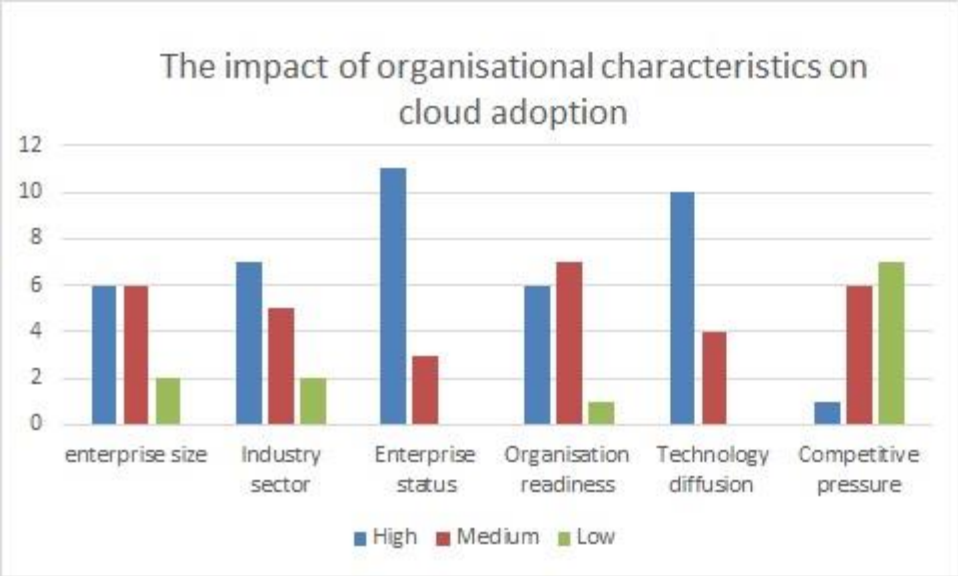


Figure 4-1: The impact of organisational characteristics on cloud adoption

4.4.5 IT infrastructure readiness

One of the objectives of this study is to investigate the IT infrastructure readiness in Saudi Arabia for cloud computing industry; Figure 4-2 illustrates the findings. The IT infrastructure readiness was classified based on Kurdi et al. (2011) from three different perspectives: technology readiness, organisational readiness and the framework for regulation readiness.

Most participants felt that technology readiness in Saudi Arabia was high, and in two cases that it was very high in major cities. Almost half of the participants argued that the most business in Saudi Arabia is conducted in major cities, which makes cloud computing adoption easier. However, this argument represent the views of the CSP who provide the IT services in major city.

In terms of organisational readiness, almost 80% of interviewees stated that organisational readiness is still between low and medium. One participant stated that "there is still negative attitude toward technology from some decision makers".

In the case of framework for regulation readiness, all participants claimed that the regulation readiness is low, and it was argued that the limitations of existing regulation could slow the cloud computing adoption rate in Saudi Arabia. It was also claimed that standardisation is an important factor which is missing in Saudi Arabia to avoid vendor lock-in.

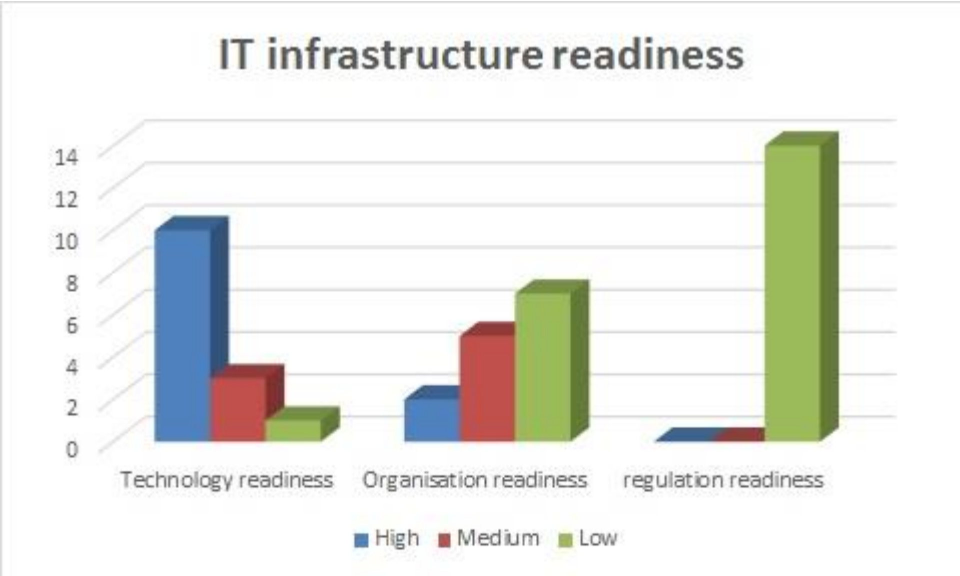


Figure 4-2: IT infrastructure readiness in Saudi Arabia

4.5 Discussion

As noted previously, the issues involved in cloud adoption decision were considered under five main headings pertaining to technological, economic, security, organisational and regulation factors.

4.5.1 Technological dimension

The current study found that the technological issues could be divided into the three sub categories of internet connectivity, integration with existing system and complexity of existing systems. The analysis, as discussed in 4.4.2 shows that the complexity of existing systems is the most challenging technological issue. This result differs from two recently published studies by Gangwar et al. (2015) and Phaphoom et al. (2015); the former concentrated on India, while the latter claimed to be global, although over 77% of the participants were from Europe and North America. A possible explanation of this might be lack of IT expertise in Saudi Arabia compared with India, Europe and North America. Integrating cloud services with in-house system was seen as a barrier to the adoption of cloud computing by half of interviewees, in agreement with previous studies (Yeboah-Boateng & Essandoh, 2014; Phaphoom et al., 2015). In contrast with other findings (Yeboah-Boateng & Essandoh, 2014; Doherty et al., 2015) based on studies carried out in Ghana and Ireland respectively, internet connectivity appeared to be the least important inhibitor, as only four interviewees considered it to be an issue. This variation may be due to the nature of cloud adoption in Saudi Arabia, which is in its early stage; cloud consumers are few and are located in major cities, which means the internet connectivity issue has not been fully tested yet.

4.5.2 Security dimension

The CSPs who took part in the interviews identified data security and privacy as the main client concerns comprising a barrier to adopting cloud services. This result is in line with previous studies from different technology diffusion contexts (Lian et al., 2014; Yeboah-Boateng & Essandoh, 2014; Phaphoom et al., 2015). These results confirmed the discussion in chapter two in regard to issues of data confidentiality. In addition, the lack of trust between CSPs and cloud consumers was seen as a barrier to adopting cloud by about a third of interviewees. This finding corroborates previous studies (Yeboah-Boateng & Essandoh, 2014; Doherty et al., 2015). As discussed above, one of the main differences between technologically developed and technologically developing countries is that enterprises in the former may have previous experience of off-site IT provisioning, such as outsourcing, which creates a climate in which enterprises are more prepared to build trust with third party. Consistent with previous studies (Yeboah-Boateng & Essandoh, 2014 Doherty et al., 2015; Phaphoom et al., 2015), low availability was not found to be a barrier. It should be noted however this is a CSP point of view, while different issues were identified by some cloud consumers, as discussed in the next chapter.

4.5.3 Economic dimension

Two elements were highlighted in the findings, one related to CSPs, which is the lack of funding to support IT services to provide cloud services. The second is related to cloud consumers, which is actually a consequence of the first issue, reflecting the high cost of cloud service compared to technologically developed countries. This result is consistent with other studies carried out in Saudi Arabia (AlBar & Hoque, 2015; Tashkandi & Al-Jabri, 2015). In the case of lack of funding, although Alshamaila (2013), Doherty et al. (2015) and Phaphoom et al. (2015) did not investigate the impact of lack of funding for cloud project, several studies indicated that the lack of funding from government might limit cloud adoption in the education and health sector (Parakala & Udhas, 2011; Surya & Surendro, 2014). In addition, some industries need more investment and funding from the public and private sectors to provide appropriate solutions; Ruan et al. (2013) claimed that there is a lack of funding for cloud forensics.

4.5.4 Organisational dimension

Based on the results of analysis of interviews, organisational factors have been seen as the most important barrier. Lack of knowledge and the lack of top management support are the most significant inhibitors to the adoption of cloud services in Saudi Arabia. This result is consistent with findings obtained by Yeboah-Boateng and Essandoh (2014). These two inhibitors suggest the differences between technologically developed and developing countries. A survey carried out in Ireland found that the enterprises are more likely to adopt cloud because they are knowledge intensive companies (Doherty et al., 2015).

4.5.5 Environmental issues

Two environmental factors were identified from the analysis as possibly inhibiting the decision to move to cloud computing. The first relates to lack of regulation and also to the impact of existing regulation. It is not permitted to store citizens' data outside the country in KSA, and some sectors such as the financial sector also restrict data being stored outside the company. For example, rule 17 by SAMA (2008) stated that "the data must be kept by the company in the Kingdom". This result contrasts with previous studies (lshamaila et al., 2013; Yeboah-Boateng & Essandoh, 2014; Doherty et al., 2015; Gangwar et al., 2015), albeit there is agreement on specific comments concerning the lack of standardization inhibiting cloud migration decision (Yeboah-Boateng & Essandoh, 2014; Doherty et al., 2015).

External support, whether from government or IT providers, was identified as an issue in Saudi Arabia. The findings indicate that the small number of CSPs and the resulting low level of competition between CSPs are linked to the slow adoption rates in KSA. This result further supports the view that government support is an important factor in influencing the adoption of technology in technologically developing countries (Alghamdi et al., 2013). The findings from our study should be considered alongside those of Doherty et al. (2015), discussing a technologically developed economy, who argued the Irish government should ensure there is adequate investment and improve the IT infrastructure to support cloud computing adoption. In contrast, the lack of CSPs support was found to be a barrier to adopt cloud in Saudi Arabia, corroborating Alshamaila et al. (2013). In addition, government initiative is important to encourage both government agencies and the private sector to adopt cloud, as in Italy (Rossignoli et al., 2016), Malaysia (Abolfazli et al., 2015) and Taiwan (Parakala & Udhas, 2011).

4.6 Implications of this study

The findings from this preliminary study, together with the findings from the literature review and the hypotheses discussed in chapter three, were used in the next stage of the research to support the development of a survey to examine in more detail and with a larger group of users, the issues that surround decision making for the adoption of cloud computing. In the preliminary study discussed in this chapter, organisational issues were seen as the most critical factors affecting cloud adoption decision making. This contrasts with the findings of Phaphoom et al. (2015), who determined that the most influential factor was the technological context. However, one possible explanation of that is the background of the participants of this study mainly is technical while in Phaphoom study the background of the participants came from different areas including IT (24.15%), CEO/VP (15.34%), sales/business development (13.64%) and the rest from different backgrounds. Most of interviewees in the research presented here argued that lack of knowledge about cloud computing is the major challenge inhibiting the adoption of cloud computing. These findings must be understood in the context of the development of cloud computing in a technologically developing environment.

Overall, participants rated organisational readiness to adopt cloud services as medium while some interviewees identifying a resistance to accept change. Paradoxically, technological readiness in Saudi Arabia was rated as high, and the issues were felt to relate to decision makers' attitudes (i.e. at the director level) toward technology. The majority of respondents were involved with CSP and were therefore able to evaluate the problem from the perspective of suppliers of technology. It has been suggested that while technology adoption by the individual is high, organisationally, it is still at an early stage and there is ten-year time lag compared to technologically developed countries (Participant 1).

These findings suggest that in addition to other factors which deter enterprises from adopting cloud computing, one of the main inhibitors in Saudi Arabia are regulatory and organisational issues. In the case of the regulation issues, it was suggested that the government and private sector need to work together to create a regulatory framework for the cloud computing industry and to launch initiatives to encourage the business community to invest more in cloud industry. One of the issues raised during the interviews was that there is a lack of IT resources, including human resources, to support SMEs in developing cloud computing in Saudi Arabia. In terms of organisational issues, the discussion above shows that there are three main organisational factors that affect cloud adoption decision making: lack of knowledge about cloud computing for decision makers, low commitment from top management and lack of support from CSPs. This demonstrates a need for a strategic approach to support cloud migration decision making and a need for structured support for decision makers dealing with the issue of cloud computing adoption both in Saudi Arabia and in other similar technologically developing environments.

4.7 Conclusion

This chapter discussed the findings of initial fieldwork which involved interviews carried out with 14 different subject experts in five different enterprises. The findings highlighted the main drivers for CSPs to provide cloud services in and the issues and benefits related to cloud computing in Saudi Arabia. The study suggested that security concerns, lack of knowledge about the cloud and lack of regulation are the main barriers to adopting cloud services while access to better IT capability and cost-effectiveness are the main drivers for enterprise to adopt cloud solutions. This preliminary study found that enterprise status and technology diffusion play an important role in cloud adoption decision. In contrast, competitive pressure was not found to impact on cloud adoption. In the context of Saudi Arabia, technological readiness was not seen as a barrier to cloud computing adoption while organisational issues were considered to have a major impact. The next chapter discusses the survey, which explored the issues identified in this preliminary study and in the literature review in more depth from cloud consumers' perspectives.

Chapter 5: Questionnaire Findings

5.1 Introduction

This chapter discusses the survey conducted in Saudi Arabia about cloud computing adoption. The aim of this study is to identify the drivers and barriers that influence the adoption of cloud computing in Saudi Arabia to support the development of a cloud migration framework and supporting models. The questionnaire was developed based on the results of the literature review discussed in chapter two, the hypotheses discussed in chapter three and the preliminary fieldwork discussed in chapter four. This chapter describes the conduct of the survey, the data collected and the way in which the data was analysed and presents the results of the survey.

5.2 Purpose of the survey

The aim of this survey was to investigate motivation and issues related to cloud computing adoption in Saudi Arabia. In addition, this questionnaire tests the hypotheses developed in chapter three and the conclusions from the literature review and the interviews in order to determine the main factors that influence cloud migration decision making to support the development of the cloud migration decision making framework and supporting models. A further motivation for the survey was that the literature review had found that there is currently no empirical study which investigates cloud adoption in Saudi Arabia from an enterprise perspective although some work has been done in the higher education sector (Tashkandi & Al-Jabri, 2015) and on individual rather than enterprise attitudes to cloud computing adoption (Alharbi, 2012). The preliminary fieldwork carried out as part of this research focused on interviews with CSPs in KSA, and the conclusion from those interviews was that the cloud adoption rate in Saudi

Arabia is slow. This survey focussed on the issues and benefits of cloud adoption from the cloud user perspective, looking at enterprise views. An additional motivation for the survey was that the use of a questionnaire enabled us to seek enterprise views about cloud computing adoption and examine issues from a user as well as a CSP perspective.

The questionnaire was developed based on technology adoption theories, particularly the TOE framework and the DOI theory, as discussed in 3.10, and the hypotheses developed from these theories and from the interviews, as discussed in 3.11 and 3.12 and summarised in Table 3-1. The questionnaire was designed in four parts and was aimed at enterprises, not individuals, since the focus of the research is about cloud computing adoption at the organisational level. It was for this reason that we restricted participation in the survey to individuals with relevant knowledge and experience. For this reason, in the first section we asked participants about their role within the enterprise. The first section collected data about the enterprise, asking about enterprise sector, size and status. This data was required to allow us to examine whether there were any relationships between, for example, enterprise size and cloud adoption or type of enterprise and cloud adoption. The second section asked about cloud deployment model decision making and the factors which influenced the choice of cloud deployment model. The third section asked about choice of cloud service provider and the factors that influenced the choice of cloud service provider. The final section in the questionnaire consisted of three multi-part questions which each used a Likert scale. The first question in the section investigated factors which might restrict migration to the cloud, the second investigated technological factors in relation to cloud computing adoption and the third investigated benefits and assumptions about cloud computing adoption. All the questions in the survey are linked to one of the hypotheses developed in chapter 3.

5.3 Description of the survey

5.3.1 Development of the survey

The survey questions were developed based on the hypotheses discussed in chapter four, which were derived from the literature review and informed by the TOE framework and DOI theory. Some of the questions in the survey were in addition developed from the preliminary fieldwork, which highlighted elements important in the context of KSA.

Questionnaires can be administered by an interviewer or self-administered by respondents (Brace, 2013). A self-administered survey was used in this study to obtain a larger number of respondents across the large and formidable terrain of the country with constant of the study cost in time and resources. A closed question approach was used as this reduces the time taken to complete the survey and is more likely to encourage a higher response rate.

5.3.2 Constraints of the study

As reported from the preliminary field study and supported by the findings of a survey conducted by KSA state Communication and Information Technology Committee (CICT, 2014), which investigated the ICT market in Saudi Arabia, the adoption of cloud computing technology in the country has been slow, limiting the number of enterprises with the necessary background to take part in the research. The implications of cloud computing technology and the available infrastructure in KSA meant that micro enterprises did not form part of the study. The level of technology engagement in KSA can be gauged from the fact that only 11% of enterprises in KSA provided e-payment facilities for their clients as of 2010 (CITI, 2010). A requirement for participation in our survey was that the respondents representing enterprises had some knowledge of and/or involvement with cloud computing. This again limited the number of potential respondents. As the research was examining cloud computing from an enterprise perspective, the aim was to secure responses from enterprises rather than individuals, with the intention that each response provided information about an organisation rather than about the views of an individual.

5.3.3 Identification and selection of respondents

The sample frame refers to the set of people/enterprises from the targeted population that have an opportunity to be selected to participate (Fowler & Floyd, 2008). One of the objectives of this survey was to examine whether enterprise size and industry sector have a significant impact on the adoption of cloud computing. Therefore, the sample was designed to include participants from different types of enterprises and industry sectors and take into account both government sector organisations and private sector organisations. However, as noted above, micro enterprises were excluded on the grounds that these enterprises would not meet the participation criteria for the survey.

Two approaches were used to select the respondents. A major cloud services provider called ELM was selected to distribute questionnaire to their clients. There are a number of reasons why ELM was an appropriate choice. ELM is one of the largest CSPs in KSA and provides government e-services to businesses and individuals, meaning that it had perhaps the largest technology adoption contact list in KSA. ELM clients include government and private sector organisations and ELM has clients from all enterprise sizes and industry sectors and serves both established and start-up companies. ELM is one of the few CSPs in Saudi Arabia providing a range of cloud services. ELM supported the research and agreed both to pilot the questionnaire and to distribute the questionnaire to its customers. In addition, the questionnaire was also distributed to customers of a start-up CSP called Gulf Cloud. Gulf Cloud provides a SaaS.

To avoid selection bias that all respondents came from one or two CSPs, the survey was also distributed using the professional network, LinkedIn but limited to respondents in KSA. LinkedIn has a Premium service which allows to the user to full profile viewing and send email to any member without need to send invitation. This service allows the researcher to reach to targeted samples in efficient way. As discussed in 3.4, enterprise social networks play an important role in sharing knowledge and for this reason LinkedIn was seen as an appropriate forum. A set of criteria was developed to select participants as follows. The participants should be in a position to allow them knowledge of enterprise decisions/plans regarding cloud adoption, should not have previously completed the questionnaire, and should have knowledge of cloud computing. In addition, each enterprise was represented by only one participant. For reasons of participant confidentiality we do not identify which responses were received from CSP contacts or LinkedIn.

5.3.4 Content validity

Validity refers to “the degree to which a measure accurately represents what it is supposed to measure” (Hair et al., 2006, p. 8). Content and construct validity were used to ensure the validity of the questionnaire.

Content validity refers to an appropriate way of measuring whether the construct items represent the proposed concepts that the survey intends to measure (Rattray & Jones, 2007). Bryman and Hardy (2004) argued that expert judgement could be used to establish content validity. Straub et al. (2004) claimed that content validity components are literature review and expert panel or judges. The content validity of this survey was established through the extensive literature review of technology adoption, including cloud computing, e-business, mobile and RFID, underpinned by theories on technology adoption and supported by the interviews conducted during the first stage of the fieldwork.

Construct validity refers to "how well the items in the questionnaire represent the underlying conceptual structure" (Rattray & Jones, 2007), which can be understood as how well the items measure the construct (Straub et al., 2004). Pallant, (2007) argued that principle component analysis (PCA) could be used to measure construct validity. PCA can be measured using factor analysis through Bartlett's test and Kaiser-Meyer-Olkin (KMO) (Pallant, 2007). The KMO values vary from 0 to 1, with values greater than 0.5 indicating that construct validity is acceptable (Pallant, 2007). Other studies gave different acceptable values; Hair et al. (1998) claimed that a factor greater than 0.35 is acceptable (Al-Jabri & Sohail, 2012). The Bartlett and KMO test were applied to the factors used in this questionnaire and all items were found to have a value greater than 0.50, with the exception of H3Q1, H3Q3 and H14Q2, which were found to be 0.383, 0.432 and 0 430, respectively. This complies with the values given above and all the factors have been confirmed from the literature review and findings of interviews. The results of Bartlett's tests and KMO are explained in Appendix D.

5.3.5 Piloting the survey

Piloting the questionnaire is a process to determine questionnaire reliability, validity and error testing (Brace, 2013). Therefore, to enhance the internal validity of the questionnaire, a pilot study was conducted in two phases. The questionnaire was developed with two versions (Arabic and English) as shown in appendix C. The first stage of the pilot was conducted to test participant comprehension of the questionnaire, to ensure the two versions provided the same meaning, and technical compatibility with different devices (laptop, IPad and smartphone). Eight questionnaires were sent to IS professionals from industry and academia who speak Arabic and English fluently. A second phase of the pilot study was conducted at ELM Company by their marketing team, who have experience in questionnaire design and analysis. Some changes were made following comments from the two pilot groups, including changes to some phrasing in Arabic to ensure that both language versions had the same meaning, and to provide more clarity.

5.3.6 Administration of the survey

The questionnaire was distributed using a web-based questionnaire platform (Survey Monkey). Two versions were available, one in Arabic and one in English. The links of both version of questionnaire were sent to ELM and Gulf Cloud. In addition, approximately 100 emails were sent using LinkedIn. After two weeks, reminders were sent. After the deadline of the questionnaire collection time, 103 responses were received, of which 81 were evaluated as valid and included in the analysis. As noted in section 5.3.3, the survey was designed to collect responses from organisations, not individuals, and these figures represent the participation of 81 separate organisations. Some questionnaires were excluded from analysis either because the questionnaire was not completed in full, some questions were left blank, responses to more than five questions were unclear, or the same answer was selected for all questions (due to internal validity).

5.4 Data analysis

This study used two types of statistical data analysis, descriptive statistics and inferential statistics. Descriptive statistics cover frequency, percentage and measures of central tendency. Inferential statistics were used to draw a conclusion from collected data by testing the hypotheses. The descriptive statistics analysis shows the frequency data about participants, including enterprise size, industry sector, and enterprise status and percentage of cloud adopters in terms of size, sector and status. Central tendency measures are to identify the mean and median of cloud computing drivers and barriers. Inferential statistics approaches are the chi-square test (to test the relation between cloud adopter), and enterprise characteristics (size, status and industry) and logistic regression, to test the hypotheses. The chi-square test is used to test the relationship between two nominal variables (Altinay & Paraskevas, 2008).

This study developed three categorical variables (size, status and industry) in order to examine the relationship between these variables and cloud adoption. Therefore, the chi-square test was used to examine the relationship between the enterprise characteristics and cloud adoption. The second test used in this study is logistic regression, which is a method that used to test the relationship between the dependant variable and independent variables. For reasons of space, some of the graphs and data visualisation produced as part of the analysis are not shown in this chapter, but are included in Appendix D.

5.4.1 Cloud adoption within enterprises

To address the factors affecting cloud adoption, respondents were asked if their enterprise had moved to cloud computing or planned to in the future; 51.9% of those surveyed indicated that their organisation does not have plans to move to cloud computing, while 48.1% (n=39) have already migrated to the cloud or plan to do so. A global study conducted by Phaphoom et al. (2015), mainly regarding Europe and North America (as explained previously), found that cloud computing adopters represent approximately 57%, while the non-adopters represent only 42.6%; thus the rate of cloud computing adoption in Saudi Arabia found in this survey is comparable to that in technologically developed countries.

However, there is a major difference between the studies in that this study classifies the adopter and the enterprise that plans to adopt in one group and the non-adopter and the enterprise that has no plan to adopt in another. In contrast, Phaphoom et al. (2015) considered only adopters and non-adopters. When this is taken into account, the adoption rate is significantly greater in technological developed countries than in technologically developing countries. The finding from the questionnaire used in this research is supported by the views expressed by CSPs in the preliminary fieldwork.

5.4.2 Industry sectors

Error! Reference source not found. shows the enterprises that participated in this survey in terms of the industry sectors to which they belong. ICT companies represent the highest number of respondents (n=14). Among the industry sectors, the retail sector represents the highest percentage of cloud computing adopters, with an adoption rate for this section of 80% of respondents, followed by the telecommunication and information technology with an adoption rate of 71%. The respondents in the survey were selected because of their knowledge of cloud computing and this way may have influenced the responses. In contrast, the figure shows that the banking and financial sector have the lowest percentage, and approximately 77% of them have not adopted cloud computing. One reason why bank and financial sector has the lowest rate of cloud adoption is that the Saudi Arabian Monetary Agency (SAMA) sets rules that restrict data migration beyond enterprise firewalls.

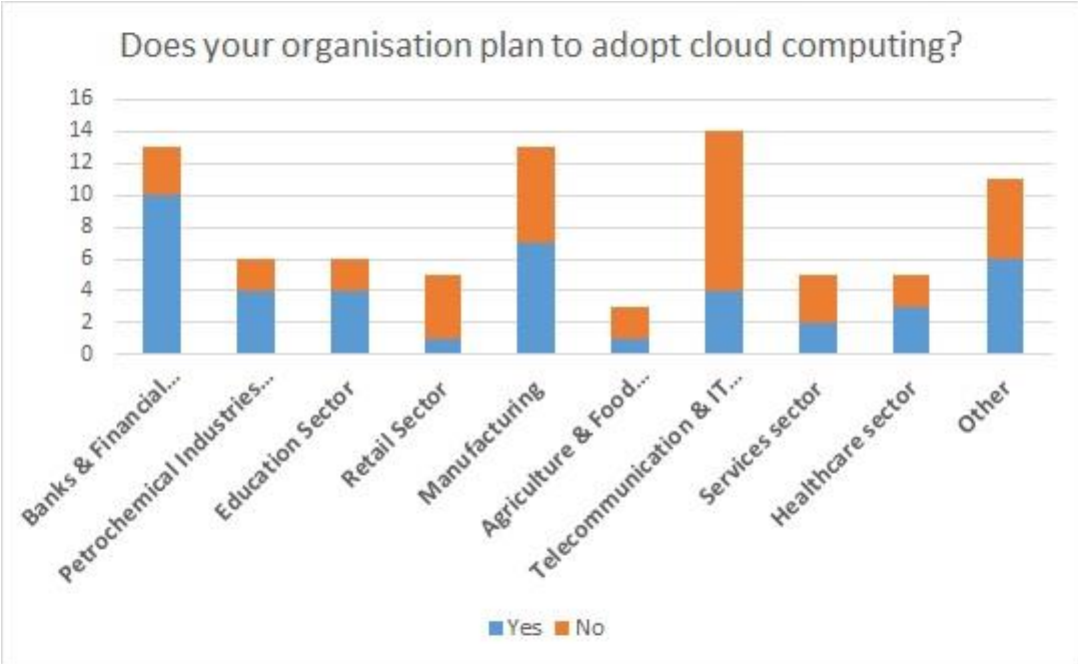


Figure 5-1: Distribution of cloud computing adoption based on industry sector

In addition, participants were asked to indicate whether their enterprises work in private or government sectors. It can be seen that more than half of the organisations represented belong to the government sector, which plays a major role in the Saudi economy. When Al-Gahtani (2003) carried out a study to investigate technology adoption in Saudi Arabia, he reported that the 66.4% of participants were from the public sector while only 33.6% were private.

The relationship between sector and cloud adoption was investigated using the chi-square test. No significant differences were found between private and government sectors in terms of adopting cloud computing (chi-square test X2(1), p=0.448). However, the cross tabulation shows that the 52.5% of enterprises belonging to the private sector have adopted or plan to adopt cloud computing, compared to less than

45% in the state sector. This could be explained by the state sector being concerned with more sensitive data than private firms.

5.4.3 IT assessment level

To gauge IT readiness within enterprises, the questionnaire identified six applications to examine the relation between IT readiness and adopted cloud computing. Table 5-1 shows that there is no significant relationship between IT maturity level and the adoption/planned adoption of cloud computing.

	Email	*Webpages*	*Eservices portal*	*Transaction processing systems*	*Enterprise resources planning*	*Business intelligence*
Percentage of application usage	82.1	78.75	71.1	71.1	59.2	35.8
Adopted	54.7%	52.4%	53.7%	51.9%	45.2%	50.0%

Table 5-1: Relationship between cloud adoption and IT maturity level

5.4.4 Enterprise size

Enterprise size is one of the most accepted indicators for the adoption of new technology. This study divided enterprise size into three categories: small (11 – 50 employees), medium (51 – 250 employees), and large (over 250 employees). It should be noted that micro industries were not part of the target sample for this questionnaire. Table 5-2 illustrates the distribution of enterprises according to its size. As shown in Table 5-3, the chi-square test $X^2(2)$ =2.04, p=0.361 shows that enterprise size does not have a statistically significant impact on cloud adoption. However, Table 5-2 shows that more small and medium enterprises adopted or plan to adopt cloud services than the large enterprises. A possible explanation for this might be the small and medium enterprises have a lack of resources to build their own IT services in-house, thus the cloud could offer them high quality IT services at low cost. In addition, the benefits of cloud computing for large enterprises could be limited by the complexity of their legacy IT systems.

Enterprise size	*Frequency*	*Adopted or plan to adopt*
Small	18	55.6%
Medium	13	69.2%
Large	50	40%
Total	81	

Table 5-2: Relationship between cloud computing adoption and enterprise size

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.040[a]	2	.361
Likelihood Ratio	2.048	2	.359
Linear-by-Linear Association	1.357	1	.244

Table 5-3: Chi-square test for enterprise size

5.4.5 Enterprise status

Enterprise status is divided into two categories, namely start-up and established enterprises. Almost 70% of enterprises involved in this survey were classified as established companies. There is only about 40% of established companies have or planned to adopt cloud computing, compared to 85% of start-ups. Further analysis using chi-square test $X^2(2) = 0.001$ showed that enterprise status has a significant impact on the adoption of cloud computing.

5.4.6 Cloud computing service models

Enterprises in Saudi Arabia use a range of cloud service models. The results show that for enterprises in this survey there is no relationship between industry sectors and cloud service models except that the banking and financial service sector uses only IaaS. This is perhaps to be expected given the restrictions on the location of financial data in force in KSA and size of the financial sector, making it better able to afford a cloud service model which is likely to have high start-up costs. Table 5-4 shows that there is no association between cloud service models and enterprise characteristics. However, the most used cloud service models are IaaS and SaaS. One possible explanation is that, as reported in the preliminary field study discussed in chapter five, local CSPs typically provide SaaS and IaaS and there is little provision of PaaS services.

	IaaS	*PaaS*	*SaaS*
Government sector	57.90	10.52	42.10
Private sector	35	65	80
Small enterprise	30	50	50
Medium enterprise	44.44	44	88.88
Large enterprise	55	30	55
Established enterprise	22.72	22.72	40.90
Start-up enterprise	76.47	58.82	88.23

Table 5-4: Percentage usage of cloud service models by enterprise characteristics

5.4.7 Cloud computing deployment models

Figure 5-2 illustrates the distribution of cloud computing deployment models. The public cloud represents the highest usage of cloud deployment model, followed by private cloud. Many different factors play an important role in selecting cloud deployment model. To begin with industry sector, the results obtained from cross-tabulation show that almost 42% of the government sector adopted a private cloud, while the private and hybrid cloud was adopted by 21.1% and 15.8% respectively. Private cloud adoption is greater in the government sector than in the private, possibly reflecting the sensitive nature of government data and the greater resources available at the government level. In contrast, about 62% of the private sector adopted private cloud, while only 19% of them selected public cloud. The 15% of enterprises in private sector use hybrid cloud. Figure 5-3 shows the distribution of cloud deployment models in respect with enterprise sectors.

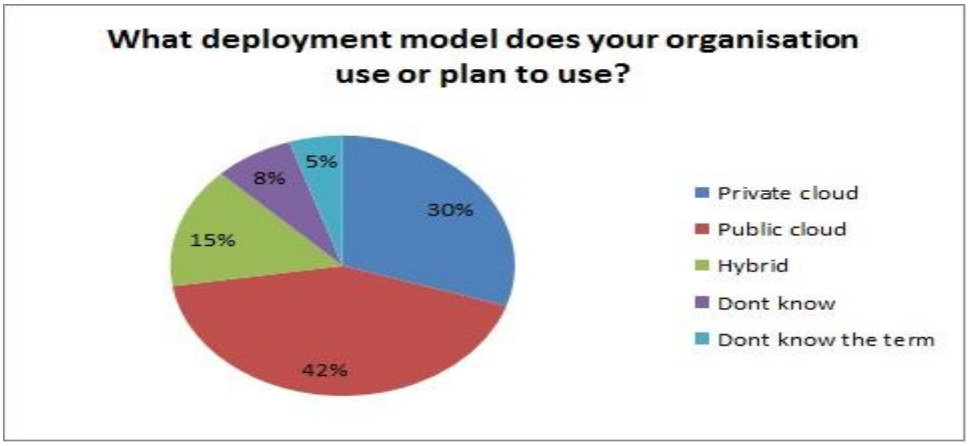


Figure 5-2: Distribution of cloud deployment models by enterprise type

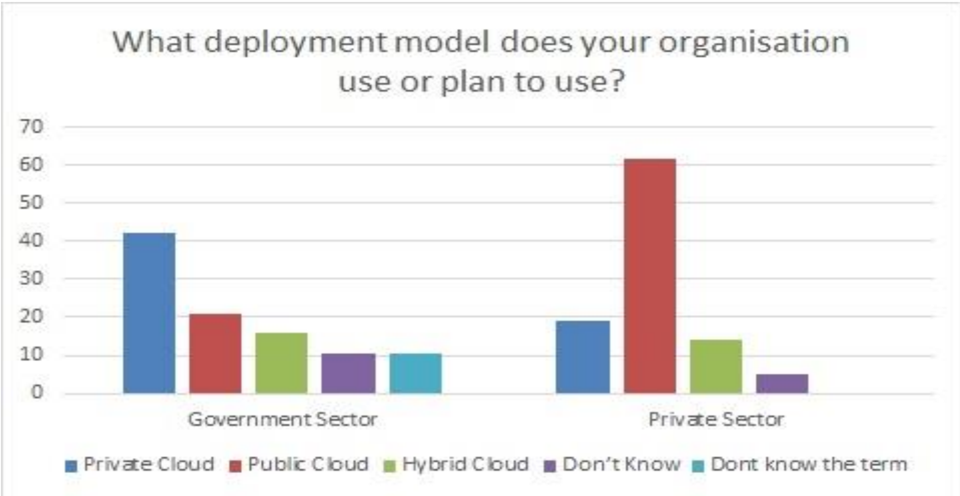


Figure 5-3: Distribution of using cloud deployment models by sector

The second perspective associated with cloud computing deployment selection is enterprise characteristics. Cross-tabulation was used to examine the association between enterprise characteristics (size, sector and status) and cloud deployment model. Table 5-5 shows that the public cloud is preferred by small, medium and start-up enterprises. In contrast, the private cloud is more likely to be used by large and established enterprises. However, a chi-square was used to test the significance of relationship between enterprise characteristics (size, sector and status) and selection of cloud deployment model. The test shows that enterprise status is the only factor that has a statistically significant impact on the selection of cloud deployment models.

	Small	*Medium*	*Large*	*Start-up*	*Established*
Private	20.0	22.2	38.1	17.6	39.1
Public	70.0	44.4	28.6	52.9	34.8
Hybrid	0.0	22.2	19.0	0.0	26.1
Don't know	10.0	0.0	9.5	17.6	0.0
Don't know terms	0.0	11.1	4.8	11.8	0.0

Table 5-5: Percentage of enterprise types adopting cloud computing deployment models

5.4.8 CSFs for selection cloud deployment models

Several factors have been identified from literature review that affect the selection of cloud deployment models. Table 5-6 shows that cost, security and focus on core competency are the most important factors considered when selecting cloud deployment models. However, all factors are important, as they are rated over 3.7.

Factors to select cloud deployment model	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
Cost	1.00	5.00	4.13	.97817
Security	2.00	5.00	4.54	.68234
Focus on core competency	1.00	5.00	4.03	.93153
IT capability within your organisation to manage your IT services	1.00	5.00	3.74	1.04423
Keep control of data and resources in-house	2.00	5.00	3.7	.97194
Data location	2.00	5.00	3.79	1.00471

Table 5-6: Critical success factors to select cloud deployment model

5.4.9 Cloud adoption motivation

The literature has identified many reasons to move to cloud computing, such as saving cost, focus on core competency and increase IT efficiency. However, as discussed in section 1.2, few empirical studies have been conducted on cloud computing adoption in technologically developing countries. Consequently, this survey asked respondents who plan to migrate to cloud or who have already migrated, about the motivation for moving to the cloud. Table 5-7 shows that the first four reasons that attracted enterprises in this study to move to cloud are (in descending order) to ensure high availability of the service, get reliable IT service, reduce the cost of IT and increase efficiency respectively. In contrast, a study conducted in UK by Sahandi et al. (2013) identified the main reasons to use cloud services as cost reduction, accessibility and flexibility and scalability.

Drivers to migrate to cloud	*Mean*	*Std. Deviation*	*Rank*
Reduce IT costs	8.35	1.754	3
Ensure high availability of service	8.61	1.34976	1
Get on-demand service	8.28	1.55511	5
Improve security	8.02	1.69344	6
Outsource IT services and focus on core competencies	7.95	1.93239	7
Get reliable IT service (accessibility, continuity and performance)	8.43	1.37257	2
Lack of internal IT resources	7.13	2.40809	9
Keep up with business growth (scalability)	7.87	1.55901	8
Increase efficiency	8.33	1.67542	4

Table 5-7: Reasons to adopt cloud computing

5.4.10 Cloud adoption barriers

Factors that restrict cloud migration were examined in this study to find out the differences and similarity of factors that restrict cloud migration between technologically developed countries and technologically developing countries. As KSA is a technologically developing country, the results of this survey were compared with technologically developed countries by reviewing published papers. The findings shows that as shown in Table 5-8 that data security and service availability are the factors that most concern enterprises in this study to move to cloud computing. Likewise, Sahandi et al. (2013) pointed out that data privacy was found to be the greatest barrier to restrict moving, followed by vendor lock-in. In contrast, the lowest factors found here that restrict cloud migration are loss of IT expertise and difficulty of migrating existing IT system to cloud.

Barriers to migrate to cloud	*Mean*	*Std. Deviation*	*Rank*
Data security	8.25	2.27	1
Availability of service	7.91	2.11	2
cost of services	7.19	2.25	9
Loss of control over resources	7.18	2.28	10
Loss of IT expertise	6.96	2.46	13
Data location	7.45	2.24	6
Vendor locked-in	7.48	1.95	5
Regulation compliance	7.01	2.40	11
Interoperability with existing systems	7.34	2.22	7
Trust in CSPs	7.90	1.83	3
Difficulty of migrating existing system to cloud	6.97	2.109	12
Lack of knowledge about cloud computing	7.28	1.85	8
Absence of government regulations on cloud computing	7.54	2.185	4

Table 5-8: Cloud computing adoption barriers

5.4.11 Enterprise description

The final section of the questionnaire presented respondents with a series of statements with which they were asked to agree or disagree. The design of this section of the questionnaire was directly influenced by the theories on technology adoption discussed in chapter four. Statements were divided into four groups based on TOE and DOI. From DOI we took the concepts of relative advantage, compatibility and complexity. The statements presented to the respondents were used to examine the current state of the enterprises participating in the survey and the enterprise attitude to cloud computing adoption. Appendix D gives the mean figures for all statements. Two statements were agreed upon by the majority of participants, namely that adopting cloud computing will require additional effort and training and adopting cloud computing will reduce the time taken to manufacture products or provide services.

5.4.12 Inferential analysis

As discussed in section 5.4, logistic regression was used to test the hypotheses. Chapter four described the fourteen hypotheses developed from the literature review to support the investigation of the factors associated with cloud computing adoption. The hypotheses serve as the independent variables for the analysis, while the dependent variable is cloud computing adoption. Binary values were used; a rating of 1 was given if the enterprise had adopted or planned to adopt cloud computing and 0 otherwise. The independent variables are shown in Table 5-9.

	No Items	*Minimum*	*Maximum*	*Mean*	*Std. Deviation*
Technology readiness	2	1.50	5.00	3.6914	.74401
Security concerns	3	1.00	10.00	7.8765	1.87116
Technology barriers	3	3.67	10.00	7.2469	1.41792
Organisational readiness	2	1.50	5.00	3.5247	.76199
Firm size	1		Categorical		
Firm status	1		Categorical		
Industry sector	2		Categorical		
Top management support	1	1.00	5.00	3.6790	1.21272
Competitive pressure	3	1.00	5.00	3.7654	.91658
External support	3	1.67	5.00	3.4609	.77919
Government support	2	1.00	5.00	3.1790	1.16003
Relative advantage	2	1.50	5.00	3.8148	.84204
Compatibility	2	1.00	10.00	7.1543	2.07009
Complexity	3	2.00	5.00	3.6914	.73933

Table 5-9: Description of independent variables (hypotheses)

After coding the hypotheses and calculating the mean of the items for each of them, logistic regression was applied. The Wald and Sig columns shown in Table 5-10 were used to test the hypotheses; the Wald provides the chi-square value and the Sig provides the p-value. The independent variable is significant when the P value is less than 0.05 (McDonald, 2009). Consequently, it can be seen from the data shown in Table 5-10 that there are six predictors which were found to statistically significant.

In the technological context, in this survey only security barriers were found to be statistically significant (p=0.008) in relation to cloud computing adoption. In contrast, technological readiness and technology barrier were not found to be statistically significant (p=0.616, p=0.248 respectively).

	B	S.E.	Wald	df	Sig.	Exp(B)
Technology readiness	.391	.780	.252	1	.616	1.479
Security Barriers	-1.147	.435	6.951	1	.008	.318
Technology Barriers	.459	.397	1.336	1	.248	1.583
Organisational readiness	1.989	.946	4.425	1	.035	7.312
Firm Size	-.900	.660	1.856	1	.173	.407
Firm Status	-2.936	1.218	5.811	1	.016	.053
Industry Sector	.619	.888	.485	1	.486	1.856
Top Management Support	1.768	.546	10.476	1	.001	5.858
Competitive pressure	-.176	.935	.035	1	.851	.839
External support	.396	.920	.185	1	.667	1.486
Government support	-1.774	.699	6.453	1	.011	.170
Relative advantage	.606	.900	.454	1	.501	1.833
Compatibility	1.039	.507	4.202	1	.040	2.827
Complexity	-1.080	.751	2.069	1	.150	.340
Constant	-3.611	3.852	.878	1	.349	.027

Table 5-10: The summary of logistic regression test

In terms of organisational factors, three hypotheses were found to be statistically significant, as shown in Table 5-10: organisation readiness, enterprise status and top management support. Firm size and industry sector were not found to be significant.

In the environmental context, only government support was found to be statistically significant p= 0.011. In the case of DOI elements, only compatibility was found significant p=0.040, while relative advantage and complexity were not found to be statistically significant. It is noteworthy that three of these factors belong to the organisational readiness category.

5.5 Discussion

5.5.1 Technological context

The three dimensions of technological context are technology readiness, security concerns and technology barriers. Of these, only security concerns were observed as having a significant relationship with cloud adoption. The impact in this case was a negative one, in that security concerns may inhibit the adoption of cloud computing. This result agrees with findings of result of interviews discussed in chapter four (that security issues represent a barrier to cloud adoption decision). Oliveira et al. (2014) reported that security was not a significant inhibiting factor for cloud adoption, and suggested that this was due to improvements in cloud computing. It is argued here that cloud consumers may have security concerns due to a lack of understanding of security, and that this may reflect the particular issues in technologically developing environments. Enterprises need to understand data security issues and the sensitivity of their data in order to identify security issues and select the most suitable cloud deployment and service models.

Technology readiness and technology barriers were not found to be statistically significant. This result is consistent with the study of Low et al. (2011), who found that technology readiness was not a significant predictor. In terms of interview findings, technology readiness was not found to influence cloud migration in Saudi Arabia. As discussed in section 4.5.5, the findings show that although technology readiness in Saudi Arabia is high in major cities, cloud adoption rate is low. This might be because of differences in attitudes between decision makers in technologically developed and developing countries. This suggests that the barriers to cloud computing adoption in KSA are not primarily technical, but organisational.

5.5.2 Organisational context

Interestingly, three predictors were found to significantly influence the decision on adopting cloud computing: organisation readiness, top management support and enterprise status. From the literature, we had identified only one study which discussed organisation readiness as a factor that influences cloud computing adoption, and this study also found a significant relationship between organisation readiness and cloud adoption (Gangwar et al., 2015). In addition, the findings of interviews discussed in chapter four found that one of the barriers to cloud migration is the low organisation readiness in Saudi Arabia. This is in agreement with the findings of Aldraehim et al. (2012), which showed that organisational culture and readiness can be one of the main barriers to adopting e-services. Therefore, it is argued that enterprises having high organisational readiness are more able to adopt new technology, including cloud computing.

The literature review did not identify any prior studies which examined enterprise status empirically in relation to cloud adoption or technology adoption in general. The results from our study are that enterprise status has a significant impact (p=0.016) on the adoption of computing, as start-up enterprises were found to be more likely to adopt or consider adopting cloud computing. This result confirms the result of chapter four, which indicated that start-up companies were more likely to support cloud adoption. This is largely attributable to start-up companies' lack of existing IT legacy system, which could make the adoption decision more costly and difficult. In addition, start-up enterprises prefer to spend on Opex rather than Capex (Firli et al., 2015).

The results from our investigation show that top management support significantly influences the adoption of cloud (P value at 0.001). This finding is in-line with previous studies (Low et al., 2011; Alshamaila et al., 2013; Borgman et al., 2013; Oliveira et al., 2014; Gangwar et al., 2015). This emphasises that in the technology context, top management support is a key factor in adopting cloud technology; thus, as highlighted in the interviews, one of the main inhibitors preventing cloud adoption is the lack of top management support.

Contrary to the findings of the literature review, the findings of the questionnaire found there is no statistically significant ($p= 0.173$) impact between cloud adoption and enterprise size. However, as discussed in section 5.4.4, medium and small enterprises adopted cloud computing more than larger ones. This study confirmed the interview results, which argued that the enterprise size has impact on general, but in the case of Saudi Arabia, because cloud adoption is generally slow, it is difficult to pinpoint the exact relationship between enterprise size and cloud adoption. Previous studies conducted in UK and Portugal (Alshamaila et al., 2013; Oliveira et al., 2014) found a significant relationship between cloud adoption and enterprise size.

Industry sector was not found to be statistically significant ($p= 0.486$). However, as discussed earlier and shown in **Error! Reference source not found.**, industry sectors with more sensitive data, such as banking and finance, have low a rate of adoption of cloud computing in KSA. Other sectors with less sensitive data have higher adoption, particularly the ICT and services sectors. However, this study differs from the findings of Alshamaila et al. (2013), which found the industry sector is a significant factor. One possible explanation for that is the representation of the different sectors in the survey and also factors specific to Saudi Arabia, such as legal restrictions for some sectors (e.g. finance) on the location of the storage of data.

5.5.3 Environmental context

The environmental context was examined from three dimensions, namely competitive pressure, external support and government support. Only one factor was found statistically significant, which is government support, unlike in the studies of Borgman et al. (2013) and Oliveira et al. (2014). Previous studies have found that in technologically developing countries, government support plays a major role in enabling enterprises to adopt new technology in terms of setting regulations and initiatives (Alghamdi et al., 2011; AlGhamdi et al., 2012). This finding is confirmed by the results of interviews; that the lack of regulation related to cloud computing is the one of the main barriers to increased growth of cloud computing adoption. One of the differences between developed and developing countries is that the private sector rely on government support.

One unanticipated finding from this survey was that external support, in the sense of support provided by CSP, did not significantly affect cloud adoption. Alshamaila et al. (2013) had found that computer supplier support has a significant effect on cloud adoption. However, the results from this survey, supported by comments made during the preliminary fieldwork and interviews, lead to the conclusion that cloud services provided by local (Saudi) CSPs are not yet mature.

In this study, competitive pressure was not found to be a significant factor affecting Could Commuting adoption, which is supported by the findings from interview discussed in section 4.4.4, corroborating Alshamaila et al. (2013) and Oliveira et al. (2014). Conversely, Gangwar et al. (2015) and Low et al. (2011) found that competitive pressure has a significant impact in association with cloud computing. A possible explanation for this is that the studies that found competitive pressure has a significant factor were limited to particular industry sectors: a high-tech industry (Low et al., 2011) or manufacturing, finance and ICT (Gangwar et al., 2015).

5.5.4 Diffusion of innovation

It is somewhat surprising that relative advantage was not found to be a significant factor in this study, unlike in most existing work (Low et al., 2011; Alshamaila et al., 2013; Borgman et al., 2013; Oliveira et al., 2014; Gangwar et al., 2015). However, the findings do not mean the cloud computing does not have a relative advantage, since both adopters and non-adaptors reported some advantage to cloud computing adoption. In addition, relative advantage has the highest mean among all hypotheses, indicating that it is seen as an important element. In the interviews, respondents argued that adopting cloud computing could benefit enterprises in a number of ways such as saving cost, reduced time to produce applications or services, and focusing on core competencies.

Another important finding was that incompatibility has a significant negative impact on cloud computing adoption, This finding is in accord with recent studies that indicated a positive impact of incompatibility on cloud adoption (Alshamaila et al., 2013; Gangwar et al., 2015). Finally, unlike the findings of interviews, the complexity of migrating existing systems did not significantly affect cloud adoption. In the same way, Borgman et al. (2013) and Low et al. (2011) found that the challenge of migrating to the cloud did not have a negative impact on cloud computing adoption. This differs from recent studies affirming that complexity negatively influences cloud computing (Alshamaila et al., 2013; Oliveira et al., 2014; Gangwar et al., 2015). A summary of the findings from the survey is given in Table 5-11.

Technological context		
H1	Technology readiness	Not supported
H2	Security barriers	Supported
H3	Technology barriers	Not supported
Organisational context		
H4	Organisational readiness	Supported
H5	Firm size	Not supported
H6	Firm status	Supported
H7	Industry sector	Not supported
H8	Top management support	Supported
Environmental context		
H9	Competitive pressure	Not supported
H10	External support	Not supported
H11	Government support	Supported
Diffusion of innovation		
H12	Relative advantage	Not supported
H13	Compatibility	Supported
H14	Complexity	Not supported

Table 5-11: Summary of hypotheses testing results

5.6 Results implications

The findings from the literature review, interviews and questionnaire identified five main categories or groups of factors that influence cloud migration decision making: technology, organisational strategy, security, economic and regulatory. Table 5-12 shows the main factors and sub-factors identified from the findings. The findings from the investigation highlighted the main issues related to cloud adoption in Saudi Arabia. A significant finding to emerge from the study is that organisational issues can act as a significant barrier to cloud computing adoption. As discussed in four, and supported by the survey results, lack of knowledge about cloud computing, low commitment from top management support, and organisational readiness are the main issues inhibiting the adoption of cloud computing.

As previously discussed, there are a range of drivers and barriers related to cloud computing adoption. Decision makers in enterprises need to balance between the drivers and barriers, and the relative weight of these factors will differ depending on enterprise-specific issues and the wider business and organisational context. This is illustrated by the fact that although, for example, the general hypothesis that external support is significant was not supported, some respondents/interviewees did identify this as an issue for them. One of the most important findings of the investigation is that although there is some consensus as to the factors which should be taken into account, there are also variations. For this reason, this research adopts a multi-criteria decision making approach, based on knowledge management, to support decision makers as they balance between these barriers and drivers. This will allow decision makers to identify the elements that are significant in an enterprise specific context.

Lack of knowledge of cloud computing and of the issues involved in cloud adoption decisions were identified as issues in the interviews conducted in the preliminary fieldwork and in the analysis of the survey responses. One of the challenges of cloud adoption is that it is a strategic decision, with consequences for the whole enterprise, but as the cloud is a disruptive technology, there is unlikely to be relevant prior experience which can be used to support the decision. This is particularly an issue in a technologically developing environment where, as has been identified for KSA, adoption rates are slower, meaning that expertise is less widely available. The KCADF developed for this research is supported by a Case-Based Reasoning Approach, which will support the sharing of knowledge between enterprises or from project to project within one enterprise. Table 5-11 summarises the critical factors that influence cloud adoption decision. The main factors were identified from the secondary as well as primary research, as discussed in chapters two and four. As discussed in 1.2 these factors are holistic and cover all aspects that influence cloud adoption decision. In addition, some sub-factors were identified from primary research, such as reduced total cost of ownership, lack of knowledge about cloud computing and fast access to new technology; while some sub-factors were identified from secondary research, such as on-demand service and compliance with regulations. Some issues were highlighted in primary research as being specifically related to technology in developing countries, such QoS provided by local CSP, trust in CSP, and lack of knowledge about cloud. Some sub-factors were grouped in one categorisation, such as vendor lock-in and availability. The sub-factors discussed above play an important role in adopted cloud computing. For example, the technical factors attract enterprises to adopt cloud services. In contrast, the security issues could inhabit adopted cloud solutions.

Technical	Economic	Security	Organisational	Regulatory
On-demand service	Reduce IT cost	Data security	Focus on core competency	Data location
Quality of the service	Lower up front cost	Availability of service	Competitive advantage	Compliance with regulation
Fast access to new technology	Convert Capex to Opex	Disaster recovery and business continuity	Loss of IT expertise and knowledge	Standardization
Better IT capability		Trust in CSP	Loss of control over resources	
Flexibility			Lack of knowledge	
			Top management support	

Table 5-12: Critical factors that influence cloud adoption decision

5.7 Conclusion

This chapter discussed the investigation carried out to determine the factors which affect cloud decision making about cloud computing adoption. We used the questionnaire to investigate the hypothesis developed in chapter three. Of the fourteen hypotheses put forward, six were found to be statistically significant. Three of these hypotheses related to organisational factors. One of the significant findings from the survey is that barriers to cloud adoption are related to organisational issues. We also noted that views and priorities differed between decision makers. The following chapter builds on the information obtained through the initial fieldwork and the survey to develop a cloud adoption framework and supporting decision models.

Chapter 6: Cloud Adoption Framework and Models

6.1 Introduction

This chapter presents the Knowledge Management Based Cloud Computing Adoption Decision Making Framework (KCADF) and the supporting models and tools developed to support decision making for Cloud Computing Adoption. In this chapter we first summarise the aims of the Framework and then describe the three models that make up the KCADF and the relationship between the models and the levels of decision making. The first model in the KCADF supports strategic decision making; the second model supports tactical decision making and the third supports operational decision making.

We describe the way in which the levels of the framework interact with each other and with the different levels of decision making. The different tools used at each level of the framework are discussed and a justification is given for the development choices made at each level. We show how the secondary research and the data obtained through the primary research have informed the development of the framework and we present an overall summary of the Framework and the supporting models. The validation and evaluation of the framework are discussed in the following chapter.

6.2 Background

Decision making is a complex process which challenges enterprises (Benítez et al., 2012), because organisational decision making is affected by internal and external and tangible and intangible factors. One such organisational decision is the provisioning of IT services within enterprises. It has been argued that there is a lack of knowledge and reliable approaches to support enterprises when selecting the appropriate IT model for the provisioning IT services (Kauffman et al., 2014). Today, there are three main classes of model for the delivery of IT services; in-house provision, traditional outsourcing and cloud computing, which is sometimes also seen as a form of outsourcing. The literature shows that there is little research that focuses on supporting decision making during the cloud computing adoption process (Alshamaila et al., 2013; Azeemi et al., 2013; Gonzenbach et al., 2014). The primary research identified that a lack of understanding of the issues affecting cloud computing was one of the factors which inhibited cloud adoption. Chang et al. (2013) argued that a structured approach is necessary to manage the challenge of adopting new technology. As discussed in chapter three, we propose in this thesis that cloud computing adoption should be supported by a structured approach based on KM and OL. The process of cloud adoption decision making tends to be ad hoc in enterprises. The existing models and frameworks discussed as part of the literature review do not cover all aspects of cloud adoption and do not guide decision makers on deciding between the different factors. This chapter presents a Knowledge Management Based framework to support decision making for Cloud Computing adoption. The framework takes account of the range of factors that influence decision making for cloud adoption and can be customised to meet the needs of organisations and decision makers, meaning that the Framework is generalisable to different contexts and different technical and organisational environments.

6.3 Overview of Cloud Computing Adoption Decision Making Framework

As discussed in section 3.8.3 there are three levels of decision making: strategic, tactical and operational, each of which deals with a different type of decision. All levels of decision making are involved in the process of cloud computing adoption and the process is divided into three phases, as shown in Figure 6-1, the strategic level which covers the decision as whether to move to cloud computing or not, the tactical level which covers the selection of the cloud deployment model, and the operational level which covers the selection of cloud service model and actual migration.

In the strategic decision making phase, where the decision is taken as to whether or not to migrate to the cloud, the framework employs a cloud adoption decision model, based on an integration of the analytic hierarchy process (AHP) and case based reasoning (CBR) approaches. The AHP element can be used independently but the advantage of the CBR element is that it helps to validate the decision and provides information derived from previous cloud adoption decisions. Tactical decision making is concerned with the selection of the cloud computing deployment model, and the model used at this stage also makes use of an integrated AHP and CBR approach. Operational level decision making, which involves amongst other things deciding on the service module and migration, uses a Pugh Decision Matrix (PDM) and checklist. Figure 6-1 shows the decision making levels and the decision type for each decision and the tools that are used to support each decision.

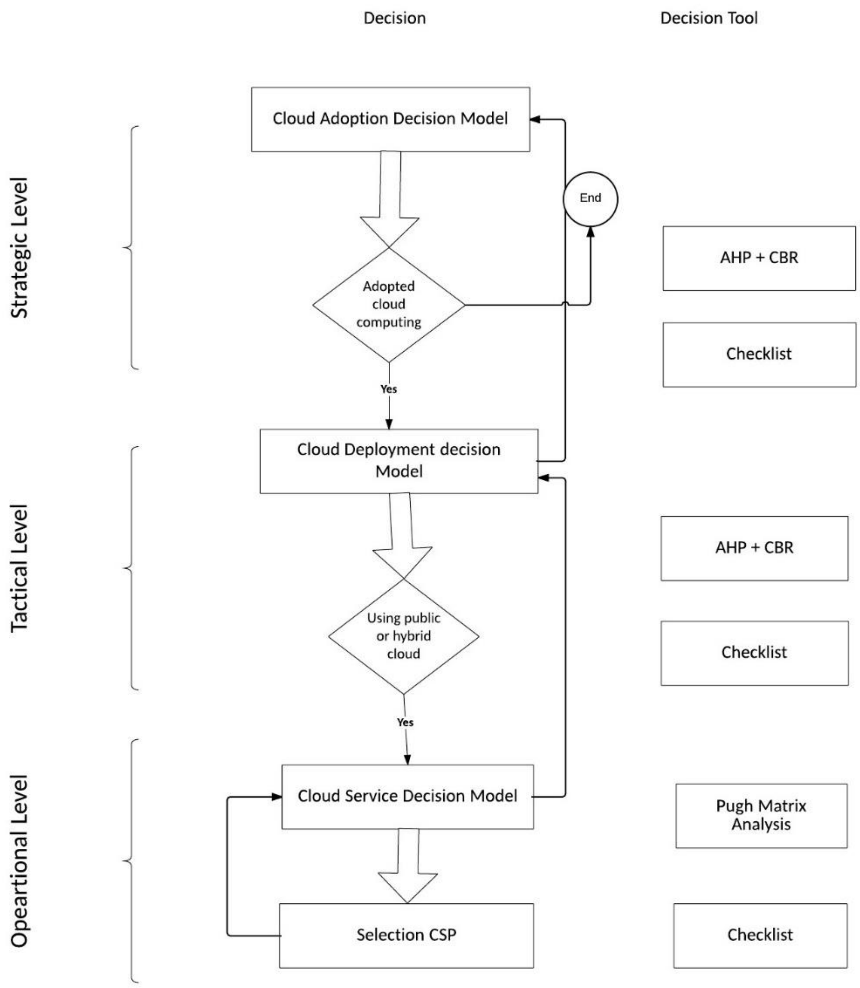


Figure 6-1: the Knowledge Management Based Cloud Computing Adoption Decision Making Framework

6.4 Multi-Criteria Decision Making

Multi-criteria decision making (MCDM) is defined as "the evaluation of the alternatives for the purpose of selection or ranking" (Özcan et al., 2011, p. 9773). The decision making literature provides different methods and approaches to support decision making in different fields including planning, outsourcing, purchasing and investment (Özcan et al., 2011). These approaches include the AHP and the Technique for Order of

Preference Similarity to Ideal Solution (TOPSIS), which are both are widely used in decision making, especially in the field of outsourcing, which is related to cloud adoption (Perçin, 2009).

AHP was used in IS outsourcing by Akomode, Lees and Irgens (1998), Yang and Huang (2000) and Bruno et al. (2012). Menzel and Ranjan (2012) used an AHP approach to selecting service providers in a cloud computing environment, although this study was limited to the consideration of technical aspects. Kahraman et al. (2009) used TOPSIS to select and evaluate service providers, while Perçin (2009) used a hybrid approach by combining the AHP and TOPSIS to evaluate the third party logistic providers.

The MCDM literature identifies some differences as well as similarities between AHP and TOPSIS. Özcan et al. (2011) demonstrated that AHP and TOPSIS differ in five key areas, as summarised in Table 6-1: the core process, the determining of weight, number and type of outranking relations, consistency checking and problem structure.

	AHP	***TOPSIS***
Core process	Creating hierarchical structure and pairwise comparison matrices	Calculating distance to positive and negative ideal point
Determination of weight	Pairwise comparison matrices. 1–9 scale	No specific method. Linear or vector normalization
Number and type of outranking relations	N (N _ 1)/2	1
Consistency check	Provided	None
Problem structure	Small number of alternatives and criteria, quantitative or qualitative data	Large number of alternatives and criteria, objective and quantitative data

Table 6-1: The difference between AHP and TOPSIS Adapted from Özcan et al. (2011)

The comparison identifies that AHP is more suitable than the TOPSIS as an approach to support cloud computing decision making, for the following reasons. As cloud computing decision making is affected by multiple factors, it is very useful to visualize the problem by structuring it in a hierarchy as in the AHP approach (Tam & Tummala 2001). Some of the factors involved in the decision making are tangible and easily measurable, while some are subjective and difficult to quantify. The AHP method provides a mechanism for measuring subjective as well objective factors. Use of AHP has been shown to decrease decision making time (Saaty, 2008).

It has been argued that the AHP approach is more explanatory, reliable and accurate than other weighting methods (Kim 2013). Finally, AHP provides methods to check the consistency of data entered by decision makers (Yang & Huang, 2000). In contrast, one of the disadvantages of AHP is that the number of pairwise comparisons may be large if there are a large number of factors (Wang & Yang, 2007) and quantifying subjective factors can be challenging (Figueira et al., 2005). AHP adopts a number scale to measure subjectivity, as shown in Table 6-2. This thesis uses the AHP to support the cloud decision making process.

6.5 The Analytic Hierarchy Process

AHP is a multiple criteria decision making tool which decomposes the problem to sub-problems then aggregates them to obtain the optimum solution (Saaty, 1994; Yang & Huang 2000; Bernasconi et al. 2010). AHP has been described as a MCDM approach which can measure objective and subjective factors without compromising them (Akomode et al., 1998). Saaty (2008, p. 83) defined AHP as “a theory of measurement through pairwise comparisons, which relies on the judgments of experts to derive priority scales”. It provides an approach to capture expert knowledge, facilitate the decision making process and reduce decision making time; however, Saaty’s (2008) definition does not discuss one of the most significant characteristics of the AHP method, which is the ability to measure subjective and objective attributes. We define AHP as a multi-criteria decision making method which measures subjective and objective attributes based on the expertise of decision makers.

The AHP method is based on three fundamental pillars: the hierarchy structure of the model, pairwise comparison of the criteria and alternatives, and final synthesis of the priorities (Dağdeviren et al., 2009). In the structure of the model, problem solving goals come at the top of the hierarchy. The goal level sets the decision making aim. The decision making criteria come in the second level of the hierarchy, and each criterion may have sub-criteria. Alternatives or solutions come at the lowest level of the hierarchy (Saaty, 1994). The way in which the problem is structured is a critical step as structuring the problem differently can lead to a different ranking of the alternatives.

The second phase of AHP is developing the weighting criteria. AHP employs pairwise comparison to weight the criteria (Rezaei, 2015). The weighting is done by comparing between criteria in each level in respect to the level above; at the criteria level, the criteria will be compared in respect to the goal. For example, our goal at the strategic level is to determine the appropriate provisioning of IT services for the enterprise. In respect to this goal, the pairwise comparison will evaluate the main factors to establish which one is most important for the enterprise. For example, it is necessary to determine whether security or economic issues are predominant in the concerns of the enterprise.

Pairwise comparison runs a square matrix from criteria and sub-criteria, and from this matrix we can obtain the eigenvalue and eigenvector (Yang & Huang, 2000). Eigenvector gives the priority ordering of the criteria and the eigenvalue measures the consistency of the matrix. Thus, the number of pairwise comparisons needed to have a complete matrix is equal to equation (1) (Wang & Yang, 2007); for example, if we have three criteria that means we need three pairwise comparisons. If we assume there are three criteria, the matrix can by represented as shown in (2).

$$N = {}^{n(n-1)}/_{2} \tag{1}$$

Where N is the number of pairwise comparisons and n number of factors

$$A = \begin{matrix} 1 & a12 & a13 \\ a21 & 1 & a23 \\ a31 & a32 & 1 \end{matrix} \tag{2}$$

The numbers used in comparison and their meanings are shown in Table 6-2.

Intensity of importance	Definition
1	Equal importance
2	Weak or slight
3	Weak importance of one over another
4	Moderate plus
5	Essential or strong importance
6	Strong plus
7	Very strong or demonstrated importance
8	Very, very strong
9	Absolute importance

Table 6-2: AHP ratio scale and meaning Source Saaty (2008, p. 86)

Saaty (1994) argued that there are several steps which should be taken into account before applying AHP as follows: identify and collect the knowledge needed to support the judgment, identify the people who have the knowledge and expertise, and access external knowledge that could support the decision. The AHP approach used with the cloud computing decision making framework and models developed in this thesis were based on the understanding gained during the primary and secondary research.

6.6 Case-Based Reasoning (CBR)

AHP is based on the knowledge and expertise available to the decision makers and their understanding of the problem (Levary, 2008). The information available to the decision makers is critical to the success of the approach. This investigation therefore proposes using CBR to improve the information available to decision makers by retrieving similar cases to support the evaluation of the problem.

CBR is a knowledge based method which uses knowledge of similar situations adapted to solve a new problem (Allen, 1994). CBR is defined as a problem-solving approach that relies on past, similar cases to find solutions to problems, to modify and critique existing solutions and explain anomalous situation (McIvor & Humphreys, 2000, p. 296). The use of CBR means that decision makers can benefit from previous solutions. The advantages claimed for CBR are that its use can reduce the risk of repeating mistakes and reduce time required to make decisions (Işıklar et al., 2007). McIvor & Humphreys (2000b) claim that to use CBR activates a constantly growing knowledge base and a willingness to improve existing problem solving methods, and supports the capability of learning. CBR has been used in a number of different disciplines including cloud computing adoption, outsourcing and decisions as to whether to purchase or make in house (McIvor & Humphreys, 2000Yan et al., 2003;Hsu et al., 2004; Choy et al., 2005; Maurer et al., 2010). LOPEZ DE MANTARAS et al (2005)described CBR as having four phases: retrieval, reuse, revise and retain. The four phases of CBR are illustrated in Figure 6-2.

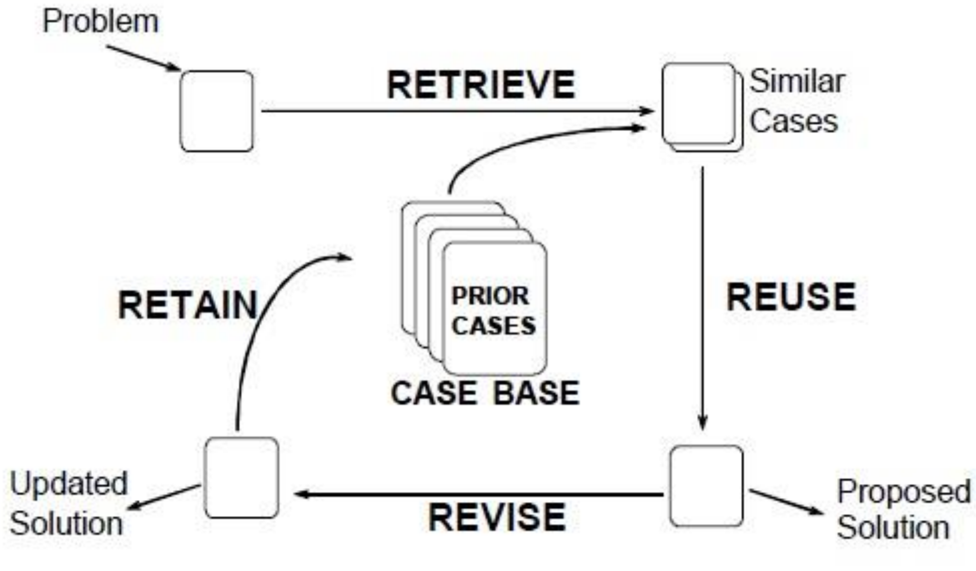


Figure 6-2: The five phases of case based reasoning (LOPEZ DE MANTARAS et al., 2006)

Bergmann & Schaaf (2003) described three types of CBR: the textual, conversational and structural approaches. The textural CBR approach is based on text documents such as FAQ. In conversational CBR, knowledge is captured from the customer/agent conversation, where the cases lack a standardized structure. In structural CBR, cases are described with attributes and pre-defined values. This thesis adapts structural CBR to support decision makers. CBR is particularly relevant in the cloud adoption environment, since cloud migration is typically a single decision, taken once in any organisational lifecycle, and there are therefore limited opportunities for organisations to learn from their own experiences. Using a structural CBR approach helps decision makers to understand the factors that need to be considered and allows them to compare their own decisions with those made by other similar organisations. As problems and solutions differ, CBR adapts to particular context, but it can also be used to critically analyse and similar cases and devise modifications (Mclovor & Humphreys 2000).

Adopting CBR could support capturing tacit as well as explicit knowledge. One of the issues with CBR is ensuring that there are sufficient similar cases to provide the case base.

6.7 Developing the KCADF

6.7.1 Cloud Adoption Decision Factors

The AHP method hierarchy consists of three levels: goal, criteria and the alternatives. In this thesis, the goal is to evaluate and select the best IT delivery model for providing IT services in an enterprise. There are three popular IT delivery models for provisioning IT services, which are in-house, traditional outsourcing previously discussed, and cloud computing. It should be noted that the decision on IT services provisioning could be for a whole organisation, or for part of the organization such as a single unit or application. At the criteria level, the factors represent the main tasks involved in making the decision (Saaty, 1990; Yang & Huang, 2000). Choosing the appropriate criteria is a critical step in building the model. The criteria used for the model developed in this thesis were developed from the primary and secondary research.

In IS outsourcing literature, which is relevant to cloud computing, Yang and Huang (2000) proposed management, strategy, technology, economic and quality. Yang et al. (2007) looked for different factors, which are expectation, risk and environment. Despite the similarities between IS outsourcing and cloud computing, there are also some differences. Cloud computing has extra concerns, which are security and regulations that restrict the adoption of cloud, and the implementation and management issues are different. As discussed in chapter two, there are a large volume of published studies suggesting that security is one of the main factors to consider when discussing cloud adoption.

Financial benefits have been identified as one of the main drivers for enterprises to migrate to the cloud (Misra & Mondal, 2011; Hao et al., 2009). In addition, there are numerous studies which take more than one factor, such as: cost and security (Johnson & Qu, 2012); cost and security, cost and SLA (Dillon et al., 2010); financial and socio-technical (Khajeh-Hosseini et al., 2010a); and company policy, IS development environment, business need and relative advantage (Lin & Chen, 2012). Moreover, as we discussed in section 2.7.4 and 2.8.4, adopted cloud computing could bring benefits as well as organisational risk to enterprises.

The technical capabilities provided by cloud computing are also regarded as one of the main factors which influence enterprises to move to the cloud. Based on the combination of the findings of literature review and the primary research we classify the factors that influence decision makers into five: technical, organisational, security, economic and regulatory. Table 6-3 shows the main criteria and the sub-criteria for each criterion, developed from the primary and secondary research. The technical factors involved in making these decisions were summarised in Table 5-12 which discussed in chapter five.

Factor	***Sub-factor***
Technical	*On-demand service* *service quality* *flexibility*
Strategic	Focus on core competency Competitive advantage Lose expertise and tacit knowledge
Security	Data confidentiality Service availability Disaster recovery & business continuity
Economic	Saving cost Transfer CAPEX TO OPEX Return on investment
Regulatory	Data location Compliance with regulation

Table 6-3: Criteria and sub-criteria of cloud adoption decision model

6.7.2 Cloud adoption decision model

This section presents the first model in the Framework, the strategic level cloud adoption decision model, which was developed based on the primary and secondary research. The cloud adoption model presented here integrates an AHP approach with CBR and uses the five factors described further below in the section headed Phase One. The decision model is shown in Figure 6-3.

The AHP approach will support the decision makers in weighting criteria to evaluate and select the best IT services delivery model. However, one criticism made in much of the literature on AHP is that judgments based on the expertise of the decision maker and the knowledge available is limited, particularly when dealing with uncertainty (Dağdeviren et al., 2009). For this reason, as discussed in 6.6, this study proposes that previous cases should be used to support help decision makers to understand and weight criteria and to validate their results

In addition, the CBR approach is able to handle incomplete and imprecise data (Işıklar et al., 2007) because gaps in the data for any given case can be filled in by reference to similar cases. Combining the AHP approach with CBR provides users with a knowledge base to support decision making. The decision as to whether to migrate to the cloud is a strategic decision which may not occur more than once in an enterprise's lifecycle. This means that users may lack the necessary underpinning knowledge to develop appropriate weightings; this is one of the limitations of the AHP approach. Using CBR to provide a knowledge base gives users access to information about decisions taken in similar and different contexts and allows users access to a wider range of experiences.

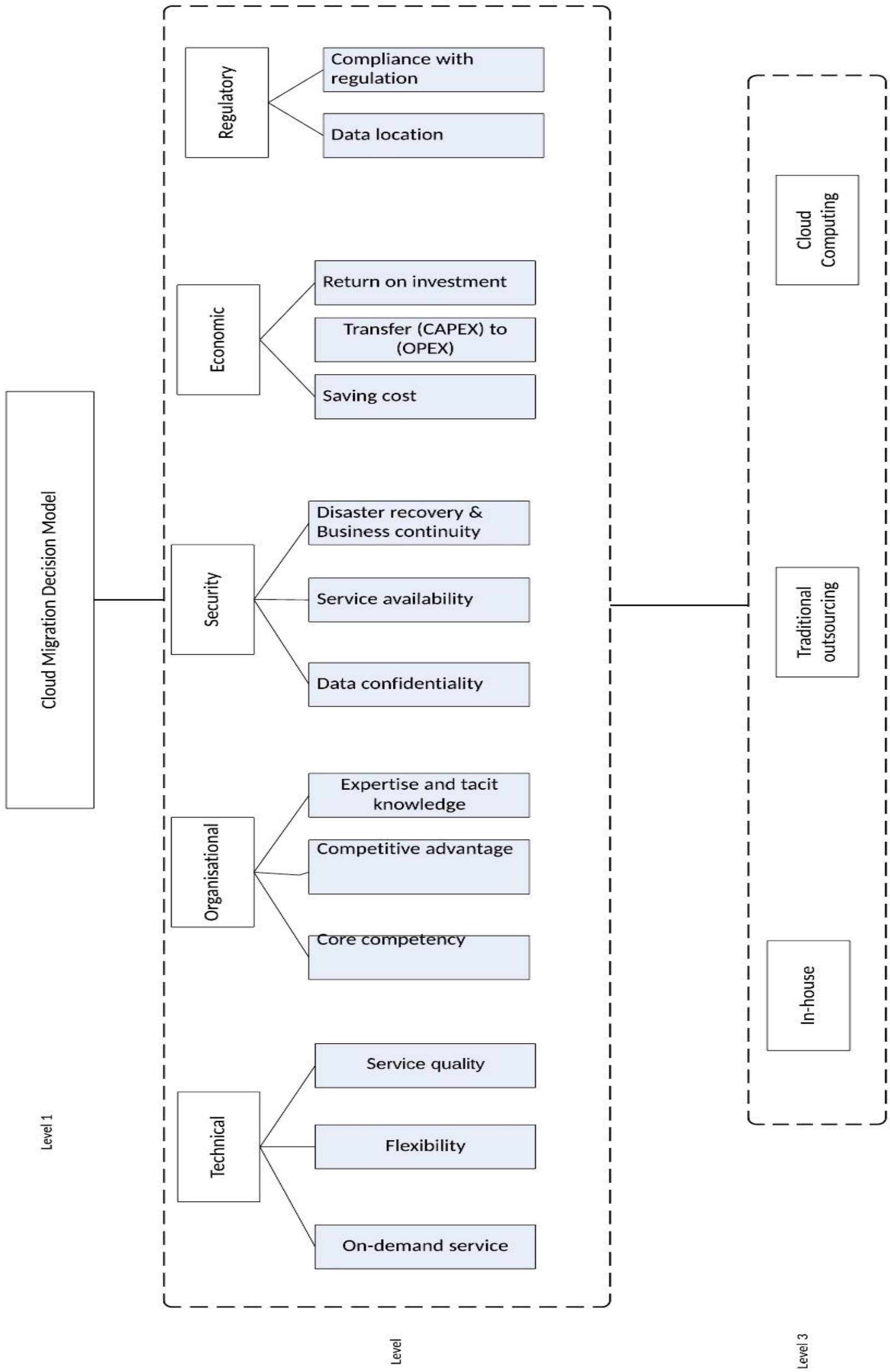


Figure 6-3: Cloud adoption decision model

- *Phase 1: case based reasoning component*

This phase developed the case base to store previous cases. Each case is indexed with five attributes, each of which has a pre-defined value. The attributes used are enterprise size, sector type, enterprise status and IT maturity rate and level of technology diffusion. The attributes chosen were identified from the literature and validated during fieldwork which confirmed these factors as relevant to cloud adoption decision making. These attributes used to retrieve similar cases.

Enterprise size: this was identified as a key determinant of cloud adoption by previous studies (Alshamaila et al., 2013; Avram, 2014), but our primary research found no statistically significant relationship between enterprise size and cloud adoption, although this may reflect factors specific to Saudi Arabia. We did find a relationship between enterprise size and the selection of cloud deployment model. We included enterprise size partly because of the findings from the literature review and also because this would help decision makers match cases to their own organisations.

Industry sector: cloud adoption rates have been shown to vary between sectors (Low et al., 2011), which was supported by our primary research.

Enterprise status: the literature shows that start-up enterprises find it easier to adopt cloud computing than established enterprises (Alshamaila et al., 2013; Gupta et al., 2013); this was supported by our primary research.

Enterprise readiness: IT enterprise readiness has been shown to affect the adoption of a cloud computing environment (Khajeh-Hosseini et al., 2012), and was identified in our primary research as an important factor affecting cloud adoption decision making.

The complexity of existing system: as discussed in section 4.4.2.1, the complexity of existing systems and the implications for migrating these systems to a cloud environment is one of the main factors inhibiting a move to cloud computing.

Technology diffusion: technology diffusion in general and specifically for cloud computing varies between developing and developed countries (Molla & Licker, 2005; Avram, 2014); this influences the cloud adoption decision. Technology diffusion may also be an issue within economies as well as between economies. Our primary research shows that the technology diffusion varies between the major cities and rural cities in Saudi Arabia. Including technology diffusion as one of the indexed attributes contributes towards the generalisability of the framework.

Phase 2: AHP model

In this phase the AHP model was developed. The AHP model (Figure 6-3) uses pairwise comparison to weight the criteria, sub-criteria and alternatives. Level 1 in the model presents the problem-solving goal; Level 2 presents the criteria; and Level 3 presents the alternatives for the problem solution, which for this research have been identified as providing an in-house service, adopting a traditional outsourcing solution or migrating to a cloud computing solution.

The criteria in the second level of the AHP model are based on five factors derived from the literature and the primary research: technical, organisational, security, economic and regulatory. Each criterion has a set of sub-criteria, which provide more detailed factors for decision making and the sub-criteria were also identified from the literature review and the primary research.

- *Phase 3: integration*

This phase combines the CBR element with the AHP element. Using the AHP model described in Phase 2, pairwise comparisons are performed for sub-criteria with respect to the main criteria (parent in the hierarchy), while pairwise comparisons are performed for criteria with respect of the goal. AHP provides two methods for weighting alternatives, absolute and relative measurement.

Relative measurement performs the pairwise comparisons between the alternatives with respect to each criterion. The use of absolute measurement allows alternatives to be ranked with a standard scale (Saaty, 1994). The absolute approached reduces the decision time and is easier to use by decision makers, supporting the customisation of the model. Therefore absolute measurement was used in this research.

The first step in the model is comparing the new case with stored cases and finding similar cases, as shown in **Error! Reference source not found.**. When the similar case is found, the AHP will be run to weight the criteria. One of the features of using CBR is to validate the decision with similar cases. Therefore, the AHP result will be compared with the result of the similar case, and if the decision makers are satisfied with the result, the new case will be added to the case base; otherwise the AHP process is repeated.

If the new case is not similar to the stored cases, the decision maker can choose to run the AHP and add the case as a new case to case base. In addition, the CBR will store the details of each case including decision, selection of cloud deployment and services models and the issues that associated with cloud adoption and how they solve these issues and make them available to use with other cloud adoption projects. The process is illustrated in **Error! Reference source not found.**.

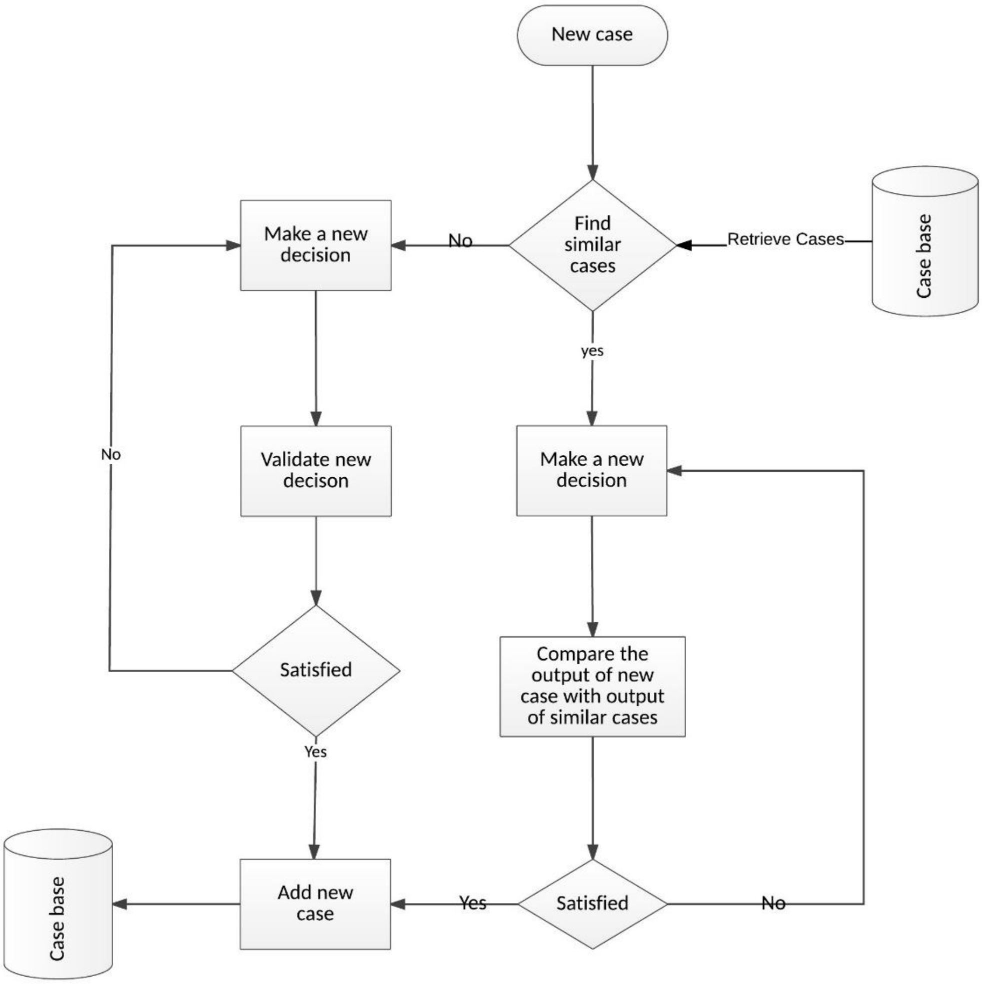


Figure 6-4: Flow chart of the process of cloud adoption decision model

6.8 Cloud Deployment Selection Model Factors

The second model in the framework is the selection of a cloud deployment model. As discussed in chapter two, there are four deployment models for cloud computing: private cloud, public cloud, hybrid cloud and community cloud. As discussed in section 2.5, for cloud adoption purposes, we discuss the virtual private cloud as part of the private cloud. The cloud deployment selection model will consider only three deployment models: public, cloud and hybrid. Community cloud was excluded from the alternatives due to its limited usage in a business context, particularly in Saudi Arabia.

A large and growing body of literature has investigated the factors that influence the selection of a cloud deployment model, as discussed in chapter 2. Factors identified include benefit, cost, opportunity and risk (Lee et al., 2012). The primary research discussed in chapter five identified seven factors that affect the selection of cloud deployment models, which are cost, security, focus on core competency, IT capability to manage IT services, control over resources and data location. Based on the literature review and the results of the primary research, critical factors are categorised into four main categories, which are organisational, technology, security and economic.

6.8.1 Organisational

In the case of organisational factors, focus on core competency was considered as one of the main factors determining the selection of cloud deployment models (Lee, 2014; Qasim & Abu-Shanab, 2014). The second organisational factor is the organisational capability to manage IT services. We understand organisational capability as the extent to which the enterprise has sufficient staff and other resources with appropriate knowledge and skills to support the decision making process. The third factor is the implementation lead time. Implementation lead time refers to the time taken to make the product or service available for use by the organisation. Thus, the implementation lead time helps to determine the selection of the cloud deployment model.

6.8.2 Technical

Technical features of cloud deployment models play an important role in determining the selection of the deployment model. A key element is the issue of control over the enterprise's resources and data. In a private cloud the enterprise has full control over resources, while in VPC the cloud consumer has full control over the virtual networking environment but physical resources are managed by the CSP. In terms of public cloud, the user has no control over the physical resources although some control is available with an IaaS. A hybrid cloud is in-between public and private clouds. The VPC is considered as part of the category of private cloud in this thesis although the model could be customised to include VPC as a separate category if this better suited the requirements of the user. Control of enterprise resources and data were identified as critical factors in the selection of the cloud deployment model.

The second factor in the technical category is scalability. Scalability of cloud deployment models varies between the public and private cloud and the virtual private cloud. The degree to which scalability is important depends on the business requirements of the enterprise; for example, where demand is unpredictable, scalability may be very important. The third factor is reliability. Reliability refers to the performance of the system under all conditions (Fernandes et al., 2013). As discussed in chapter two, the performance in a public cloud could be affected by internet connectivity issues, while private cloud and virtual private cloud performance could be affected by the network, VPN and/or internet connectivity. Private cloud performance can also be affected by the limitations of physical resources. Some enterprises may wish to consider a hybrid cloud solution.

Flexibility refers to the freedom to select IT services, freedom in provisioning and releasing services, and freedom in adding or removing services. Cloud computing in general provides flexibility for enterprises to specify the amount of time for which resources are required, and different configurations depending on the needs of users and service agreements. However, the degree of flexibility varies between cloud deployment models.

6.8.3 Security

Security is one of the important determinants in the section of cloud deployment models, particularly for enterprises that have sensitive data. Service availability is the second factor in the security group. Many cloud service providers promise their clients 99.9 up time service in SLA. However, cloud computing relies mainly on the internet, which means that services are affected by the quality of the internet connection. At the same time, as discussed in chapter two, the available infrastructure limits the capacity of a private cloud, although elasticity is provided through virtualisation and resource allocation. Service availability is a key consideration when selecting a cloud deployment model. Data location is crucial for enterprises in industry sectors where government regulation restricts the locations where data can be stored or processed, and for enterprises which have policies that do not allow data to be stored beyond the enterprise boundaries. Interoperability and portability can also be considered as security and availability issues.

6.8.4 Economic

The economic benefits of cloud computing are considered as one of the main drivers for moving to cloud computing. Reducing the total cost of ownership (TCO) is attractive for many enterprises. The TCO includes reducing the cost of software development, hardware purchasing and maintenance. Reduction in TCO is primarily associated with a public cloud and in this context, a VPC but the private cloud can also reduce the TCO when a large enterprise is consolidating its data centre (Marston et al., 2011). While computing, specifically the public cloud, could offer a reliable IT system with no up-front cost. This is one of the factors that makes a public cloud or VPC solution attractive to many start-up companies. The lower up-front cost of cloud computing is one of the factors considered in this model.

Error! Reference source not found. describes the model for the selection cloud deployment model. This model uses the same approach as the first model, AHP and CBR. If the decision in the first level is to go to cloud computing, this model will be used to select the cloud deployment model. The best cloud deployment model that meets the enterprise requirement will be selected based on the preferences set by the decision makers for the criteria and sub-criteria.

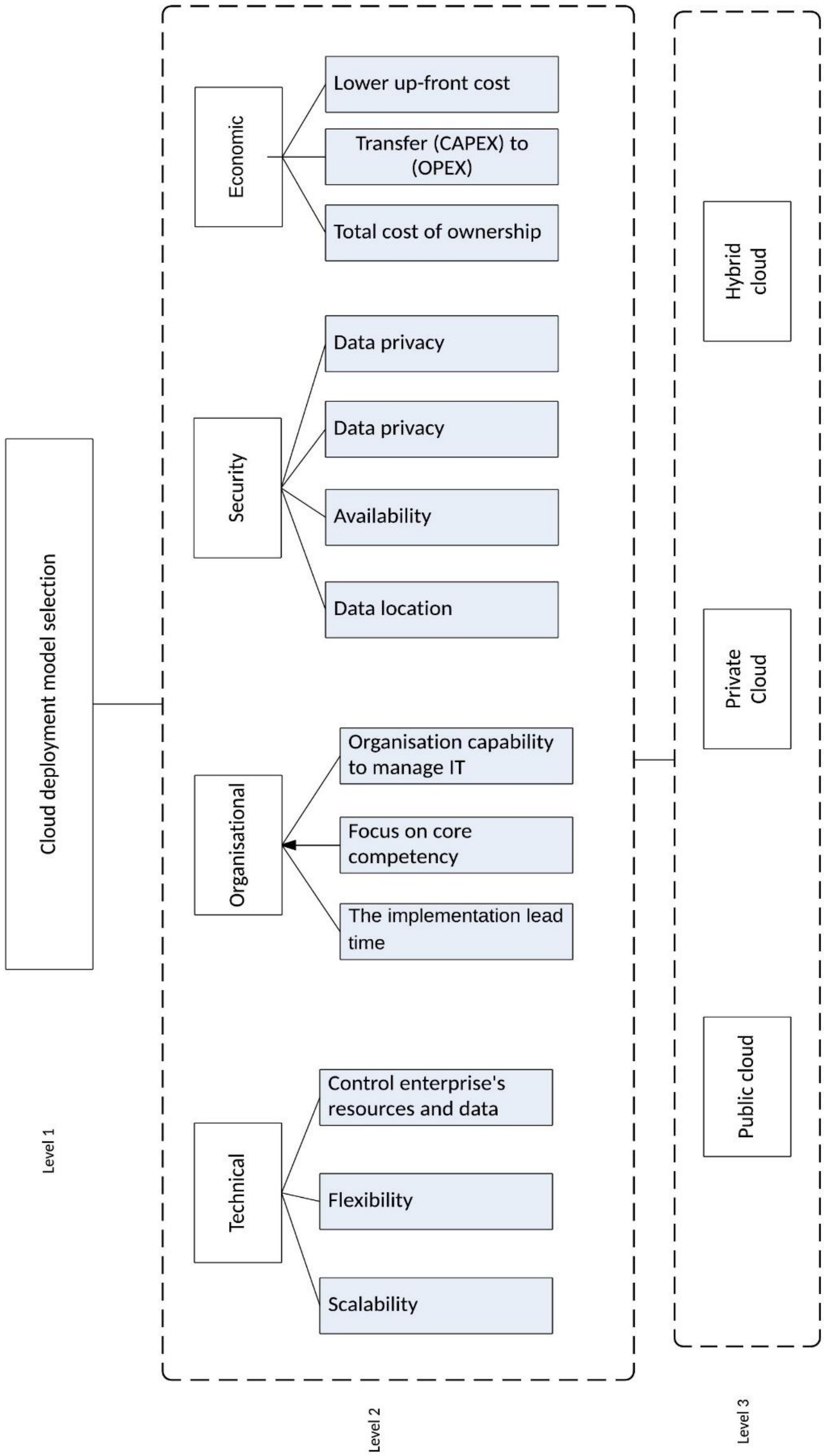


Figure 6-5: Cloud deployment model selection model

6.9 Cloud Service Model Selection

Selection of the cloud service model is supported through the third model in the KCADF. Although the choice of service model requires a multi-criteria decision making approach, AHP is not considered an appropriate tool in this context, given the limited number of factors involved in the selection of cloud service models and the fact that an hierarchical approach is not appropriate here, as the majority of factors are technical and are at the same level of decision making. For the model developed in this stage of the framework, the Pugh Matrix Analysis was used. This is because there are only a small number of criteria used at this stage and there is only one level in the matrix. PDM is a MCDM technique which compares alternatives based on criteria but is less complex than the AHP approach (Cervone, 2009), thus it is better suited to the criteria and the decisions required at this stage of the decision making process.

6.9.1 Criteria for selecting cloud service models

The literature review and the primary research identified nine factors to be taken into account when deciding on a cloud service model, as shown in Table 6-4. There are three main cloud service models, as discussed in chapter two, namely IaaS, PaaS and SaaS, each of which has different characteristics, so different criteria are needed for each. Each criterion has been given an indicative weight, developed based on the discussion in Table 2-4 in chapter two. Users will be able to set their own weightings, according to their business requirements. Table 6-5 provides a description of weight values, providing information for users to support users in setting their own weights.

Weighting	IaaS	PaaS	SaaS
Data sensitivity	3	2	1
Control over resources	3	2	1
Capability of IT dept. to manage services	3	2	1
Short lead time	1	2	3
Cost	1	2	3
Scalability	3	2	2
Performance	3	2	1
Availability	3	2	2
Interoperability	3	2	1
Total			

Table 6-4: Decision Matrix for the selection cloud service models

Sarif and Shiratuddin (2010) identified three symbols to measure the weights: + for better, - for worse and S for equal. In this case, we developed a scale from 0 to 2 to measure the weights as shown in Table 6-5. Chapter seven provides an example of how the matrix works in practice.

Critical Factors	Description	Scale
Data sensitivity	To what extent is the data sensitive	2-0 (2 Very high, 0 normal)
Control over resources	To what extent is the control over resources important	2-0 (2 Very important, 0 Unimportant)
Capability to manage services	To what extent can the enterprise manage IT services	2-0 (2 Advance, 0 Easy)
Short lead time	To what extent is short lead time important	2-0 (2 Very important, 0 Unimportant)
Cost	To what extent is cost important	2-0 (2 Very important, 0 Unimportant)
Scalability	To what extent is scalability important	2-0 (2 Very high, 0 normal)
Performance	To what extent is performance important	2-0 (2 Very high, 0 normal)
Availability	To what extent is availability important	2-0 (2 very high, 0 normal)
Interoperability and portability	To what extent are interoperability and portability important	2-0 (2 Very important, 0 Unimportant)

Table 6-5: The critical factors of selection cloud service model

6.9.2 Checklist

Checklists are used at two stages in the Framework. The first checklist is used at the deployment model decision stage to identify the issues that should be considered by decision makers choosing a private or virtual private cloud; and the second checklist is used at the cloud service model and cloud service provider stage to highlight key issues.

A checklist is defined as a tool for assessing the critical factors that influences the usage of IT in a specific context (Kaptelinin & Nardi, 1997). Checklists are used for different purposes such as developing guidelines for implementation planning (Gagliardi et al., 2015), and as an assessment method for product selection (Marušić, 2015). Use of checklists can increase the success of a project by identifying the critical success factors that should be taken into account when managing the project (Parfitt & Sanvido, 1993; Ranganathan & Balaji, 2007), and they have been identified as a way of preventing project failure (Gawande, 2009).

The checklist developed as part of the Cloud Adoption Decision Making Framework takes the form of a set of questions to be answered by the decision maker. Developed from the primary and secondary research, the checklist highlights the main issues that should be considered when deciding to move to cloud computing, selecting cloud deployment model and choosing a cloud service model. The checklist has been colour-coded to show how important each element is in the context of the three different service models: red indicates highly important, yellow relevant but not as important and green indicates not important in this context.

To begin with deciding to move to cloud computing, the following points should be considered when making the decision:

- Ensure the enterprise has sufficient funding to move to cloud environment.
- Ensure the cost of migrating the existing system does not exceed the expected economic benefits from moving to cloud.
- Ensure there is sufficient funding for education and training related to cloud computing for existing staff.
- Ensure the evaluation of existing IT infrastructure as well as existing applications and to what extent they are compatible with cloud requirements.

- Ensure that the enterprise as well as employees are aware of the implications on IT roles and organisational change when moving to cloud computing.

In the case of selecting cloud deployment models, the checklist was developed to highlight the key issues related to cloud deployment model. The Table 6-6 shows the checklist of cloud service model.

Task	*Private cloud*	*Public cloud*	*Hybrid cloud*
Ensure the enterprise has sufficient funding			
Ensure compatibility of existing infrastructure with cloud computing requirements			
Ensure and estimate the effort required for the code modification and the cost needed			
Ensure data/application can be moved/integrated with different platforms/CSPs			

Table 6-6: The checklist items for cloud deploymment model

In terms of cloud service model, the importance of the items on the checklist varies between cloud service models, as some factors such as the use of a standardised virtual machine are very relevant in an IaaS and PaaS context, but not in a SaaS context. The Table 6-7shows the checklist of cloud service model.

Question	*IaaS*	*PaaS*	*SaaS*	*Yes*	*No*	*N/A*
Security dimension						
Is the data stored locally?						
If not, is its location in compliance with government regulations?						
Does the SLA guarantee proper data privacy control						
Can data be brought back on-premises or moved to another CSP?						
Does CSP apply the data security life cycle (create, store, use, share, archive and destroy)?						
Do you ensure that the CSP provides two-way authentication?						

Question	*IaaS*	*PaaS*	*SaaS*	*Yes*	*No*	*N/A*
Technical dimension						
Is there sufficient bandwidth to prevent network latency?						
Is there sufficient internet connectivity?						
Can more than one CSP support enterprise requirements?						
Are cloud-based applications integrated easily with other applications with different CSP or on-premises applications?						
Is the existing hardware compatible with cloud requirements, or could it be integrated with cloud solution?						
Does the CSP support a standard data format?						
Does the CSP support a standardised API?						
Does the CSP support a standardised VM?						
Economic dimension						
Have you calculated all related costs including subscription, storage, and connection fees (if needed)?						
Have you calculated the other hidden costs?						
Are there sufficient funds to migrate the existing IT system to a cloud environment?						
Organizational dimension						
Do personnel have sufficient knowledge and skills to build/manage the application/VM?						
Is there sufficient funding for training and education?						
Regulatory dimension						
Has the CSP been audited regularly by a third party to ensure compliance with data confidentiality agreements?						
Does the CSP clearly show the service uptime level and downtime per hours per year in SLAs?						

Table 6-7: The checklist items for cloud service models

6.10 Conclusion

This chapter described the development process of the Knowledge Management Based Cloud Computing Adoption Decision Making Framework and the supporting models and tools. The theoretical underpinnings for the framework were provided by KM, organisational learning, the concept of the learning organisation and theories of decision making and the approaches used included AHP, CBR and the PDM supported by checklists.

The framework includes a model to support the strategic decision on cloud adoption, a model to support the selection of a cloud deployment model and a PDM to support the selection of the cloud service models. Checklists were developed to provide guidance as to how to select the cloud service provider and to highlight the main issues that should be considered when moving to cloud and selecting the cloud deployment models. The next chapter discusses the validation and evaluation of framework and the tools developed to support the validation.

Chapter 7: Validation and Evaluation

7.1 Introduction

The process used to develop the Knowledge Management Based Cloud Computing Adoption Decision Making Framework has been discussed in the previous chapters. This chapter describes the way in which the framework was evaluated, the lessons learnt from the evaluation and the changes made to the framework following validation. The aim of the validation was to examine the clarity, usability and practicality of using the KCADF in an enterprise environment and to extend and improve the framework based on the feedback received.

7.2 Validation Approach

Validation is used to assess whether a proposed model/framework is accurate and reliable when used in real life (Oberkampf & Trucano, 2008). Fenz and Ekelhart (2011) distinguished between verification and validation, stating that the former is used to examine whether the proposed model/framework complies with the (theoretical) specifications, while the latter is to check if it meets the (functional) requirements. A generally accepted definition of validation is the "process of determining the degree to which a model is an accurate representation of the real world from the perspective of the intended uses of the model" (Oberkampf & Trucano, 2008, p. 719). In this research, the proposed framework and supported models were validated through four workshops that brought together participants, also referred to as stakeholders, from CSPs and cloud consumers.

The CSPs who participated in the workshops also participated in the interviews discussed in chapter four, and the cloud consumers who took part in the workshops were nominated by the CSPs. One possible limitation of the workshop validation process was that the validation might be too heavily influenced by the CSPs. In order to ensure that cloud consumer views were fully represented, two of the workshops made use of a case study-type approach, whereby the cloud consumers applied the framework to their own organisations' real-life experiences of cloud computing adoption. A further possible limitation of the workshops was the use of closed questions about the strengths and weaknesses of the framework, which restricted the options available to respondents.

To overcome this, the workshops used two types of questions to validate the proposed framework. A five-point Likert-scale was employed for the closed questions, where 1 represented strongly agree and 5 strongly disagree. This gave the participants a range of choices as to whether agree or disagree with the question asked and whether to agree in whole or in part. Open questions were also used to ensure that participants could express their views and raise issues and a number of comments were received from the open questions.

7.3 Validation Process

7.3.1 Design of the Validation

As discussed in section 4.2, Saudi Arabia is regarded as a technologically developing country. As already noted, levels of IT adoption are less than in technologically developed countries, and the rate of cloud adoption has been slower in KSA than in comparable economies with higher rates of technology adoption. Cloud adoption in Saudi Arabia, as discussed in Chapter 5: is associated with both government as well as private enterprises, while start-up companies are seen as more likely to adopt a cloud solution. The CSP market in Saudi Arabia is regarded as immature as discussed in section 4.2 but major providers in KSA include ELM and STC. The framework validation process reflected these factors.

The nature of cloud computing adoption means that effective validation requires expert judgement (Angkananon et al., 2013), since the framework needs to be assessed for technical as well as business relevance. This required working with experts who had experience in both fields, which in turn raised an issue of verification, since it was necessary to ensure that the experts taking part in the validation had the required expertise, and the pool of available experts was limited by technology adoption factors. ELM, which is one of the major CSPs in KSA, supports technology innovation by providing a mechanism for review and validation through expert workshops, and ELM agreed to allow the framework to be validated through the expert workshop mechanism.

Although ELM is one of the largest CSPs in Saudi Arabia, the CSP market is developing and in order to ensure that validation was not limited to ELM experts and clients, validation workshops were also conducted with two other CSPs, STC and Gulf Cloud. STC is one of the largest telecommunication operators in Saudi Arabia, and it has started to provide cloud solutions for different groups of enterprises. Gulf Cloud is a newer cloud service provider, focussing mainly on SaaS. SaaS solutions typically appeal most strongly to start-up companies.

ELM and Gulf Cloud both hosted one validation workshop each while STC hosted two. Each validation workshop involved two stakeholders, in addition to the researcher who chaired the sessions. All the stakeholders who took part in the workshops had been involved in the cloud adoption decision process. Each workshop included a CSP representative, ensuring technical expertise and familiarity with the cloud adoption process and a representative of a cloud computing client. This meant that the framework was validated from a service user as well as a service provider perspective and ensured that organisational as well as technical aspects were considered. The validation examined the concepts which underpinned the framework and supporting models, the factors and sub-factors for each model and the contribution and usability of the KCADF. The workshops consisted of four elements:

1. A twenty-minute presentation in which the background of the research was discussed, including its aim and objectives, outlining the framework and the supporting models and tools and the desired outcomes of the research.
2. A simulation session, in which we ran the KCADF to validate the proposed models.
3. Gathering feedback through the use of closed questions with a five-point Likert scale.
4. Open-ended questions and open discussion to obtain feedback from stakeholders to improve the proposed framework and models.

7.3.2 Participant Profiles

The participants had a wide range of experience in their respective fields, and as the position data shows Table 7-1, they had relevant background and skills. The participants were identified by the CSPs who hosted the workshops as having cloud computing adoption experience. In addition, some of the participants in the workshops has also been involved in the interviews discussed in chapter four and were able to give detailed insights as to whether the KCADF dealt with the issues that had been identified. Participant information has been anonymised to ensure confidentiality.

Participant experience (yrs)	*Participant status*	*Position*	*Sector*
More than 5 years	Cloud provider	Enterprise demand manager	ICT
More than 5 years	Cloud client	Project manager	Multi investment
More than 5 years	Cloud provider	Service manager	ICT
More than 5 years	Cloud client	IT service manager	Education
10 years or more	Cloud service	Expert system	ICT
10 years or more	Cloud client	Project manager	ICT
More than 20 years	Cloud provider	Cloud Computing Manager	ICT
More than 5 years	Cloud client	IT specialist	Healthcare

Table 7-1: Summary of participant backgrounds

7.3.3 Validation Workshops

The workshops started with a presentation to give an overview of the research, aim and objectives. In addition, the design prototype for the AHP and CBR elements was demonstrated to show how the decision making model could be applied. As shown in Figure 7-1, the user entered the enterprise characteristics to retrieve similar cases.

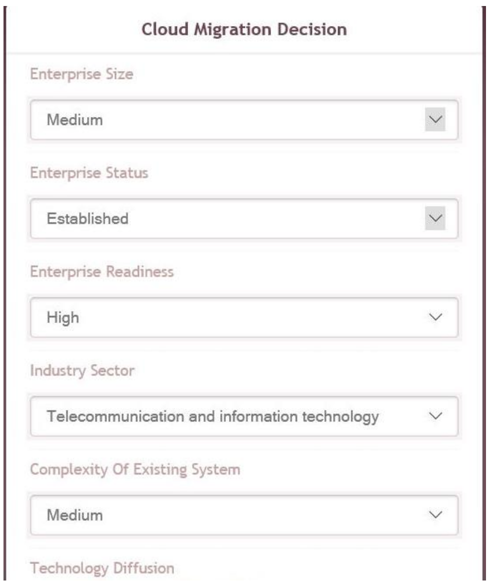
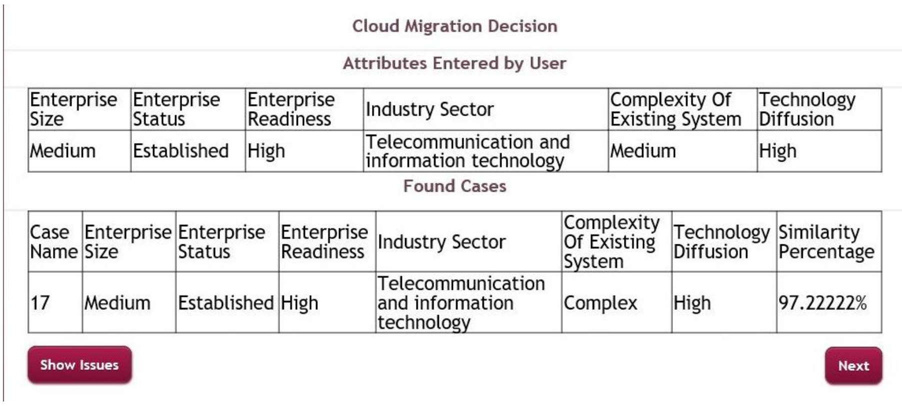


Figure 7-1: The loading page of the cloud adoption decision model tool

Based on the enterprise characteristics entered by the users, the system will show the similar cases Figure 7-2.



Cloud Migration Decision

Attributes Entered by User

Enterprise Size	Enterprise Status	Enterprise Readiness	Industry Sector	Complexity Of Existing System	Technology Diffusion
Medium	Established	High	Telecommunication and information technology	Medium	High

Found Cases

Case Name	Enterprise Size	Enterprise Status	Enterprise Readiness	Industry Sector	Complexity Of Existing System	Technology Diffusion	Similarity Percentage
17	Medium	Established	High	Telecommunication and information technology	Complex	High	97.22222%

Show Issues　Next

Figure 7-2: Identifying similar cases

The decision maker then runs the AHP. As discussed in chapter six, the decision makers use knowledge and judgment to compare between the factors. Figure 7-3 shows a technical sub-factors example.

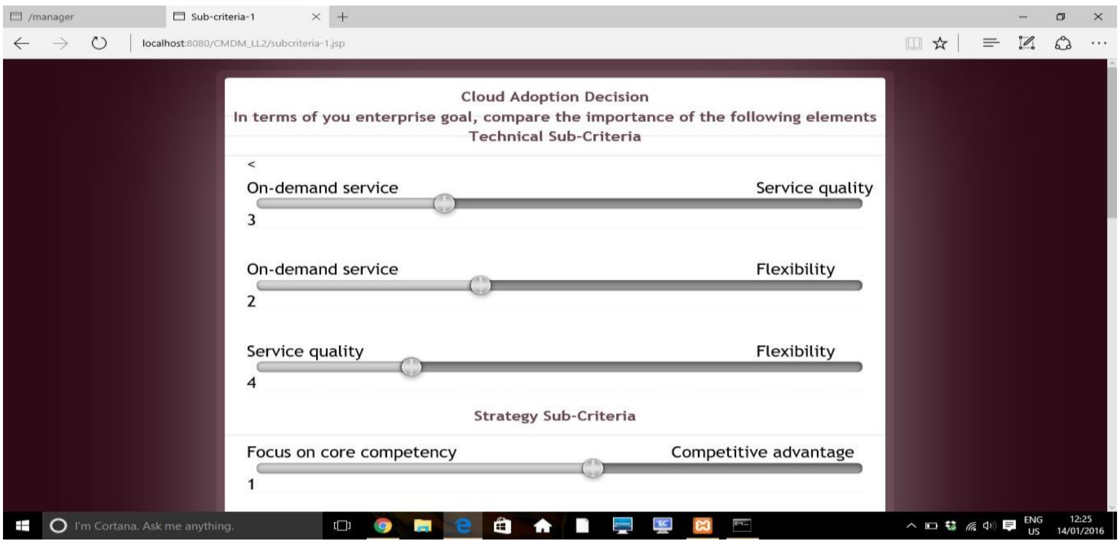


Figure 7-3: Pairwise comparison for technical sub-factor

7.4 Framework Approach Validation

The KCADF was presented to the stakeholders involved in the workshops in order to review and obtain feedback. A feedback sheet which included both closed and open questions was distributed to the stakeholders. An example of the feedback sheet is given in Appendix E. The feedback is discussed under three headings

7.4.1 Review of KCADF Approach

The framework approach assessment shows a high percentage of agreement between all the stakeholders involved in the workshops. The framework was examined using nine questions divided into four aspects: sharing knowledge, economic, usability and usefulness to the enterprise.

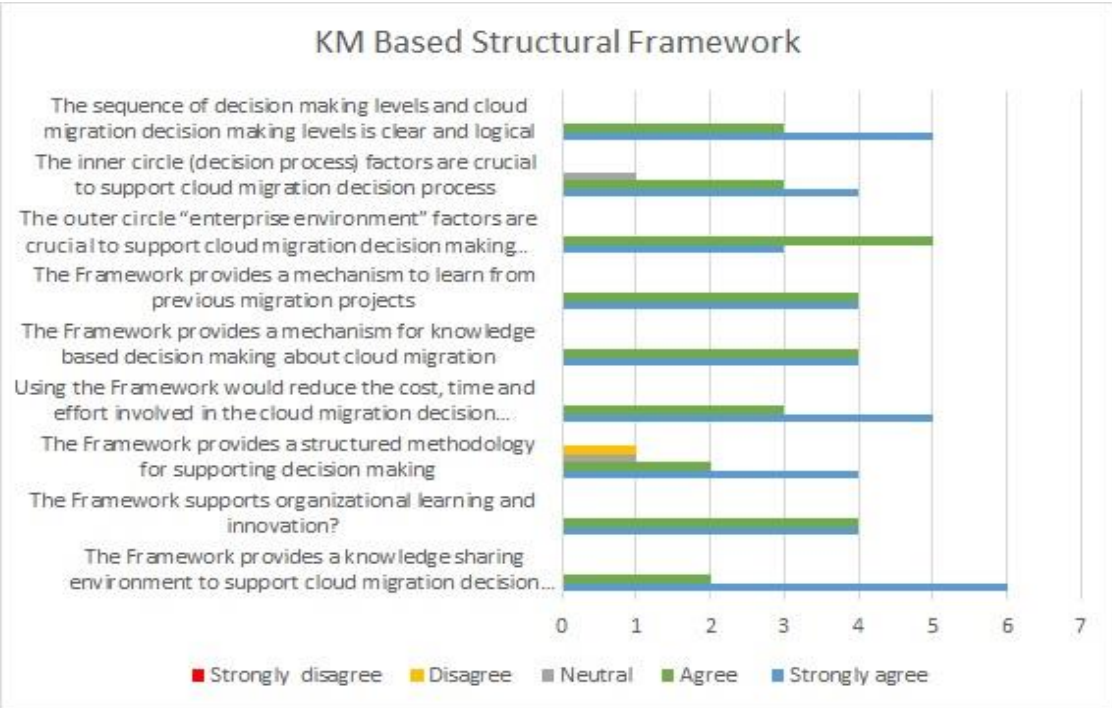


Figure 7-4: Summary of closed question results

The first question asked participants if the framework provides a knowledge sharing environment to support cloud migration decision. All participants agreed with the statement that the framework provides a knowledge sharing environment to support cloud adoption decision, with six participants strongly agreeing.

The second question asked whether the proposed framework supports organisational learning and innovation. All participants agreed with the statement. In question three, the participants were asked if the framework provides a structured methodology for supporting decision making. All but two participants agreed with the statement. One of the cloud clients involved in these workshops neither agreed or disagreed, while the other disagreed with this statement.

The fourth question investigated whether the framework reduces the time, cost and effort involved in cloud migration decision process. All the participants agreed with this statement; four strongly agreed and three agreed. In the fifth and sixth questions participants were asked to indicate whether the framework provides a mechanism for knowledge based decision making about cloud migration, and if the framework supports learning from previous projects. All agreed or strongly agreed with this statement.

7.4.2 Review of the factors which support cloud computing adoption decision making

As part of the discussion of knowledge management and cloud computing adoption given in chapter 3, a diagrammatic representation of the elements which support cloud computing adoption decision making was produced (Fig. 3-4). The diagram is given again below.

The diagram originally presented to the stakeholders included a middle circle which showed the flow of knowledge. Following criticism from some stakeholders, who felt the knowledge flow element was unclear and detracted from the usability of the diagram, the middle circle was removed.

The participants were asked if the factors identified in the outer circle were required to support the cloud adoption decision making process. All participants agreed that they were. Question eight tested the importance of the factors of the inner circle in the cloud adoption decision process. All of the stakeholders who expressed a view agreed with the importance of these factors. The final question in this section asked for comments on the sequence of decision making levels and all stakeholders agreed that the sequence was clear and logical.

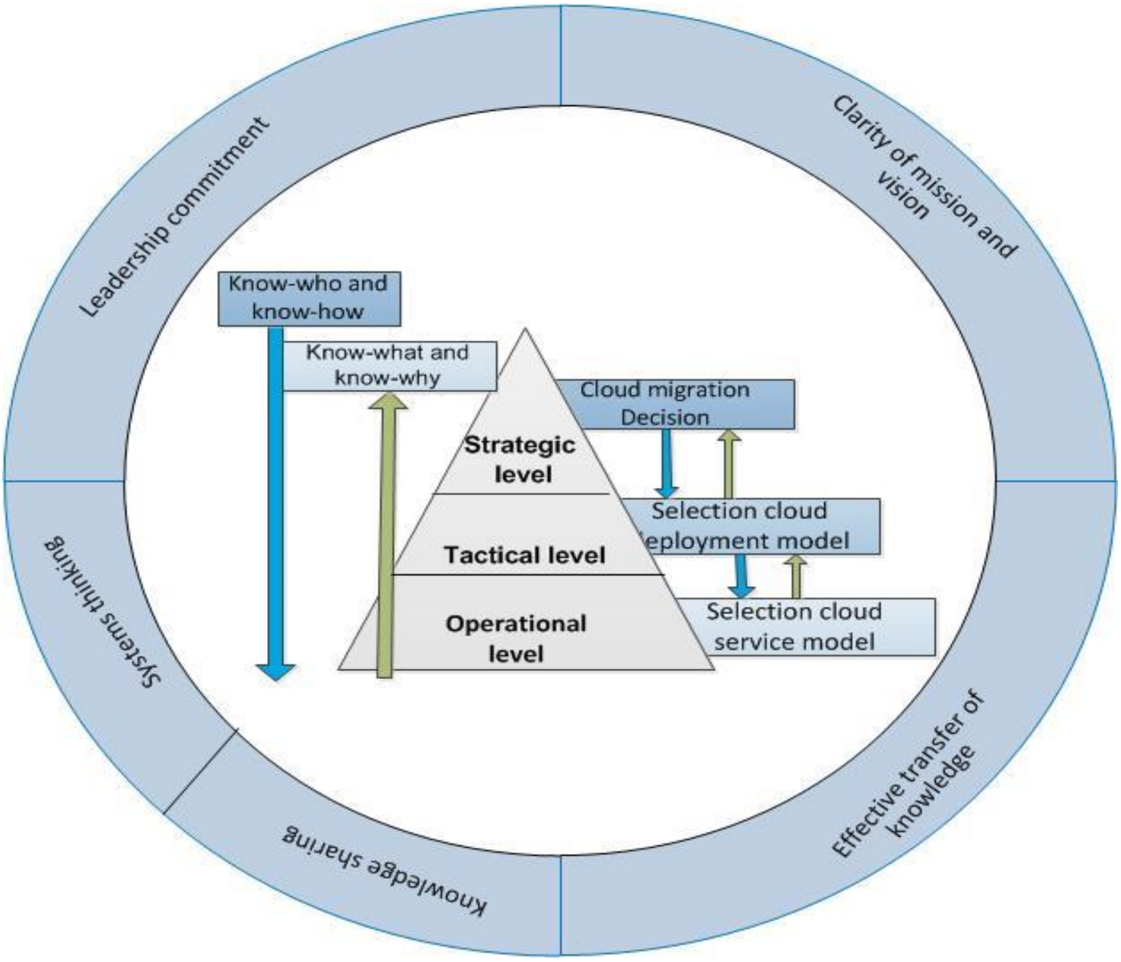


Figure 7-5: The revised KM structure framework to support cloud adoption

7.4.3 Future Development

The next stage of the validation used a focus group approach in each workshop. This was to obtain suggestions and modifications to improve the framework. One participant suggested considering the current financial status of the organisation in the framework but other than this there were no suggestions to amend the framework. The diagram which represents the factors which support decision making for cloud computing adoption was also reviewed. While most participants felt the diagram was helpful or very helpful in terms of identifying the environment for cloud computing adoption decision making, two of the participants believed that there was a duplication of knowledge factors in the diagram as originally presented and made suggestions for revising the diagram. Based on the discussion, minor changes were made to the framework, as discussed further in section 7.9 and the middle circle of the diagram was removed, as discussed in section 7.4.2

7.5 Review of the Model to Support Strategic Cloud Adoption Decision Making

This section discusses the validation of the model developed to support the strategic decision on cloud adoption.

7.5.1 Review of the Approach

The model was assessed using ten closed questions. In general, the model received a high level of support from all stakeholders. All the participants agreed with the statement that the model provides a knowledge sharing environment to support cloud adoption decision making at the strategic level.

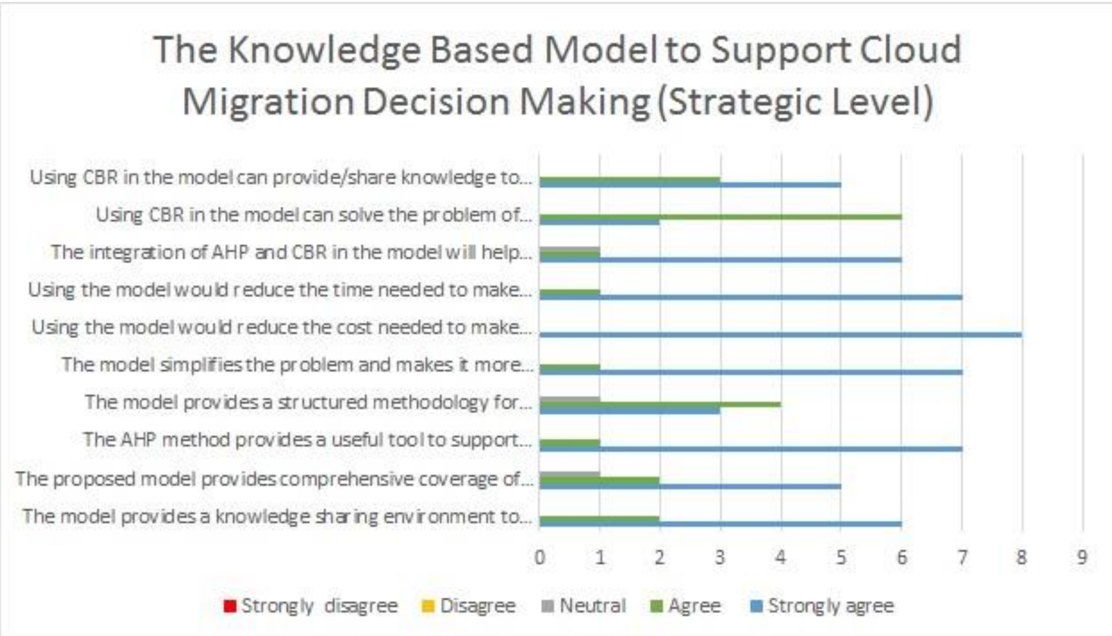


Figure 7-6: Summary of closed question results for proposed strategic model

All stakeholders who expressed a view agreed that the model provides a structured methodology to support cloud migration at strategic level, and that the factors used in the strategic model are comprehensive. Stakeholders strongly endorsed the statement that the hieratical structure of the model makes it simpler and more understandable for decision makers. In terms of time and cost, the participants strongly agreed that using the model could reduce the time and cost taken to make decisions. The participants were asked if the AHP approach provides useful tools to support cloud migration decision making; all agreed. Finally, all stakeholders except one who did not express a view agreed with the statement that the integration of AHP and CBR will help decision makers to make better decisions. All participants agreed with the statement that the CBR could fill the knowledge gap about cloud adoption and support the decision making process.

One of the key objectives of the workshop was to examine the factors that affect cloud migration decision making at the strategic level. Table 7-2 shows the factors, scored from 1 to 5, with one indicating less important and five most important. Table 7-2 shows the mean of the importance of the factors when making the decision to move to cloud computing. Every factor scored more than four out of five, indicating that all factors were regarded as important. The stakeholders identified that the factors have a significant impact on the strategic decision on cloud computing adoption. One technical and two economic elements were scored highest, flexibility (4.8), reduce total cost of ownership (4.87) and return on investment (4.87).

Factor	**Sub-factor**	
Technical	Access to new technology	4.5
	On-demand service	4.5
	Service quality	4.5
	Flexibility	4.8
Organisational	Focus on core competency	4.12
	Competitive advantage	4.5
	Expertise and tacit knowledge	4.37
Security	Data confidentiality	4.25
	Service availability	4.5
	Disaster recovery & business continuity	4.75
Economic	Reduce total cost of ownership	4.87
	Transfer CAPEX TO OPEX	4.62
	Return on investment	4.87
Regulatory	Data location	4.25
	Compliance with regulation	4.5

Table 7-2: The results of important factors for cloud adoption decision

The participants agreed that the model supports the cloud migration decision at the strategic level. Two participants stated that using feedback from other projects is very helpful in terms of reducing risks and time.

7.5.2 Future Development

Considering the factors addressed in the model, one participant suggested adding data integrity. This suggestion was not accepted as it was considered that data integrity was already covered under the security element. Two participants suggested adding more explanation of the sub-factors, as many users might have difficulty understanding technical terms and this would increase the usability of the framework. Therefore, as discussed further in section 7.9, definitions of technical terms will be provided with the proposed tool to enhance usability.

7.6 Review of the Model to Support the Tactical Decision on choice of Cloud Deployment Model

This section discusses the validation of the model developed to support the tactical decision on choice of cloud deployment model.

7.6.1 Review of the Approach

The cloud computing deployment model was validated using four questions. Due to the similarity between the strategic model and tactical model in terms of using AHP and CBR, the questions do not revisit elements previously covered.

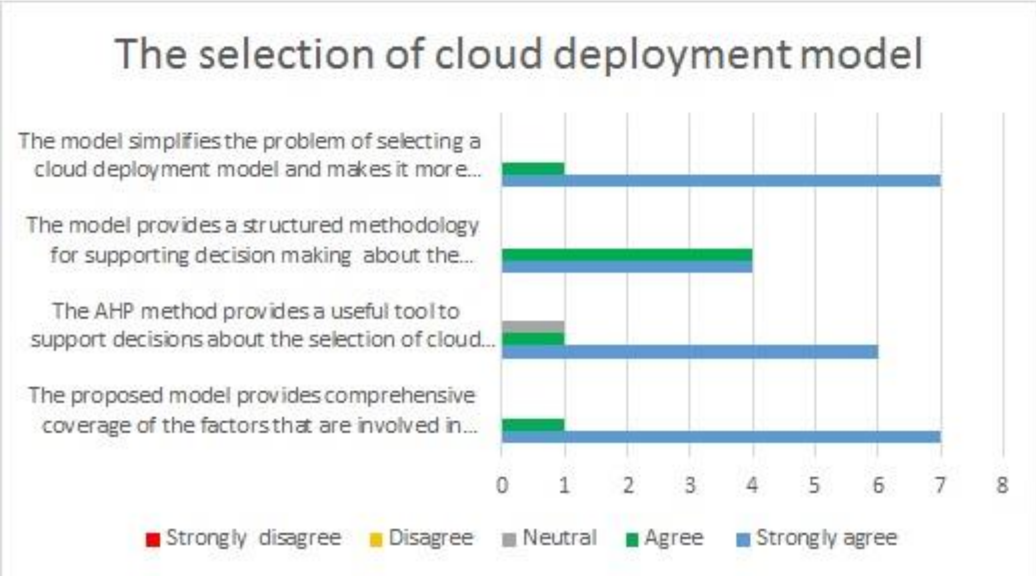


Figure 7-7: Summary of closed question results for proposed tactical model

Figure 7-7 shows that all the stakeholders agree that the model is useful. There is agreement that the proposed model is comprehensive and the factors used to select cloud deployment model are comprehensive. Of the stakeholders who expressed a view, all stakeholders agreed that using AHP method is useful to support the selection of cloud deployment models. Finally, participants agreed that the model provides a structured methodology for supporting decision making at the tactical level and that this makes the problem more understandable for decision makers.

The participants were asked to rate the factors used to select cloud deployment models, with five being the most important and one the least. There are four main groups of factors, as shown in the table below: technical, organisation, security and economic.

Factors	*Sub-factors*	*Mean*
Technical	Control enterprise resources and data	4.62
	Scalability	4.75
	Reliability	4.62
	Flexibility	4.62
Organisational	focus on core competency	4.87
	Organisational capability to manage IT	4.75
	Time to market	4.87
Security	Data privacy	4.75
	Service availability	5
	Data location	4.62
	Interoperability	4.62
Economic	Total cost of ownership	4.87
	Transfer CAPEX TO OPEX	4.5
	Lower up-front cost	4.87

Table 7-3: Results of important factors for cloud deployment model

The factors in the selection of cloud computing deployment model, as shown in the table above, obtained a high average score between all participants for validation. The highest score is 5, which is service availability, while the lowest score is 4.5 for transfer CAPEX TO OPEX.

7.6.2 Future Development

No suggestions were made for the future development of the tactical model.

7.7 Review of the Decision Matrix developed to Support the operational Decision on choice of Cloud Computing Service Model

This section discusses the validation of the decision matrix model developed to support the operational decision on choice of cloud service model

7.7.1 Review of the Approach

To validate the decision matrix, four questions were developed to examine the comprehensiveness of the model, usefulness and cost-effectiveness. The participants were given examples of how to use the decision matrix and were asked to comment after the practice session. Figure 7-8 shows the results of the discussion.

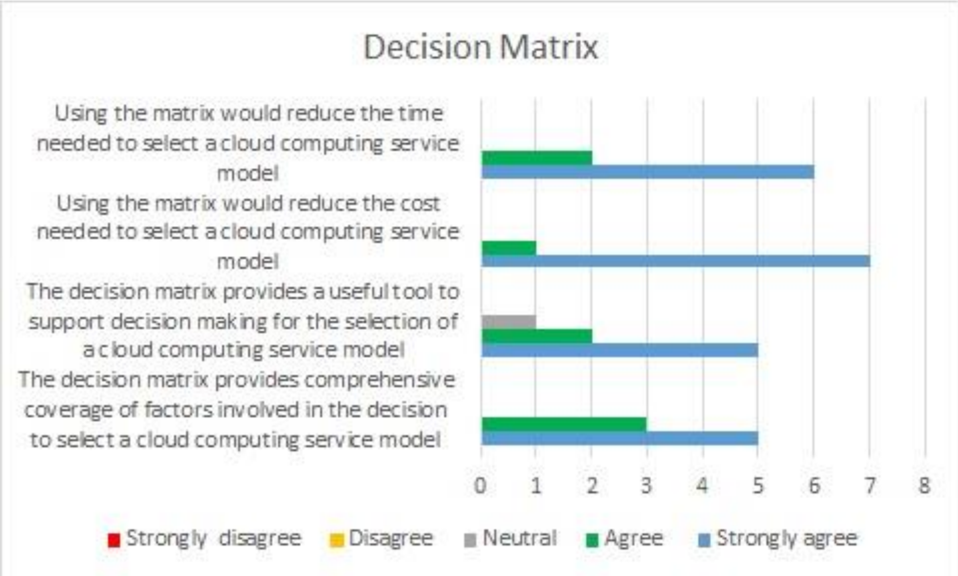


Figure 7-8: Summary of closed question results for proposed decision matrix

The overall assessment of the decision matrix achieved a high degree of agreement between the participants, as shown in the figure above. The statement that the factors used in the decision matrix are comprehensive and supportive of selecting the cloud computing service model was strongly supported. All the participants who expressed a view agreed that the decision matrix provides a useful tool to support the selection of cloud service model. All participants agreed that the matrix would reduce the cost in terms of time and costs needed to make the decision on the selection of the cloud service model.

7.7.2 Future Development

No suggestions were made for the future development of the decision matrix.

7.8 Case Study Evaluation

As part of the evaluation process, two of the workshops were extended to include case studies which reflected the experience of the participants. The case studies were used to examine the practicality of using the KCADF in a real life environment. One workshop case study considered an IT company which planned to expand IT resources by adopting cloud computing. The second case study, considered in a different workshop, related to a small medical clinic.

7.8.1 The IT Solution Provider

The first scenario is an IT service solution provider with around 70 employees. The company designs IT services to different enterprises and manages IT services for many enterprises. The company is planning to increase their IT resources to meet demand from clients but the company has a limited budget for expanding IT resources.

- *Cloud adoption decision*

As discussed at the beginning of this chapter, a presentation was given to explain the models and how to use the tool developed to run the AHP and CBR. The stakeholders were asked to employ pairwise comparison to weight and prioritise the factors. The table below shows the square matrix for level one. As discussed in 6.5, the eigenvector was used in pairwise comparison matrix to prioritise and calculate the factors weights. This was calculated by dividing each row by the total sum of all rows (Saaty, 2008). Therefore, to make the calculation easier and faster we used Excel to run the AHP in the simulation session. All these processes were explained to the stakeholders, who found that using Excel makes the calculation easier and provides a user-friendly user interface that makes the AHP easier to use.

	Technical	Economic	Security	Organisational	Regulatory	Weights (%)
Technical	1	1/3	2	3	3	24.41
Economic	3	1	2	3	4	40.53
Security	1/2	1/2	1	2	2	16.6
Organisational	1/3	1/3	1/2	1	2	10.82
Regulatory	1/3	1/4	1/2	1/2	1	7.65

Table 7-4: Weights of the main factors for cloud adoption decision

As shown in the Table 7-4, the most important factor in the selection of the optimum IT provisioning services is economic, followed by technical. The decision makers continuously compute the weights of the sub-factors in the next level. Table 7-5 shows the result of pairwise comparison matrix of the technical sub-factors. The other tables of sub-factors for the other factors are shown in appendix E. The weights of sub-factors are: 25.8, 10.5 and 63.7 (financial); 27.9, 7.2 and 64.9 (security); 14.29, 57.14 and 28.57 (organisational); and 75 and 25 (regulatory).

	On-demand service	Service quality	Service flexibility	Weights (%)
On-demand service	1	1/3	½	16.3
Service quality	3	1	2	54.0
Service flexibility	2	½	1	29.7

Table 7-5: Weights of the technical sub-factors for cloud adoption decision

As discussed in the previous chapter, in this research absolute measurement with ranking from one to five was used for alternative weights. The weighting values were set by the workshop participants after discussion with the researcher. The values for all sub-factors have been set through the workshops. Appendix E shows all weights for alternatives. After running the AHP and obtaining the weights of all factors, sub-factors and alternatives, as shown in Table 7-6, the final results are 3.77 for cloud computing, 3.1 for traditional outsourcing, and for in-house solution is 2.75. The cloud computing obtained the highest ranks weights. In Table 7-6 we multiplied the weights of factor in sub-factors, and then multiplied it by the weight of alternatives.

Factors and sub-factors	*Weights (W)*	*Cloud computing*	*Outsourcing*	*In-house*
FactorsW * subfactorW	FactorW*sub-factorW	W*cloud weight	W*outsourcing weight	W*in-house weights
T * t1	0.039	0.198	0.119	0.119
T*t2	0.131	0.659	0.527	0.395
T*t3	0.072	0.362	0.289	0.217
E*e1	0.104	0.522	0.313	0.209
E*e2	0.041	0.206	0.165	0.082
E*e2	0.025	0.129	0.077	0.077
S*s1	0.046	0.138	0.138	0.231
S*s2	0.119	0.478	0.358	0.358
S*s3	0.107	0.430	0.323	0.323
O*o1	0.064	0.257	0.257	0.192
O*o2	0.026	0.107	0.134	0.080
O*o2	0.016	0.050	0.067	0.084
R*r1	0.057	0.172	0.229	0.286
R*r2	0.019	0.057	0.076	0.095
		3.772	3.079	2.755

Where T technology, E economic, S security O Organisational and R regulatory

$t_{1,2,3}, E_{1,2,3}, S_{1,2,3}, O_{1,2,3}, R_{1,2}$ are the sub-factors presented in Table 6-3 discussed in chapter seven

Table 7-6: Results of AHP calculation for cloud adoption decision

- *Selection cloud deployment model*

After running the AHP to decide whether to move to cloud computing or to select other IT provisioning models, cloud computing was selected as the best alternative for the enterprise supported by the importance of economic and technical factors, which represents a relative advantage for cloud computing. The decision makers were asked to compute the weights of the factors that influence the selection of cloud deployment models by running the AHP. After running the AHP, economic was selected as the most important factor when selecting cloud deployment models. Figure 7-9 shows the importance of each factor for the company when selecting cloud deployment models. All the tables with factors and sub-factors weights are shown in appendix E.

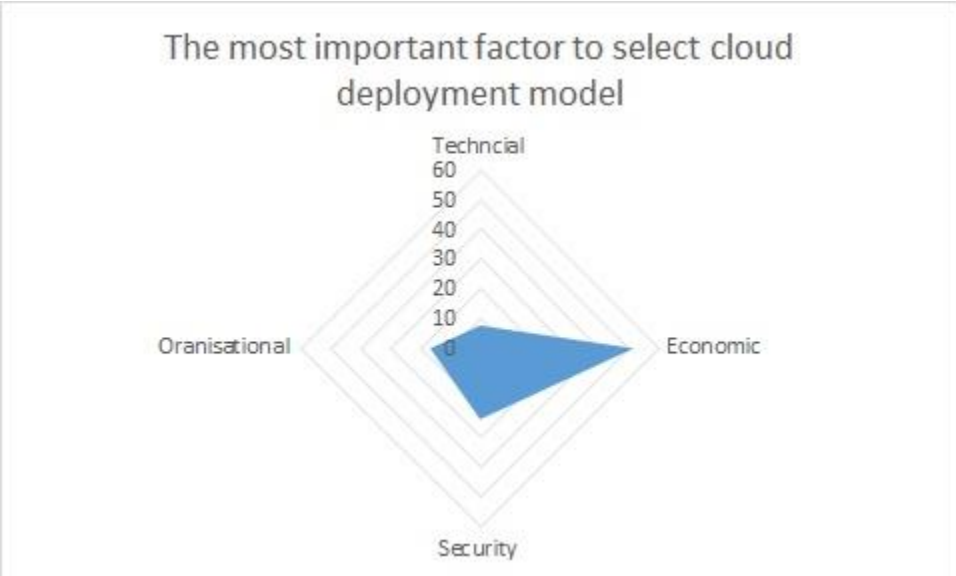


Figure 7-9: The important factor to select cloud deployment model

The decision makers involved in this session continued to compute the weights of the sub-factors using AHP. As shown in Figure 7-10, scalability was defined by the stakeholders as the most important sub-factor between the technical factors, with a weight of just under 65%. In the case of economic factors, the reduced TCO was found to be the most important factor that decision makers considered when selecting cloud deployment models. Data confidentiality was found to be the greatest factor under the security category, with weights just above 47%. Among the organisational factors, the implementation lead time and focus on core business was highlighted as important when selecting cloud deployment models.

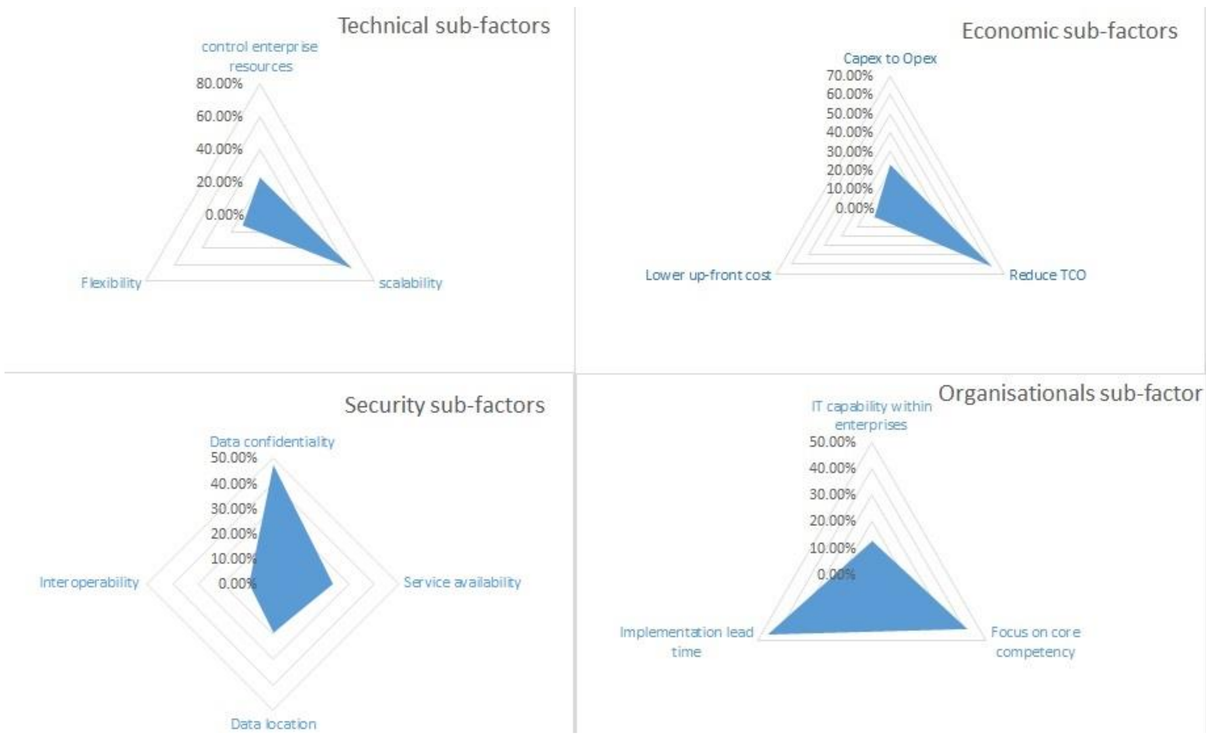


Figure 7-10: The important sub-factors for each cloud deployment model factor

By using the absolute measurement, the weights of the alternatives were set, as shown in appendix E. The results indicate that the public cloud is the best solution for the enterprise, as the most influencing factors in the cloud decision are scalability, reduce TCO, implementation lead time and focus on core competency and data confidentiality. The first four factors are supported in public cloud while the last one was supported by the private cloud. This result shows the benefits of using AHP to balance between different factors to obtain the best decision. The public cloud obtained 5.17, whereas the private and hybrid clouds obtained 3.46 and 3.35 respectively as show in Table 7-7.

Factors and sub-factors	*Weights (W)*	*Public cloud*	*Private cloud*	*Hybrid cloud*
FactorsW * subfactorW	FactorW*sub-factorW	W*cloud weight	W*outsourcing weight	W*in-house weights
T * t1	0.017	0.035	0.088	0.071
T*t2	0.049	0.249	0.149	0.199
T*t3	0.009	0.037	0.028	0.037
E*e1	0.119	0.597	0.238	0.358
E*e2	0.325	1.629	0.325	0.652
E*e2	0.048	0.243	0.0973	0.1460
S*s1	0.114	0.341	0.568	0.454
S*s2	0.056	0.284	0.170	0.227
S*s3	0.046	0.046	0.232	0.139
S*s4	0.232	0.927	1.159	0.463
O*o1	0.021	0.042	0.107	0.085
O*o2	0.070	0.353	0.141	0.283
O*o2	0.077	0.389	0.155	0.233
		5.177	3.463	3.351

Table 7-7: The result of AHP calculation for the selection of cloud deployment model

- *Cloud service models*

In this section, the user selects the best cloud service models (IaaS, PaaS and SaaS) and the PDM is used to select the cloud service models that meet the enterprise requirements. In Table 7-8, the user has given weights for cloud service models for each factors. The decision makers were asked to assign weights for each factor according to the enterprise requirements. After weighting the factors, the weights for each factors were multiplied by each weight for each cloud service model. After the decision makers assigned the values of factors, IaaS obtained the best score, as shown in Table 7-8

	Data sensitivity	*Control over resources*	*Capability of IT to manage the services*	*Short lead time*	*Cost*	*Scalability*	*Performance*	*Availability*	*Interoperability and portability*	*Total*
Weights	1	2	2	1	1	2	2	2	1	
IaaS	3	3	3	1	1	3	3	3	3	38
PaaS	2	2	2	2	2	2	2	2	2	28
SaaS	1	1	1	3	3	2	1	2	1	22

Table 7-8: The result of decision matrix

7.8.2 A Small Clinic

The second case is a small clinic with about 30 staff members, comprising doctors, nurses and administrative staff. The clinic needs a system to organise the medical records for patients. The current system is a simple database that stores some detail about the patient, such as name, file number, phone number and history. For this case study, the cloud user participant provided the domain expertise about the clinic requirements.

- *Cloud adoption decision*

To start with the first level, the decision matrix computed the weights of the main factors by running the AHP. Table 7-9 shows the weights of the main factors. Due to the restricted nature of patient data, the regulatory factors were identified as an important factor followed by the economic one.

	Technical	*Financial*	*Security*	*Organisational*	*Regulatory*	*Weights (%)*
Technical	1	1/3	1/3	1/2	1/3	7.8
Economic	3	1	3	2	1/2	27.1
Security	3	1/3	1	1/3	½	12.8
Organisational	2	½	3	1	1/2	19.4
Regulatory	3	2	2	2	1	32.8

Table 7-9: The weights of the main factors for cloud adoption decision for the case two

In the second level of hierarchy, the decision makers compute the sub-factors for each factor by running AHP. Figure 7-11 shows the weights for the sub-factors.

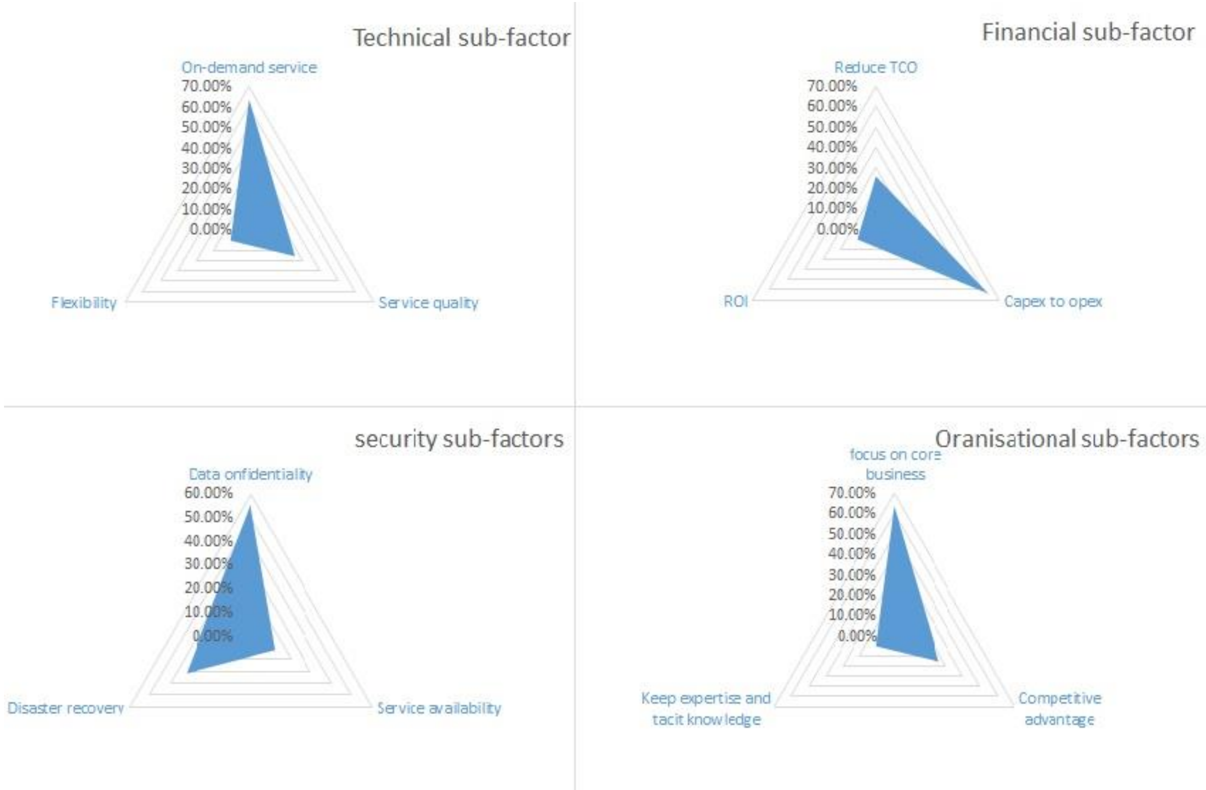


Figure 7-11: The important sub-factor for each cloud deployment model factor

After weighting the weights of all factors and sub-factors, cloud computing is selected as the most appropriate IT service model to support the clinic. Figure 7-12 shows the weights for each alternative. The whole table is shown in appendix E.

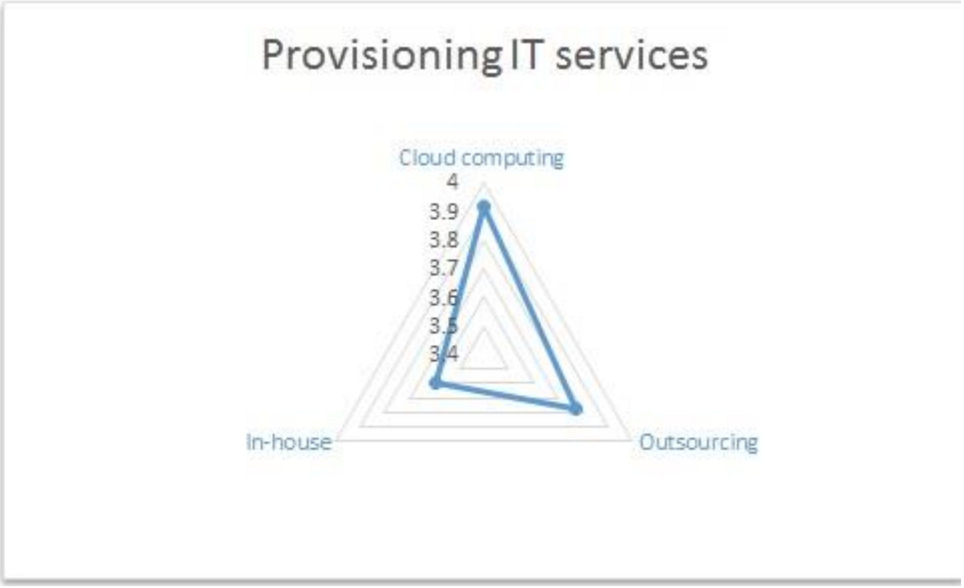


Figure 7-12: The result of the best provisioning IT service for case two

- *Selection of cloud deployment model*

After deciding move to cloud computing, the process to select the cloud deployment models is carried out. Figure 7-13 shows that the most important factor as selected by the stakeholder for the clinic is financial.

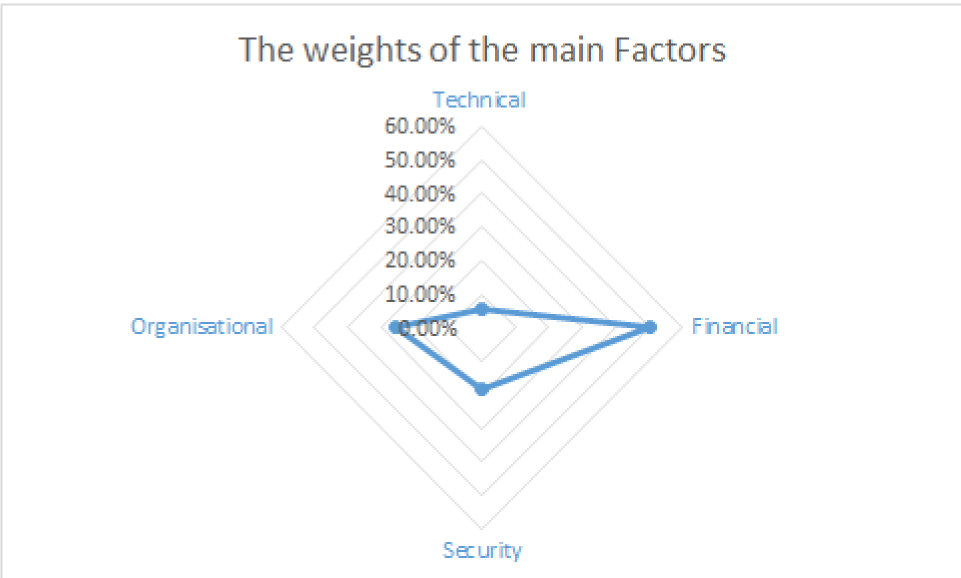


Figure 7-13: The weights of the main factors

Using the judgment and expertise of decision makers, the weights of sub-factors for each factor were computed using the tool. All the tables are shown in appendix E, which shows the weights of all sub-factors. After that, the decision makers decided to use the weightings developed in the previous workshop. After computing these weights, the public cloud was selected as the best choice for the clinic. Figure 7-14 shows the weights for each alternative.

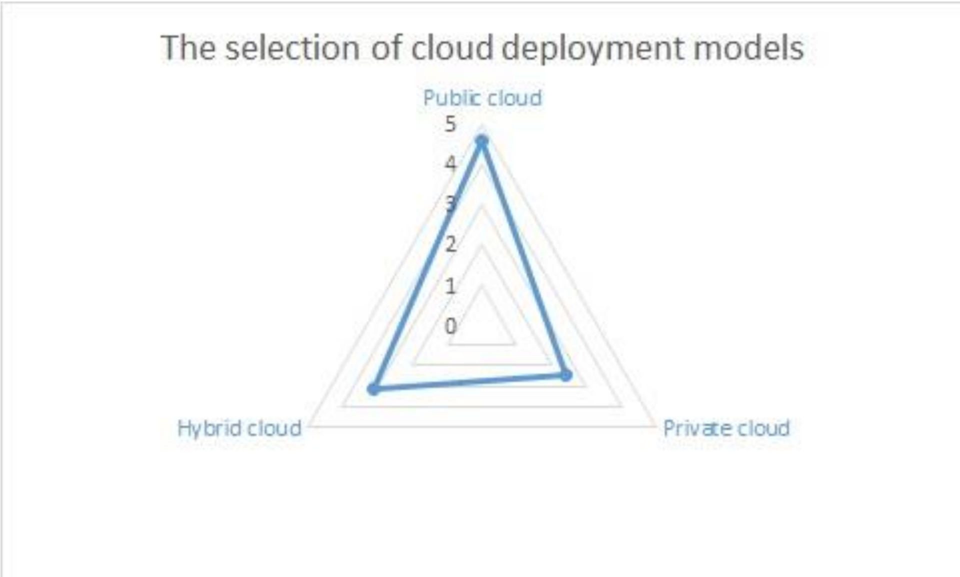


Figure 7-14: The selection of cloud deployment models for case two

- *Cloud service models*

The cloud service models were evaluated using the PDM, revealing that the SaaS model obtained the highest weights (Table 7-10). `

	Data sensitivity	*Control over resources*	*Capability of IT to manage the services*	*Short lead time*	*Cost*	*Scalability*	*Performance*	*Availability*	*Interoperability and portability*	*Total*
Weights	1	0	0	2	2	1	1	2	0	
IaaS	3	3	3	1	1	3	3	3	3	19
PaaS	2	2	2	2	2	2	2	2	2	18
SaaS	1	1	1	3	3	2	1	2	1	21

Table 7-10: The result of decision matrix for selection cloud service model for case two

7.9 Changes and Improvements Suggested to the Framework and Models

The validation workshops produced some suggestions and resulted in modifications to the framework. One of the comments related to the duplication of some elements between the inner circle and outer circle. For this reason the original diagram was amended to remove the middle circle. Additionally, it was suggested that financial status be taken into account when deciding to adopt cloud computing. In response to this, a checklist to support the strategic decision has been extended to include the decision to move to cloud computing and the selection of cloud deployment model. A definition for technical terms was developed to make them understandable for decision makers. The proposal to include data integrity was not acted upon as it was felt this formed part of the security element.

7.10 Conclusion

This chapter has discussed the results of the validation and evaluation workshops. Four workshops were carried out to validate the clarity, usability and practicality of using the KCADF. The findings from the workshop supported the concept and structure of the

KCADF and enabled the framework to be evaluated in a real-life context with stakeholders. As a result of comments made during the validation process, minor changes and extensions were made to the KCADF. The next chapter evaluates the research as a whole and presents suggestions for future work.

Chapter 8: Conclusion and Future Work

8.1 Introduction

The first chapter in this thesis outlined the aim of this research, which was to develop a Knowledge Management Based Cloud Computing Adoption Decision Making Framework to support decision makers within enterprises. An additional aim was to add to the body of knowledge by investigating cloud computing adoption in a technologically developing environment. To achieve these aims, several objectives were developed. The study began by reviewing previous studies in different areas related to cloud adoption and migration, outsourcing and cloud adoption theories. Knowledge management and technology diffusion theories were investigated and primary research was carried out to determine the context of cloud adoption in a technologically developing economy and to investigate the factors which should be taken into account when making decisions about cloud computing adoption. The KCADF was developed, including supporting models and tools and this was validated using a workshop approach with domain experts. This chapter summarises the findings of this research, evaluates the research and identifies areas for future work.

8.2 Research Summary

This research developed set of objectives in order to achieve the main aim. Table 8-1 shows the method of investigation used to achieve them.

	Objective	Method of investigation	Chapter
1	To critically review of the literature of cloud adoption approaches and frameworks and identify issues related to cloud computing adoption.	Review the literature and industry documents	2
2	To investigate knowledge management and decision making theories to provide the theoretical underpinning for the research.	Review the literature on KM, OL, LO and decision making theory	3
3`	To investigate the theoretical basis of technology adoption models, frameworks and approaches.	Review the literature on technology adoption theory, including TOE and DOI	3
4	To investigate the challenges and issues and benefits involved in cloud adoption in a technologically developing environment through a field study.	Conduct 14 interviews with cloud experts and distribute a questionnaire to cloud consumers	4 & 5
5	To develop knowledge Management based cloud adoption decision making framework based on secondary and primary research.	Input from the findings from the interviews and questionnaire and the secondary research.	6
6	To develop, as part of the framework, decision making models to support the strategic decision on cloud adoption, the tactical decision on the selection of cloud deployment models and the operational decision on the selection of cloud service models.	Use of AHP, CBR and PDM	6
7	To validate the cloud adoption framework and supporting models through primary research.	Evaluate the proposed framework and supported model by designing prototype and running in four workshops involving stakeholders, including CSPs and cloud consumers	7
8	To evaluate the research and suggest directions for future research	Summarise the findings of the research	8

Table 8-1: Objectives summary

8.2.1 Discussion of Literature Review

The literature review was divided into two chapters: chapter 2 which discussed cloud computing and cloud computing adoption and chapter 3 which discussed KM, OL, LO and decision making, and technology adoption theories.

Chapter two discussed cloud computing concepts and reviewed the benefits and issues related to cloud computing adoption. Cloud deployment models were critically reviewed under five headings: location, management, security, scalability and availability. The issues and benefits related to each cloud deployment model were discussed. There are three cloud service models, IaaS, PaaS and SaaS. These three service models were discussed in chapter two, categorised into four factors, which are control over resources, responsibility for security, cost, and the level of IT skills need to adopt these services.

The literature review also discussed the issues and benefits related to cloud adoption. The issues are grouped into five categories, namely technical, organisational, financial, security and regulatory. The benefits related to cloud adoption were categorised into four main groups, which are technical, organisational, economic and security. The literature review also examined existing frameworks/models developed to support cloud adoption and migration, classifying them under five headings: risks and benefits analysis, cloud adoption decision support, application migration, factors which affect cloud adoption and assessment of organisational readiness. The literature review showed that existing frameworks/models lacked a comprehensive and holistic approach to cloud computing adoption.

8.2.2 Theoretical Underpinning for the Research

The theoretical underpinning for the research was presented in chapter three. This chapter discussed knowledge management concepts including decision making, LO and OL, and theories on technology adoption and technology diffusion. The discussion included consideration of the TOE, DOI and TAM approaches. The TOE framework and DOI theories, together with the findings from the literature review, were used in the primary research to develop fourteen hypothesises which supported the examination of factors influencing cloud adoption in enterprises in Saudi Arabia. As cloud commuting has technical as well as business implications, using the TOE framework and DOI provided a holistic perspective from which to investigate cloud computing adoption.

The interview questions were developed based on these theories as well as the literature review.

8.2.3 Primary Research

The primary research was discussed in chapter four, which presented the results of the interviews and chapter five, which discussed the survey results. As part of the primary research, interviews were conducted with fourteen IT experts involved in the cloud adoption process. The interviewees were from CSPs in Saudi Arabia but included representation from a large hospital in Saudi Arabia that had adopted a private cloud. The results from the interviews, combined with the findings of the literature review and the hypotheses developed from the literature review and the TOE and DOI frameworks, provided the basis for the questionnaire. The questionnaire results were discussed in detail in chapter five. One finding from the questionnaire was that the organisational context was seen as the most important barrier to adopting cloud computing, due to the lack of knowledge about cloud computing among decision makers in many enterprises. The primary research, combined with the findings from the literature review, identified the factors that would be included in the KCADF.

8.2.4 Development of Framework and Supported Models

Chapter six discussed the development of the Knowledge Management Based Cloud Computing Adoption Decision Making Framework and the supporting models and tools. Based in the discussion in chapter three, the cloud adoption decision was divided into three decision making levels, with three corresponding models developed to support the decision in each level.

At the strategic level, the KCADF provided support for the decision as to whether to migrate to the cloud or choose an alternative method of providing IT services. The framework takes into account five groups of factors, which are technical, organisational, economic, security and regulatory. These groups of factors were identified from the primary and secondary research. Once a strategic decision has been taken to adopt cloud computing, the next stage of the framework is concerned with the selection of cloud deployment models.

The selection of a cloud deployment model is classified in the KCADF as a tactical level decision which involves four groups of four factors identified from the primary and secondary research. These groups of factors are technical, organisational, security and economic. The KCADF uses AHP and CBR at the strategic and tactical decision making levels to support the decision making process. The cloud deployment decision making stage was also supported by a checklist.

The third level of the KCADF is concerned with the operational level decision about the selection of cloud service models. The Pugh Matrix was used to support the selection of cloud service models. Nine factors were identified from primary and secondary research to support the decision of selection of cloud service models. In addition, a checklist was developed to support the selection of CSP and to highlight the main issues related to cloud service models.

8.2.5 Validation of Framework

The validation of the KCADF was achieved by conducting four workshops in Saudi Arabia. The aim of the validation was to examine the clarity, usability and practicality of using proposed framework and the supporting models. The validation workshop showed that the proposed framework and supported models are holistic and provide support for cloud computing adoption decision making. The results from the workshop also confirmed that the factors and sub-factors identified through the primary and secondary research are important in terms of cloud adoption decision making.

8.3 Research Contribution

This research makes a number of contributions to knowledge. From the literature review, we had identified that a comprehensive, holistic framework to support the decision on cloud computing adoption did not exist. The knowledge management based cloud computing adoption decision making framework presented in this thesis is a holistic framework which covers the strategic, tactical and operational decision making involved in a cloud adoption project and considers the range of factors and perspectives involved in cloud computing adoption. The framework and supporting models are customisable by users meaning that the framework can be used in different technical and enterprise contexts.

The thesis also makes a contribution to the body of knowledge through the investigation of the factors that influence cloud computing adoption in a technologically developing country. The majority of the research that has so far been carried out on cloud computing adoption has taken place in technologically developed countries. The findings of the study are given in detail in chapter five but the main conclusions are that organisational characteristics comprise the main factor that restricts cloud adoption in Saudi Arabia and that government support is particularly important for cloud adoption in technologically developing countries. In a technologically developing environment, the adoption of cloud computing can be supported by regulation for the cloud services market, and other initiatives to support both CSP and cloud consumers.

A minor contribution to knowledge is the comprehensive review of the cloud computing adoption literature given in chapter two and the evaluation of existing frameworks and models which support cloud computing adoption.

8.4 Research Limitations

We recognise some limitations and restrictions on the research. The preliminary field work, the interviews, was largely conducted with CSPs and was limited to five enterprises. This reflected the small number of CSPs in Saudi Arabia and time and resources restrictions. One interesting result from this, as discussed in chapter five, was that we noted some difference in views between CSP interviewees and the cloud computing users who completed the questionnaire. It was notable, for instance, that CSPs attached more importance to government regulation than users, perhaps reflecting their different roles.

81 validly completed questionnaires, representing 81 separate organisations were received. A larger sample size would have been preferred but the constraints imposed by the study (the requirement that respondents had relevant experience and knowledge and were able to discuss their organisation's IT strategy and plans) combined with the slow adoption rate in Saudi Arabia limited the pool of respondents. The purpose of the interviews and the survey was to identify the factors which influenced cloud computing adoption to support the development of the KCADF. The factors identified from the primary research were used in conjunction with the factors identified from the literature review and results from the validation workshops, discussed in chapter 7, confirmed that the factors used in the KCADF were comprehensive and relevant.

As noted in chapter 7, the CBR tool demonstrated in the validation workshops was a design prototype rather than a full version of the tool and a limited number of cases were available to support the tool. This is discussed further in the following section.

8.5 Areas for Further Work

Based on the discussion, the following areas are suggested for investigation by future work:

- The KCADF supports decision making in the field of cloud computing adoption by integrating AHP and CBR. The KCADF is customisable, which allows the framework to be used in different organisational contexts and environments. An area for further research is to investigate whether the KCADF approach could be extended to provide a generic decision making approach.
- Further work will be carried out to turn the prototype CBR tool into a full CBR tool with an appropriate user interface.
- One of the issues with CBR is the difficulty of finding similar cases and an area for further research is to identify and classify similar cases to provide a library of cases to support not only the KCADF but other research in the field of cloud computing.
- Further work will be carried out in real world scenario to apply the KCADF in a complex environment such as healthcare so that the effectiveness of the KCADF can be evaluated over time.
- This study investigates cloud computing adoption in a technologically developing country using Saudi Arabia as the exemplar. Saudi Arabia is a relatively developed country among the technologically developing nations and

further investigation should be conducted in countries with different levels of technological development in order to determine if the factors identified in this study apply in countries with lower levels of technological development.

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Appendices

Appendix A

The description of LO elements:

- *Clarity mission and vision*

It has been claimed enterprises should clearly articulate the mission and vision of the enterprise to all members of organization (Heagney, 2011). It is argued that when the whole picture of cloud adoption project is clear to the top management level as well as the people in the operation level, this will create a shared vision which enables each member involved in the project to add value to it (Senge, 1990a; Goh, 2003). Martins and Terblanche (2003) went further to indicate that clarity of mission and vision increase creativity and innovation. Consequently, providing a clear mission and vision for a cloud adoption project for all members makes the members aware about the new changes caused by the cloud adoption. This could help enterprise to know the change in roles and responsibility of IT staff and how they minimise the risks associated with these changes.

- *Leadership commitment*

Leadership has been identified as an important element in the learning organisation (Senge, 1990), and leadership commitment is necessary to success the cloud migration project from multiple perspectives (Heagney, 2011), to build a shared vision of the project that is clear to all involved stakeholders. In particular, top management support is regarded as a crucial to project success in terms of resource allocation, including budget, tools and human resources (Siguaw et al., 2006), and in eliminating obstacles that could face the project as well as disseminating knowledge related to the innovation

(Siguaw et al., 2006). In the primary research, top management was highlighted as one of the main influencing factors in cloud adoption decision.

- *System thinking*

System thinking refers to see the problem from all perspectives and try to understate all factors that interrelate with the problem (Rowley & Gibbs, 2008). Garrison et al.(2012) and Azeemi et al. (2013) argued that the holistic approach supported by system thinking supports the adoption of new technology, including cloud computing. As discussed in chapter two and supported by the interview and questionnaire findings, adopting cloud computing is affected by five perspectives: technical, security, organisational strategy, economy and regulatory.

Therefore, making the decision by considering technical characteristics only could lose the advantages of other enterprise competencies. In this regard, system thinking highlights the impact of cloud adoption across the whole enterprise, enabling a more comprehensive analysis to inform the adoption decision. Additionally, it is believed that system thinking plays an important role in KM because it ensures that knowledge has been shared among all involved members in the whole enterprise (Rubenstein-Montano et al., 2001).

- *Knowledge sharing*

Knowledge sharing plays a critical role in the adoption of new technology, including cloud computing (Vandaie, 2008). Knowledge sharing could be done between one person to other, one group to other, and one enterprise to other. At the individual level, knowledge sharing includes skills, experience and explicit knowledge. In contrast, at the organizational level this includes lessons learnt and best practices of others.

Knowledge sharing can result in reduced time and cost of the project as well as mitigated risks (Park & Lee, 2014). Gaining advantages from lessons learnt, including both successful and failure experiences, are important in project management (Metaxiotis et al., 2003; Razmerita & Phillips-Wren, 2016). The lessons learnt are the output of each project, which could be conducted within enterprises or in other organisations. It is argued that sharing knowledge and experiences through the CBR tool enables decision makers to optimise their decisions. In addition, the results of the interview and questionnaire show that the decision makers in enterprises lack knowledge about cloud computing, thus the framework includes a CBR element to provide a knowledge sharing environment by utilising previous adoption projects.

- *Effective transfer of knowledge*

Goh (2003) argued that knowledge should be transferred between the different levels in an organisation as well as between different units. In addition, it is claimed that one of the characteristics of LO is transferring knowledge when needed (Bloodgood & Salisbury, 2001; Lyles, 2014). As shown in figure 7.1, the knowledge could flow down from the strategic to the operational level or conversely up. Therefore, establishing an efficient channel to transfer knowledge between the all decision making levels and members involved in a project can improve decisions in all levels.

Appendix B

A Knowledge Based Model and a Framework to Support Cloud Computing adoption

Cloud computing represents a paradigm shift in the way that IT services are delivered within enterprises. Cloud computing promises to reduce the cost of computing services, provide on-demand computing resources and a pay per use models. However, there are numerous challenges for enterprises planning to migrate to a cloud computing environment, with impacts from multiple perspectives. Cloud computing migration issues vary between organisations and between technologically developed and developing countries.

The aim of this research is to support cloud adoption decision making at all levels by developing a holistic framework to support strategic cloud adoption decision and to develop a cloud adoption model to support operational and tactical decision making. In addition, this research examines the process of cloud migration in a technologically developing environment and highlights issues related to cloud migration in Saudi Arabia.

The purpose of this interview is to identify the existing practice of cloud migration process and to address the issues of cloud computing in Saudi Arabia. This interview will investigate the factors that influence cloud migration decision. Moreover, the interview highlights the impact of cloud computing on organisation strategy and how organisation mitigate the risk of cloud computing.

Background and responsibility of respondents

Name Date

Company Position

It experience

Type of services provided by your company and the motivation to provide cloud services

What cloud service model provides?

What cloud deployment model provides?

What are the main drivers to provide cloud services?

How long have you been provide cloud services?

Addressing the issues restricting cloud adoption and drivers to move to cloud

What are the main issues related to cloud computing in general and in Saudi Arabia specifically from service providers' point of view according to the following perspectives?

Technical

Organisational

Security

Economic

Regulatory

What are the main issues related to cloud computing in general and in Saudi Arabia specifically from the client point of view?

Technical

Organisational

Security

Economic

Regulatory

What are the drivers for enterprises to migrate to cloud computing?

Technical

Organisational

Security

Economic

The existing strategy/road map to manage cloud migration process

What methods/approaches are used to support cloud computing migration?

To what extent do the existing methods/approach can support cloud migration process?

Cloud you describe how the decision of migrating to cloud computing was made?

Factors with a significant role in migrating to cloud computing in Saudi Arabia

Which of the following factors has a major impact on cloud adoption rate?

Firm size

Industry sector

Firm status (established/startup company)

IT maturity level

IT infrastructure

Competitive pressure

How do you see the IT infrastructure readiness to adopt cloud computing technology in Saudi Arabia?

Technological readiness

Organizational readiness

Regulatory readiness

Do you think there are other factors that have a significant role in the adoption of cloud computing services?

Thank you for your time.

Abdullah Alhammadi

a.alhammadi@staffs.ac.uk

PhD student

School of Computing

Staffordshire University

Appendix C

Cloud Adoption in Saudi Arabia

Dear Participant:

My name is Abdullah Alhammadi and I am a PhD student at Staffordshire University in the UK. My research sponsored by government of Saudi Arabia. The purpose of this questionnaire is to find out the issues and the benefits which affect decision making about cloud computing migration in Saudi Arabia.

I am inviting you to participate in this research study by completing the following questionnaire. It will require approximately 15 minutes completing. There is no compensation for responding nor is there any known risk. All information will remain confidential and will be used for academic purpose.

This research will follow the Staffordshire University's code of conduct for research. The findings of this research will be made available to you upon your request.
If you require additional information or have questions, please contact
me at the number or email listed below. If you agree to participate please
click on next to commence.

Sincerely,
Abdullah Alhammadi
Staffordshire University
School of Computing
a.alhammadi@staffs.ac.uk
00447429565769
00966548756132

1. What is your job role?

- Chief executive officer (CEO)
- Vice President
- Owner
- Senior Manager
- Manager
- Team Leader
- Other (please specify)

2. To which sector of industry does your organisation belong?

- Banks & Financial Services Sector
- Petrochemical Industries Sector
- Cement Sector
- Retail Sector
- Energy & Utilities Sector
- Agriculture & Food Industries Sector
- Telecommunication & Information Technology Sector
- Insurance Sector
- Multi-Investment Sector
- Industrial Investment Sector
- Building & Construction Sector
- Real Estate Development Sector
- Transport Sector
- Media and Publishing Sector

- [ ] Hotel & Tourism Sector
- [ ] Other (please specify)

____

3. Please select the answer which best describes your organisation.

- ○ Government sector
- ○ Private sector
- ○ Non profit

4. Which of the following systems are used in your organisation?

- [ ] E-mail
- [ ] Webpages
- [ ] E-services portal
- [ ] Transaction Processing Systems such as Payroll, Purchasing
- [ ] Enterprise resources planning such as SAP, Oracle and Microsoft Dynamic
- [ ] Business Intelligence
- [ ] Other (please specify)

____

5. How many people work in your organisation?

- ○ 10—50
- ○ 51—250
- ○ 251—1000
- ○ >1000

6. The organisation was established:

- ○ 3 years or less
- ○ More than 3 years

7. Does your organisation plan to migrate services and data to cloud computing?

- ○ Yes
- ○ No
- ○ It has already migrated to the cloud.

○ Don’t know

8. What type of cloud computing does your organisation use or plan to use? (You can select more than one.)

☐ Infrastructure as a Service (IaaS)

☐ Platform as a Service (PaaS)

☐ Software as a Service (SaaS)

☐ Don’t know

☐ Don’t know the terms

9. What deployment model does your organisation use or plan to use?

☐ Private cloud

☐ Public cloud

☐ Hybrid cloud

☐ Community cloud

☐ Don’t know

☐ Don’t know the terms

10. Please indicate the level in your organisation at which decisions about cloud computing migration are made (You can select more than one).

☐ Strategic level

☐ Tactical level

☐ Operational level

☐ Don't know

11. Which of the following is most important to you when selecting the cloud deployment model?

	Very Unimportant	Unimportant	Neither Important or Unimportant	Important	Very Important	Don't know
Cost	○	○	○	○	●	○
Focus on core competency	○	○	○	○	●	○
IT capability within your organisation to manage your IT services	○	○	○	○	●	○
Keep control of data and resources in-house	○	○	○	○	●	○

	Very Unimportant	Unimportant	Neither Important or Unimportant	Important	Very Important	Don't know
Data location	○	○	○	○	◉	○

- *12. On scale of 1 to 10, with 10 being the most important, please rate the following reasons for moving to cloud computing in your organisation.*

	1	2	3	4	5	6	7	8	9	10	Don't know
Reduce information technology (IT) costs	○	○	○	○	○	○	○	○	○	○	○
Ensure high availability of the service	○	○	○	○	○	○	○	○	○	○	○
Get on-demand service	○	○	○	○	○	○	○	○	○	○	○
Improve security	○	○	○	○	○	○	○	○	○	○	○
Outsource IT services and focus on core competencies	○	○	○	○	○	○	○	○	○	○	○
Get reliable IT service (Accessibility of the service, Continuity of the service and Performance)	○	○	○	○	○	○	○	○	○	○	○
Lack of internal IT resources	○	○	○	○	○	○	○	○	○	○	○
Keep up with business growth (scalability)	○	○	○	○	○	○	○	○	○	○	○
Increase efficiency	○	○	○	○	○	○	○	○	○	○	○
Other (please specify)											

13. On scale of 1 to 10, with 10 being the most important, please rate the following factors which might restrict migration to cloud in your organisation

	1	2	3	4	5	6	7	8	9	10	Don't know
Data security	◉	○	○	○	○	○	○	○	○	○	○
Availability of service	○	○	○	○	○	○	○	○	○	○	○
Cost of services	○	○	○	○	○	○	○	○	○	○	○
Loss of control over resources	○	○	○	○	○	○	○	○	○	○	○
Loss of IT expertise	○	○	○	○	○	○	○	○	○	○	○
Data location	○	○	○	○	○	○	○	○	○	○	○
Vendor lock-in	○	○	○	○	○	○	○	○	○	○	○
Regulation compliance	○	○	○	○	○	○	○	○	○	○	○
Interoperability with existing systems	○	○	○	○	○	○	○	○	○	○	○
Trust in cloud service providers	○	○	○	○	○	○	○	○	○	○	○
Difficulty of migrating existing system to cloud	○	○	○	○	○	○	○	○	○	○	○
Lack of knowledge about cloud computing	○	○	○	○	○	○	○	○	○	○	○
Absence of government regulations on cloud computing	○	○	○	○	○	○	○	○	○	○	○
Other (please specify)											

14. Please Rate the extent to which you agree or disagree with the following statements in relation to your organisation

	Strongly disagree	Disagree	neutral	Agree	Strongly agree	Don't know
The organisation's connectivity to the internet is adequate	○	◉	○	○	○	○
The quality of the service provided by local service provider is good.	○	○	○	○	○	○

	Strongly disagree	Disagree	neutral	Agree	Strongly agree	Don't know
Top management believes that adopting cloud computing services can add value to the organisation	○	●	○	○	○	○
The level of knowledge about cloud computing within the organisation is low.	○	○	○	○	○	○
Cloud service providers support your business line applications.	○	●	○	○	○	○
Adopting cloud computing will give your organisation competitive advantages.	○	○	○	○	○	○
Adopting cloud computing will increase the customer retention rate.	○	●	○	○	○	○
Government policies, support and initiatives have an impact on cloud adoption decisions.	○	○	○	○	○	○
Existing regulations influence the adoption of cloud computing services	○	○	○	○	○	○
Cloud computing services have more vendor support than traditional software.	○	●	○	○	○	○
Adopting cloud computing will reduce the time taken to manufacture products or provide services.	○	○	○	○	○	○
A cloud service provider will be more capable of handling data security.	○	●	○	○	○	○
Incompatibility with existing systems impedes moving to cloud computing.	○	○	○	○	○	○
Adopting cloud computing will require additional effort and training.	○	●	○	○	○	○
Migrating the existing system to cloud computing is too complex.	○	○	○	○	○	○

عزيزي المشارك:

اسمي عبد الله الحمادي وأنا طالب دكتوراه في جامعة ستافوردشاير في بريطانيا. الغرض من هذا الاستبيان هو معرفة العوائق والفوائد التي تؤثر على اتخاذ القرار حول الانتقال الى الحوسبة السحابية في المملكة العربية السعودية. أدعوكم للمشاركة في هذه الدراسة البحثية عن طريق تعبئة الاستبيان التالي. وسيتطلب ما يقرب من 10 الى 15 دقيقة لإكماله. نضمن لكم بأن إجاباتكم ستعامل بسرية تامة ولن يتم استخدامها إلا لأغراض إحصائية.

أشكركم على المشاركة في هذا الاستبيان وهذا البحث سوف يتبع نظام جامعة ستافوردشاير لأجراء الابحاث. نتائج هذا البحث

سوف تتاح لك بناء على طلبك.

إذا كنت تحتاج إلى مزيد من المعلومات أو لديك أسئلة، يرجى الاتصال بي على الرقم أو البريد الإلكتروني المذكور أدناه.

إذا وافقت على المشاركة الرجاء الضغط على التالي.

مع خالص التقدير،

عبد الله الحمادي

جامعة ستافوردشاير

كلية الحاسبات

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00447429565769

00966548756132

ما هو دورك في المنشأة التي تعمل بها؟ .1

- مدير تنفيذي
- نائب المدير التنفيذي
- المالك
- مدير عام
- مدير
- قائد فريق
- اخرى (الرجاء التحديد)

الى اي قطاع من القطاعات التالية تنتمي المنشأة التي تعمل بها؟ .2

- قطـاع المصارف والخدمات المالية
- قطاع التشييد والبناء
- قطـاع البتروكيماويات
- قطـاع الإسمنت
- قطـاع التجزئة وشركات الاستثمار المتعدد
- قطـاع الزراعة والصناعات الغذائية
- قطـاع الاتصالات وتقنية المعلومات
- قطـاع التأمين
- قطـاع الاستثمار الصناعي
- قطـاع العقار
- قطـاع النقل والطاقة
- قطـاع الإعلام والسياحة
- أخرى (يرجى التحديد)

يرجى اختيار الإجابة التي تصف المنشأة التي تعمل بها بشكل أفضل .3

- القطاع الحكومي
- قطاع خاص
- مؤسسة غير ربحية

أي من التطبيقات التالية مستخدمة لديكم في المنشأة .4

- البريد الإلكتروني
- موقع على شبكة الانترنت لتعريف بالمنشأة
- موقع خدمات الكترونية
- أنظمة أتمته الإجراءات مثل نظام المشتريات، نظام الرواتب
- SAP, Microsoft Dynamics, Oracle مثل (ERP) أنظمة موارد المعلومات
- (Business Intelligence) أنظمة ذكاء الاعمال
- أخرى (يرجى التحديد)

5. كم عدد الاشخاص اللذين يعملون في المنشأة التي تعمل بها؟

10—50

51—250

251—1000

>1000

6. كم عمر المنشأة التي تنتمي لها

لا أعرف

3 سنوات أو اقل

أكثر من 3 سنوات

7.

7. هل لدى المنشأة التي تعمل بها خطة الى التحول لتقديم الخدمات والبيانات عبر (cloud)؟ الحوسبة السحابية

نعم

لا

تم الانتقال الى الحوسبة السحابية

لا أعرف

8. ما هو نوع الحوسبة السحابية التي تستخدمها المنشأة التي تعمل بها أو تخطط لاستخدامها (يمكنك) اختيار أكثر من خيار

(IaaS) البنية التحتية كخدمة

(PaaS) منصة كخدمة

(SaaS) البرمجيات كخدمة

لا أعرف

ليس لدي معرفة بأنواع الحوسبة السحابية

9. ما هو نموذج الحوسبة السحابية المستخدم في المنشأة التي تعمل بها او تخطط لاستخدامها؟

(Private cloud) السحابة خاصة

(Public cloud) السحابة العامة

(Hybrid cloud) السحابة الهجينة

(community cloud) السحابة المشتركة

لا أعرف

ليس لدي معرفة بنماذج الحوسبة السحابية

10. في اي مستوى من مستويات صنع القرار في المنشأة التي تعمل بها يتم اتخاذ القرار للانتقال الى الحوسبة السحابية (يمكنك اختيار أكثر من خيار

المستوى الاستراتيجي

المستوى التكتيكي

☐ المستوى التشغيلي

☐ لا أعرف

11. أي مما يلي هو الأكثر أهمية بالنسبة لك عند اختيار نموذج الحوسبة السحابية (خاص، عام، هجين)

	هام جدا	مهم	عادي	غير مهم	غير مهم جدا	لا أعرف
التكلفة	○	○	○	○	○	○
الأمان	○	○	○	○	○	○
التركيز على الكفاءات الأساسية (core competency)	○	○	○	○	○	○
قدرات تكنولوجيا المعلومات داخل المؤسسة لإدارة خدمات تكنولوجيا المعلومات	○	○	○	○	○	○
إبقاء السيطرة على البيانات وموارد النظام داخل المؤسسة	○	○	○	○	○	○
موقع تخزين البيانات	○	○	○	○	○	○

12. أي مما يلي هو الأكثر أهمية بالنسبة لك عند اختيار مزود الخدمة السحابية؟

	هام جدا	مهم	عادي	غير مهم	غير مهم جدا	لا أعرف
موقع مزود الخدمة السحابية (داخل البلد/ خارج البلد)	◉	○	○	○	○	○
(SLA) اتفاقية مستوى الخدمة	○	○	○	○	○	○
التكلفة	○	○	○	○	○	○
/الدعم الفني 24	○	○	○	○	○	○
مستوى الثقة في مزود الخدمة السحابية	○	○	○	○	○	○
الاستقرار المالي لمزود الخدمة	○	○	○	○	○	○
توافر الخدمة (Availability)	○	○	○	○	○	○
استيعاب تطور ونمو الخدمة(Scalability)	○	○	○	○	○	○
التوافق مع خدمات تكنولوجيا المعلومات القائمة داخل المؤسسة	○	○	○	○	○	○

أخرى (يرجى التحديد)

13. على مقياس من 1 إلى 10، حيث 10 هو الاكثر أهمية، يرجى تقييم الأسباب التالية للانتقال إلى الحوسبة السحابية في المنشأة التي تعمل بها

	1	2	3	4	5	6	7	8	9	10	لا أعرف
تخفيض تكاليف تكنولوجيا المعلومات (IT)	○	○	○	○	○	○	○	○	○	○	○
ضمان توافر عال من الخدمة	○	○	○	○	○	○	○	○	○	○	○
الحصول على خدمة بشكل سريع عند الطلب	○	○	○	○	○	○	○	○	○	○	○
تحسين الأمن	○	○	○	○	○	○	○	○	○	○	○
الاستعانة بمصادر خارجية لتشغيل (outsourcing) وإدارة خدمات تكنولوجيا المعلومات والتركيز على الكفاءات الأساسية	○	○	○	○	○	○	○	○	○	○	○
الحصول على خدمة موثوقة لتكنولوجيا المعلومات (سهولة الوصول للخدمة، استمرارية الخدمة والأداء reliability)	○	○	○	○	○	○	○	○	○	○	○
نقص الموارد الداخلية لتكنولوجيا المعلومات	○	○	○	○	○	○	○	○	○	○	○
مواكبة نمو الأعمال (قابلية)	○	○	○	○	○	○	○	○	○	○	○
زيادة الكفاءة	○	○	○	○	○	○	○	○	○	○	○

غير ذلك (يرجى التحديد)

على مقياس من 1 إلى 10، حيث 10 هو الاكثر أهمية، يرجى تقييم الأسباب التالية للانتقال إلى الحوسبة السحابية في المنشأة التي تعمل بها

	1	2	3	4	5	6	7	8	9	10	لا أعرف
أمن البيانات	○	○	○	○	○	○	○	○	○	○	○
توافر الخدمة	○	○	○	○	○	○	○	○	○	○	○
تكلفة الخدمة	○	○	○	○	○	○	○	○	○	○	○
فقدان السيطرة على موارد المعلومات	○	○	○	○	○	○	○	○	○	○	○
تسرب الخبرات في تقنية المعلومات	○	○	○	○	○	○	○	○	○	○	○
موقع تخزين البيانات	○	○	○	○	○	○	○	○	○	○	○
صعوبة الانتقال من مزود خدمة الى اخر Vendor lock-in	○	○	○	○	○	○	○	○	○	○	○
تعارض الحوسبة السحابية مع أنظمة وتشريعات المنشأة (Regulation compliance)	○	○	○	○	○	○	○	○	○	○	○
التوافقية مع الأنظمة والتطبيقات الحالية في المنشأة (Interoperability)	○	○	○	○	○	○	○	○	○	○	○
الثقة في مقدمي الخدمات السحابية	○	○	○	○	○	○	○	○	○	○	○
صعوبة ترحيل النظام القائم إلى الحوسبة السحابية	○	○	○	○	○	○	○	○	○	○	○
نقص في المعرفة حول الحوسبة السحابية	○	○	○	○	○	○	○	○	○	○	○
غياب اللوائح الحكومية المشرعة والمنظمة للحوسبة السحابية	○	○	○	○	○	○	○	○	○	○	○

غير ذلك (يرجى التحديد)

- **إلى أي مدى تتفق مع صحة ما يلي فيما يخص المنشأة التي تعمل به**

	لا أوافق بشدة	لا أوافق	محايد	أوافق	أوافق بشدة	لا أعرف
الاتصال بشبكة الانترنت في المؤسسة كافي للاستفادة من خدمات الحوسبة السحاية						
الخدمة المقدمة من قبل مزود الخدمة المحلي جيدة						
نحن ندرك الآثار المترتبة على أدوار تكنولوجيا المعلومات والتغيرات المترتبة على الانتقال إلى الحوسبة السحابية						
تعتقد الإدارة العليا أن تبني خدمات الحوسبة السحابية يمكن أن تضيف قيمة للمنظمة.						
مستوى المعرفة حول الحوسبة السحابية داخل المنظمة منخفضة						
يوفر مزودو الخدمات السحابية تطبيقات مفيدة لنشاط المنشأة						
الحوسبة السحابية ستعطي المنشأة ميزة تنافسي						
الحوسبة السحابية ستسهم في زيادة معدل الاحتفاظ بالعملاء						
لسياسات والمبادرات الحكومية والدعم لها تأثير على قرارات اعتماد السحابة.						
التشريعات والتنظيمات الحالية تحد من مدى الاعتماد على خدمات الحوسبة السحابية.						
تطبيقات الحوسبة السحابية تحصل على دعم أكبر من المزود مقارنة بالتطبيقات التقليدية						
اعتماد الحوسبة السحابية تودي لتقليل الوقت اللازم لتطوير المنتجات أو تقديم الخدمات.						
مزود الخدمة السحابية أكثر قدرة على التعامل مع أمن البيانات						
عدم التوافق مع الانظمة القائمة يعرقل الانتقال إلى الحوسبة السحابية.						
تبني الحوسبة السحابية تتطلب جهدا وتدريبا إضافيا.						
ترحيل الانظمة القائمة إلى الحوسبة السحابية معقد جدا.						

Appendix D

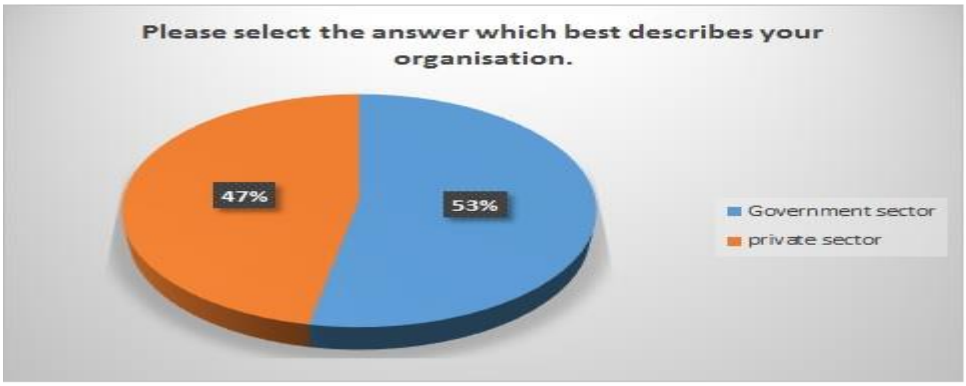


Figure A. 1: The distribution of participants based on the sector.

			Does your organisation plan to migrate services and data to cloud computing?		Total
			no	yes	
Please select the answer which best describes your organisation.	Public Sector	Count	24	19	43
		% within Please select the answer which best describes your organisation.	55.8%	44.2%	100.0%
	Private Sector	Count	18	20	38
		% within Please select the answer which best describes your organisation.	47.4%	52.6%	100.0%
Total		Count	42	39	81
		% within Please select the answer which best describes your organisation.	51.9%	48.1%	100.0%

Table Apex. 1: the cross tabulation of private and public sectors and cloud computing adopted

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	2.040[a]	2	.361
Likelihood Ratio	2.048	2	.359
Linear-by-Linear Association	1.357	1	.244

Table Apex. 2: the Chi-Square Test for enterprise size

	Frequency	Valid Percent	Adopted or plan to adopt
Start-up	20	24.7	85.0%
Established	55	67.9	40.1%
Don't know	6	7.2	0.0%

Table Apex. 3: The relationship between cloud computing adoption and enterprise status

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	13.462[a]	4	.009
Likelihood Ratio	17.544	4	.002
Linear-by-Linear Association	4.690	1	.030
N of Valid Cases	40		

Table Apex. 4: The chi-square test for cloud deployment models and enterprise status

Hypothesis	P value	Variable	Principal Component Analysis
H1	0.500	H1Q1	0.507
		H1Q2	0.507
H2	0.704	H2Q1	0.756
		H2Q1	0.681
		H2Q3	0.711
H3	0.478	H3Q1	0.383
		H3Q2	0.745
		H3Q3	0.432
H4	0.500	H4Q1	0.599
		H4Q2	0.599
H9	0.609	H8Q1	0.865
		H8Q2	0.757
		H8Q3	0.567
H10	0.647	H9Q1	0.625
		H9Q2	0.582
		H9Q3	0.539
H11	0.500	H11Q1	0.862
		H11Q2	0.862
H12	0.500	H12Q1	0.733
		H12Q2	0.733
H13	0.500	H13Q1	0.802
		H13Q2	0.802
H14	0.598	H14Q1	0.651
		H14Q2	0.430
		H14Q3	0.738

Table Aepx. 5: KMO and Bartlett's Test

	Minimum	Maximum	Mean	Std. Deviation
The organisation's connectivity to the internet is adequate	1.00	5.00	3.82	1.08155
The quality of the service provided by local service provider is good.	1.00	5.00	3.48	1.02605
We are aware of the implications on IT roles and organisation change when moving to cloud	1.00	5.00	3.49	1.00154
Top management believes that adopting cloud computing services can add value to the organisation.	1.00	5.00	3.67	1.21272
The level of knowledge about cloud computing within the organisation is low.	1.00	5.00	3.55	1.03682
Cloud service providers support your business line applications.	1.00	5.00	3.55	1.01242
Adopting cloud computing will give your organisation competitive advantages.	1.00	5.00	3.85	1.10805
Adopting cloud computing will increase the customer retention rate	1.00	5.00	3.53	1.14112
Government policies, support and initiatives have an impact on cloud adoption decisions.	1.00	5.00	3.19	1.26905
Existing regulations influence the adoption of cloud computing services.	1.00	5.00	3.16	1.22940
Cloud computing services have more vendor support than traditional software.	1.00	5.00	3.34	1.02665
Adopting cloud computing will reduce the time taken to manufacture products or provide services.	1.00	5.00	3.91	.96433
A cloud service provider will be more capable of handling data security.	1.00	5.00	3.71	1.00293
Incompatibility with existing systems impedes moving to cloud computing.	1.00	5.00	3.52	.98883
Adopting cloud computing will require additional effort and training.	1.00	5.00	3.92	.86281

Table Apex. 6: The mean of factors that influence cloud migration decision

Appendix E

Staffordshire University

Faculty of Computing, Engineering and Sciences

A Knowledge Management Migration Model and a Framework to Support Cloud Computing Migration

By

Abdullah Alhammadi

Under the supervision of

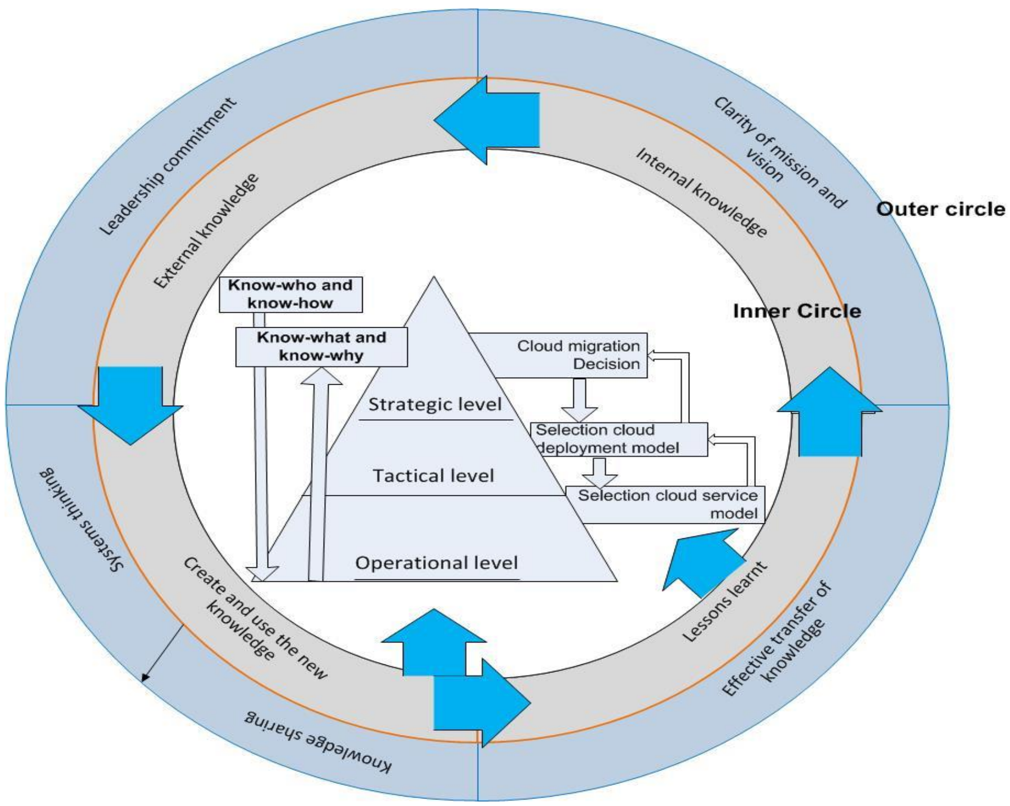
Dr. Clare Stanier and Prof. Alan Eardley

September 2015

Section A: Respondents Background

Please select the answer which best describes your organisation	A) Cloud Service Provider B) Cloud user C) Other (please specify)
Email address	What is your job role?
Have been ever involved in any cloud migration project? Yes/No	If yes, what was your role in this project?
Did you participate in the KSA cloud computing adoption survey carried out as part of this research project in Saudi Arabia? Yes/No/Don't know	To which sector of industry does your orga nisation belong?

Section B: KM Based Cloud Migration Decision Framework Decision



Please Rate the extent to which you agree or disagree with the following statements	1= strongly agree 5= strongly disagree				
	1	2	3	4	5
The Framework provides a knowledge sharing environment to support cloud migration decision making					
The Framework supports organizational learning and innovation?					
The Framework provides a structured methodology for supporting decision making					
Using the Framework would reduce the cost, time and effort involved in the cloud migration decision making process					
The Framework provides a mechanism for knowledge based decision making about cloud migration					
The Framework provides a mechanism to learn from previous migration projects					
The outer circle "enterprise environment" factors are crucial to support cloud migration decision making processes					
The inner circle (decision process) factors are crucial to support cloud migration decision process					
The sequence of decision making levels and cloud migration decision making levels is clear and logical					

Which elements in the Framework do you feel would be helpful in terms of supporting the cloud migration decision making process?

Are there any elements in the Framework which you feel would not be helpful in terms of supporting the cloud migration decision making process?

Are there any changes you would suggest to improve the Framework?

Section C: The Knowledge Based Model to Support Cloud Migration Decision Making (Strategic Level)

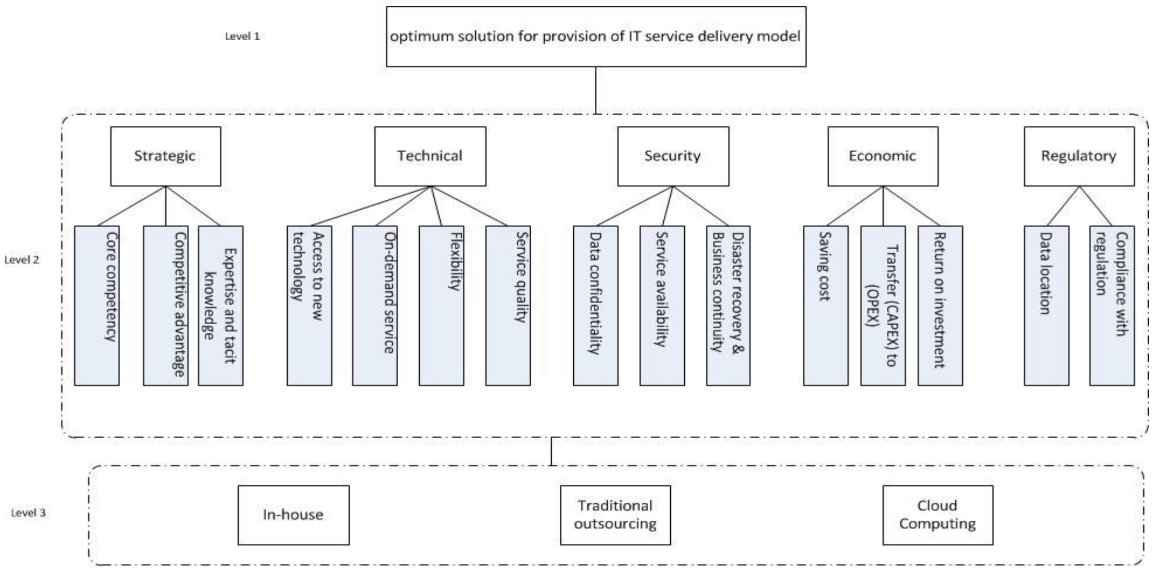


Figure 0-1:Cloud migration decision model

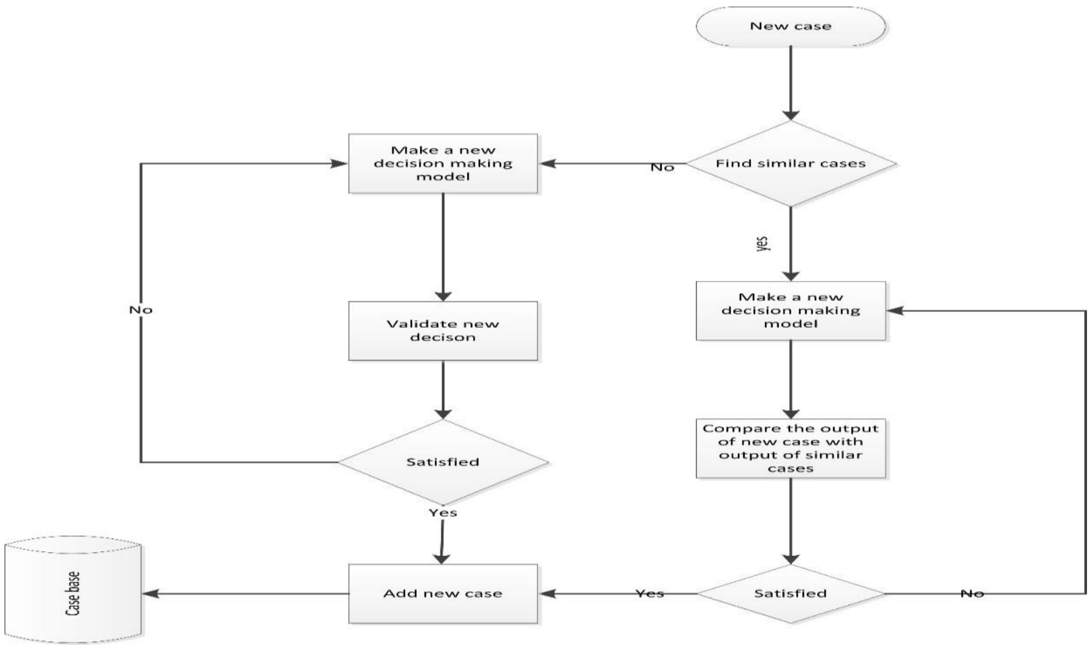


Figure 0-2: flow chart of the process of cloud migration decision model

Please rate the extent to which you agree or disagree with the following statements	1= strongly agree 5= strongly disagree				
	1	2	3	4	5
The model provides a knowledge sharing environment to support strategic cloud migration decision making					
The proposed model provides comprehensive coverage of the factors involved in cloud migration decision making at strategic level					
The AHP method provides a useful tool to support strategic decision making about cloud computing migration					
The model provides a structured methodology for supporting the strategic decision making process					
The model simplifies the problem and makes it more understandable for the decision makers.					
Using the model would reduce the cost needed to make strategic decision					
Using the model would reduce the time needed to make strategic decision					
The integration of AHP and CBR in the model will help decision makers to make better decisions					
Using CBR in the model can solve the problem of uncertain and incomplete information during the decision making process.					
Using CBR in the model can provide/share knowledge to be used when making decisions with other migration projects.					

On scale of 1 to 5, with 5 being the most important, please rate the following factors in terms of their importance to strategic cloud migration decision making

Factors	Sub-factors	1	2	3	4	5
Technical	Access to new technology					
	On-demand service					
	Service quality					
	flexibility					
Organizational	focus on core competency					
	competitive advantage					
	expertise and tacit knowledge					
Security	Data confidentiality					
	Service availability					
	Disaster recovery & Business continuity					
Economic	Reduce total cost of ownership					
	Transfer CAPEX TO OPEX					
	Return on investment					
Regulatory	Data location					
	Compliance with regulation					

Does the model support strategic decision making for cloud computing migration?

Are there any factors or sub-factors which are important for strategic decision making about cloud migration which have not been addressed in this model?

Are there any changes you would suggest to improve strategic decision making in the model?

Section D

A Knowledge Based Model to Select Cloud Deployment Model (Tactical level)

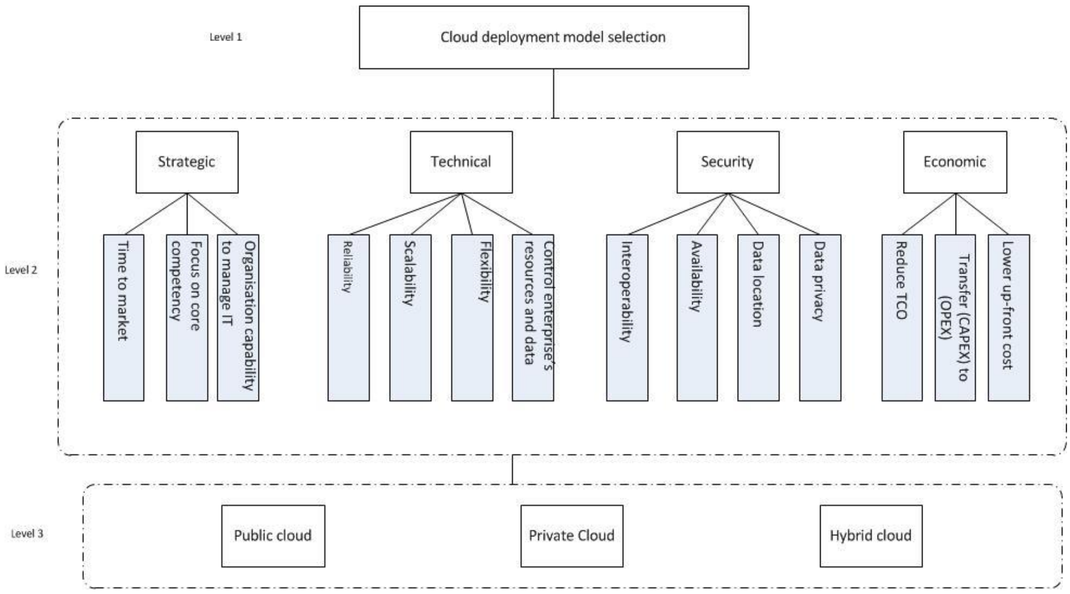


Figure 0-3: The selection of cloud deployment model

Please Rate the extent to which you agree or disagree with the following statements	1= strongly agree 5= strongly disagree				
	1	2	3	4	5
The proposed model provides comprehensive coverage of the factors that are involved in decision making about the selection of cloud deployment models at tactical level					
The AHP method provides a useful tool to support decisions about the selection of cloud deployment models					
The model provides a structured methodology for supporting decision making about the selection of cloud deployment models					
The model simplifies the problem of selecting a cloud deployment model and makes it more understandable for the decision makers.					

On scale of 1 to 5, with 5 being the most important, please rate the following factors in terms of their importance in selecting a cloud deployment model

Factors	Sup-factors	1	2	3	4	5
Organizational	focus on core competency					
	Organisational capability to manage IT					
	Time to market					
Technical	Control enterprise resources and data					
	Scalability					
	Reliability					
	flexibility					
Security	Data privacy					
	Service availability					
	Data location					
	Interoperability					
Economic	Total cost of ownership					
	transfer CAPEX TO OPEX					
	Lower up-front cost					

Does the model support cloud deployment decision making?

Are there any factors or sub-factors which are important when selecting a cloud deployment model which have not been addressed in this model?

Are there any changes you would suggest to improve support for cloud deployment model decision making?

Section E: Decision Matrix to Support the Selection of a Cloud Computing Service Model

	Data sensitivity	Control over resources	Capability of IT services to manage the services	Time to market	Cost	Scalability	Performance	Availability	Flexibility	Accessibility	Interoperability and portability	Total
Weights												
IaaS	5	5	5	3	3	5	5	5	5	4	4	
PaaS	4	4	4	4	4	4	4	4	4	4	4	
SaaS	3	3	3	5	5	3	4	4	3	4	3	

Please Rate the extent to which you agree or disagree with the following statements	1= strongly agree 5= strongly disagree				
	1	2	3	4	5
The decision matrix provides comprehensive coverage of factors involved in the decision to select a cloud computing service model					
The decision matrix provides a useful tool to support decision making for the selection of a cloud computing service model					
Using the matrix would reduce the cost needed to select a cloud computing service model					
Using the matrix would reduce the time needed to to select a cloud computing service model					

Does the decision matrix support decision makers when deciding which could service model to choose?

Are there any factors or sub-factors which have not been addressed in the decision matrix?

Are there any changes you would suggest to improve the decision matrix?

Thank you for your participation.

Sincerely,

Abdullah Alhamadi

Staffordshire University School of Computing

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00966548756132

On-demand service	Fast access to computing resources
Flexibility	The freedom to select IT services, freedom in provisioning and releasing services, and freedom in adding or removing services.
Transfer CAPEX TO OPEX	Transfer the capital expenditure to operation costs
Data Location	Where is data store?
Total Cost of Ownership	The TCO includes reducing the cost of software development, hardware purchasing and maintenance
Scalability	The capability of the service to grow to meet the demand from the consumers.
The implementation lead time	It is the time needed to produce service or product.
interoperability	The ability of a program to work with more than one CSP simultaneously

Table Apex. 8: The definition of the technical terms

Evaluation of case two

Factors and sub-factors	*Weights (W)*	*Cloud computing*	*Outsourcing*	*In-house*
*FactorsW * subfactorW*	*FactorW*sub-factorW*	*W*cloud weight*	*W*outsourcing weight*	*W*in-house weights*
*T * t1*	*0.049686*	*0.24843*	*0.149058*	*0.149058*
*T*t2*	*0.020124*	*0.10062*	*0.080496*	*0.060372*
*T*t3*	*0.00819*	*0.04095*	*0.03276*	*0.02457*
*E*e1*	*0.069918*	*0.34959*	*0.209754*	*0.139836*
*E*e2*	*0.172898*	*0.86449*	*0.691592*	*0.345796*
*E*e2*	*0.028455*	*0.142275*	*0.085365*	*0.085365*
*S*s1*	*0.071424*	*0.214272*	*0.214272*	*0.35712*
*S*s2*	*0.015616*	*0.062464*	*0.046848*	*0.046848*
*S*s3*	*0.04096*	*0.16384*	*0.12288*	*0.12288*
*O*o1*	*0.123578*	*0.494312*	*0.494312*	*0.370734*
*O*o2*	*0.050052*	*0.200208*	*0.25026*	*0.150156*
*O*o2*	*0.02037*	*0.06111*	*0.08148*	*0.10185*
*R*r1*	*0.164*	*0.492*	*0.656*	*0.82*
*R*r2*	*0.164*	*0.492*	*0.656*	*0.82*
		3.926561	*3.771077*	*3.594585*

Table Apex. 9: Results of AHP calculation for cloud adoption decision for Clinic

Factors and sub-factors	*Weights (W)*	*Public cloud*	*Private cloud*	*Hybrid cloud*
*FactorsW * subfactorW*	*FactorW*sub-factorW*	*W*cloud weight*	*W*outsourcing weight*	*W*in-house weights*
*T * t1*	*0.009617*	*0.019234*	*0.048085*	*0.038468*
*T*t2*	*0.017523*	*0.087615*	*0.052569*	*0.070092*
*T*t3*	*0.03186*	*0.12744*	*0.09558*	*0.12744*
*E*e1*	*0.07028*	*0.3514*	*0.14056*	*0.21084*
*E*e2*	*0.167166*	*0.83583*	*0.167166*	*0.334332*
*E*e2*	*0.265056*	*1.32528*	*0.530112*	*0.795168*
*S*s1*	*0.085095*	*0.255285*	*0.425475*	*0.34038*
*S*s2*	*0.059841*	*0.299205*	*0.179523*	*0.239364*
*S*s3*	*0.024522*	*0.024522*	*0.12261*	*0.073566*
*S*s4*	*0.013542*	*0.054168*	*0.06771*	*0.027084*
*O*o1*	*0.026985*	*0.05397*	*0.134925*	*0.10794*
*O*o2*	*0.163709*	*0.818545*	*0.327418*	*0.654836*
*O*o2*	*0.066306*	*0.33153*	*0.132612*	*0.198918*
		4.584024	*2.424345*	*3.218428*

Table Apex. 10: The result of AHP calculation for the selection of cloud deployment model

Appendix F

Consent letter

I volunteer to participate in a research conducted by Abdullah Alhammadi from Staffordshire University. I understand that the interview is designed to gather information about cloud computing migration issues in Saudi Arabia. I understand that my participation in this research is voluntary and there is no payment will be made on either side.

I have the right to withdraw from the interview and I have the right to decline to answer any question. The interview will take approximately 45- 60 minutes. I understand that the interview will be recorded and notes will be written during the interview.

I understand that the identified elements will be anonymised and to respect commercial confidentiality.

I have read and understand the explanation provided to me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study.

Participant signature Researcher

signature

Participant Printed Name Researcher printed

name

For further information, please contact: Abdullah Alhammadi

E-mail: A.Alhammadi@staffs.ac.uk

Staffordshire University

Beaconside

Stafford

ST18 0AD

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ELM

Kingdom of Saudi Arabia

P.O. Box 67651

Riyadh 11517

21 November 2012

Abdullah Alhammadi

79 Jacoby Place

Priory Road

B5 7UW

United Kingdom

Dear Mr ....

Confirmation of support for PhD research

This letter is written in my capacity as cloud manager for ELM. This confirms that ELM will be happy to support your research into the development of a framework for migration to cloud based infrastructures and systems. We understand that support you require is to observe processes within the company and interview company staff as appropriate and subject to the agreement of the staff concerned. We will also make relevant documentation available to you. You will be expected at all times to comply with company health and safety policy, with all relevant legislation and to respect company staff and company policies.

We expect your on-site research to take no longer than 6 months. The start and end dates are subject to negotiation but an approximate start date is 6 January 2014 and the approximate end date is 28 March 2014. We will require you to use anonymised data and to respect commercial confidentiality. No payment will be made on either side.

We are pleased to support this research into a developing technical area and look forward to meeting with you.

Nasser AlSodeis