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The effective implementation of cloud computing through project management: Conceptual framework

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M THOBEJANE
University of Johannesburg, Applied Information Systems
hlabirwa0204@gmail.com

C MARNEWICK*
University of Johannesburg, Applied Information Systems
cmarnewick@uj.ac.za
ORCID NR: https://orcid.org/0000-0002-2340-8215
* corresponding author

ABSTRACT

Organisations are interested in implementing cloud computing (CC) services, as these services are purported to enable Information Technology (IT) to become efficient and effective. However, CC brings new complexities, risks and implications into IT projects. The objective of this study is two-fold: to determine whether CC projects are significantly different from traditional IT projects and to develop a conceptual framework to effectively manage the implementation of CC projects. More specifically, the study evaluated project complexities brought about by CC, and explored the project management knowledge area and approaches required to implement CC. The literature review revealed that CC contributes to the complexity of projects and there are 18 core CC project complexity factors which are key to the successful implementation of CC projects. Apart from these 18 factors, there are 78 other factors which are important for both cloud and traditional IT projects which need to be looked at. Secondly, it is vital to understand which project management knowledge subjects are key to successfully implement cloud projects. Five (5) key knowledge areas have been identified that are linked to the complexity factors. Finally, it is suggested that an agile approach be used when implementing CC projects.

Key phrases

CC; computing project complexity; IT project complexity; knowledge area; project approach and project management

1. INTRODUCTION

Cloud computing is a new information technology trend (El-Gazzar, Hustad & Olsen 2016) and the foundation of the Fourth Industrial Revolution (Roblek, Meško & Krapež 2016). As defined by Mell and Grance (2011), CC provides people and organisations with on-demand and scalable solutions with minimal management. Organisations are interested in implementing CC services because of the benefits which come with cloud computing (Almubarak 2017; El-Gazzar *et al*. 2016; Ristov, Gusev & Kostoska 2012; Rosenthal, Mork, Li, Stanford, Koester & Reynolds 2010; Zhang, Cheng & Boutaba 2010). Cloud computing are made available through paying for what has been used. This is known as the pay-as-you-use model as it uses the concept of utility computing (Armbrust, Fox, Griffith, Joseph, Katz, Konwinski, Lee, Patterson, Rabkin, Stoica & Zaharia 2010). Cloud computing also offers great benefits to IT organisations by allowing them to focus on their core business and other business-related tasks (such as innovation and value creation) other than software and hardware administration and maintenance (Buyya, Yeo, & Venugopal 2008; Subramanian & Jeyaraj 2018). Cloud computing is cost-effective (e.g. no maintenance, support and licensing cost) and flexible. Mostly no capital expenses are required but only operating expenses, and it is less complex and easy to implement. Most importantly, IT organisations implement CC because CC providers have the required IT skills to maintain IT infrastructure and services.

According to El-Gazzar *et al*. (2016) and Stendal and Westin (2018), the implementation of CC is still relatively new and that current project management best practices are not yet adapted or developed in relation to managing it. There are still relatively few references describing how to manage CC projects (Wang, Wood, Abdul-Rahman & Lee 2016; Conway & Curry 2012) and whether CC projects should be treated different from traditional IT projects. According to Stendal and Westin (2018), CC implementations suffer from little focus from the research community. El-Gazzar *et al*. (2016) state that CC still "*lack of both knowledge and empirical evidence about which issues are most significance for cloud computing adoption decisions*". Due to these identified gaps, there is a need to determine whether CC projects differ significantly from traditional IT projects to be classified as a special type of IT project. This is done through the understanding of the factors that influence CC projects from the perspective of project complexity, project management knowledge areas and project management approaches.

Based on this identified gap and problem, the three (3) research questions for this study were:

1. What are CC project complexity factors?

2. What project management elements are earmarked to address CC project implementation?
3. How are CC project complexity factors integrated with current project management elements earmarked to enable effective CC implementation processes?

To answer these research questions, a conceptual framework is proposed for CC project implementation. Firstly, the concepts of CC, IT project complexity and CC project complexity are presented and linked to derive the concept of CC project complexity. Secondly, the concept of project management standards and project approach are examined in relation to CC. Thirdly, CC project complexity, project management and project approach concepts are conceptualised to enhance the implementation of CC projects. Finally, the key findings, managerial implications and conclusions of the study are presented.

2. LITERATURE REVIEW

2.1 Cloud computing

The goal of this section is to gain an understanding of the concept of CC. The definition, characteristics, services, deployment, benefits and challenges of CC are discussed. Cloud computing is an IT trend and the foundation of the Fourth Industrial Revolution (Marnewick & Marnewick 2020a; Marnewick & Marnewick 2020b; World Economic Forum 2016). Information technology resources (computing, storage, network and software) are provided and consumed through the internet as a pay-as-you-use service (Mell & Grance 2011; Leavitt 2009; Vaquero, Rodero-Merino, Caceres & Lindner 2008). The main difference between CC and traditional IT is in the ownership, delivery and maintenance of IT resources. In traditional IT, the IT resources are owned, installed and delivered within the premises and networks of the organisation (Accorsi 2011; Wang *et al*. 2016). In this instance, organisations are responsible for the maintenance of these IT resources. With CC, the organisations do not own and maintain IT resources; they only request what they need and pay only for what they have consumed. In this case, IT resources are owned and maintained by CC providers.

There are several definitions of CC. Buyya *et al*. (2008) define it as "type of parallel and distributed system consisting of a collection of inter-connected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resource(s) based on service-level agreements established through negotiation between the service provider and consumers". For the purpose of this article, the definition by Mell and Grance (2011) is adopted. They state that CC is "a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources (e.g.

networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction. This cloud model promotes availability and is composed of five essential characteristics, three delivery models, and four deployment models". In addition to the preceding definition, the focus is on delivery and deployment models of CC.

The characteristics of CC (Buyya *et al*. 2008; Mell & Grance 2011; Rosenthal *et al*. 2010) are as follows:

- On-demand self-service: The organisation can access computing resources automatically as needed without support from the service provider. It can access CC capabilities over the internet using heterogeneous standard mechanisms such as a mobile phone, laptop, tablet and other devices.
- Broad network access: The provider can serve and share computing capabilities with multiple organisations, without the knowledge of the organisation about the location from where the computing capabilities are served (Marston, Li, Bandyopadhyay, Zhang & Ghalsasi 2011; Mell & Grance 2011; Rosenthal *et al.* 2010).
- Rapid provisioning/elasticity: This refers to the ability to elastically provide and release computing capabilities, depending on the resource demand. Rapid provisioning helps the organisation predict their future demand requirements in advance. Resources are automatically added or removed as and when required (Marston *et al*. 2011; Mell & Grance 2011; Rosenthal *et al*. 2010).
- Pay-as-you-use: Organisations pay for computing capabilities as they use them; there is no upfront payment for resources. The positive part of pay-as-you-use is that organisations do not have high capital costs to purchase computing services *(*Marston *et al*. 2011; Mell & Grance 2011; Rosenthal *et al*. 2010).

Generally, within normal IT projects, the solution or product is deployed in a traditional data centre that is managed by the organisation. Within the CC environment, various services are available that influences the deployment of the solution or product and is deployed on the service provider's infrastructure.

2.2 Cloud computing models

There are three (3) major CC models, namely Software as a Service (SaaS), Infrastructure as a Service (IaaS) and Platform as a Service (PaaS) (Subashini & Kavitha 2011).

- With SaaS, cloud providers are responsible for the full stack of cloud services from infrastructure, platform to software/application layers (Mell & Grance 2011; Leavitt 2009;

Vaquero *et al*. 2008). The consumer is responsible for the secure access to the applications and their data.

- IaaS enables the consumer to use computing powers, network and storage as a service. The consumer is responsible for operating systems (O/S), databases and applications installed on this infrastructure, and administer and secure access to these infrastructure resources (Leavitt 2009; Mell & Grance 2011; Vaquero *et al*. 2008).
- For PaaS, the cloud providers are responsible for the underlying infrastructure and platforms such as databases, application development and middleware applications, which will enable the consumers to use them to develop and create applications.

The CC models are distinguished in terms of what the organisations and cloud provider manage as shown in Table 1.

Table 1: Cloud computing shared responsibility model

Traditional Data Centre		IaaS		PaaS		SaaS	
Organisation manages	Data	Organisation manages	Data	Organisation manages	Data	Organisation manages	Data
	Applications		Applications		Applications	Cloud provider manages	Applications
	Runtime		Runtime	Cloud provider manages	Runtime		Runtime
	Middleware		Middleware		Middleware		Middleware
	O/S		O/S		O/S		O/S
	Virtualisation	Cloud provider manages	Virtualisation		Virtualisation		Virtualisation
	Servers		Servers		Servers		Servers
	Storage		Storage		Storage		Storage
	Networking		Networking		Networking		Networking

Source: Authors' own analysis

Apart from deciding on the CC model, a decision must be made on the deployment model that is most suitable for the organisation.

2.3 Cloud computing deployment models

There are five (5) main cloud deployment models which are used by organisations:

1. Private cloud: All cloud services are maintained and managed by the single organisation. There is no sharing of resources and responsibilities with other organisations (Leavitt 2009; Mell & Grance 2011; Vaquero *et al*. 2008). There is substantial investment in terms of capital, skillset and effort required for the organisation to build up the private cloud (Dawoud, Takouna & Meinel 2010; Wang *et al.* 2016).
2. Public cloud: Cloud services are hosted and controlled by cloud providers. The organisation has the option to maintain and manage some of the cloud services, such as operating systems, databases and others. Public cloud services are cheaper but security is a concern because resources are shared among organisations (Mell & Grance 2011).
3. Hybrid cloud: This is a mix of public and private CC because the organisations use the public and private CC services at the same time.
4. Community cloud: This is a type of CC which is shared by different organisations with the same objectives, shared purpose and responsibilities (Mell & Grance 2011).
5. Cloud@customer: This is a deployment model where the external cloud provider, such as Oracle, Amazon Web Services and Microsoft Azure, will put their cloud infrastructure in the organisation's data centre. The cloud provider will manage and maintain the cloud environment on behalf of the organisation (Mueller 2019).

A comparison based on security risk, implementation complexity and cost between the CC deployment models are shown in Table 2.

Table 2: Comparison of Cloud Deployment Models

	Security Risk	**Implementation Complexity**	**Cost**
Public	High: Computing resources are shared by different organisations; also may be accessed through the internet by some of the organisations, which poses a risk because the internet is not secure.	Low: Computing resources are shared and managed by the cloud providers.	Moderate: Organisations do not own and manage the computing resources of the public cloud. They pay only for what they have used.
Private	Low: Resources are dedicated to a particular organisation. There is no sharing of resources.	High: The time to deploy the private cloud is longer. The organisation will be heavily involved and assist in managing the	High: The cost to deploy the private cloud is higher because resources are dedicated.

	Security Risk	Implementation Complexity	Cost
		implementation and support of cloud services.	
Hybrid	Moderate: The organisation can choose which services can be deployed on the public cloud (e.g. commodity) and which services are accessed on-premises (e.g. mission-critical services).	Moderate: The integrations of on-premises and cloud can be complex.	Moderate: The cost can be moderate to high because the two environments, on-premises and cloud, will need to be maintained.
Community	Moderate: Shared by different organisations with the same objectives, shared purpose and responsibilities.	Low: This is seen most in open-source projects where developers work together to explore and expand open sources projects.	Low: The costs are shared between the parties involved.
Cloud@customer	Low: The cloud services are housed on the organisation's premises but managed by the cloud providers.	Moderate: The external cloud provider will place and manage the cloud environment on behalf of the organisation's data centres. The organisation will provide facilities (power, cooling, etc.) and network connectivity.	Moderate: The organisation will be responsible for managing their facilities and related costs such as electricity, cooling and heating. They will use computing resources on a pay-as-you-use basis (subscription) as they access the services from the public cloud.

Source: Authors' own analysis

2.4 CC benefits and challenges

Cloud computing makes it easy for organisations to immediately access and use IT resources with low cost of entry. This is possible because these organisations do not have to buy expensive IT infrastructure and own data centres. In addition, CC does not require upfront capital to purchase the IT resources as organisations pay only for the IT resources they consume. The procurement cycle and deployment of IT resources is shorter. All these benefits enable businesses to enter the market faster and become competitive. Due to its elasticity, CC also enables organisations to deal with unpredictable peak demand for IT resources. It releases organisations from day-to-day IT resource administration and maintenance and enables them to focus on their core business to drive business value (Armbrust *et al*. 2010; Marston *et al*. 2011; Wang *et al*. 2016). Security is one of the biggest challenges for organisations in adopting CC. Organisations are concerned about their data privacy in the cloud, the locations where their data is stored and how they will be audited on the cloud. They feel they have lost control of their IT resources and data because these are stored away in the cloud. As to the distributed nature of the cloud, the regulatory requirements and compliance across countries is also a challenge (Subramanian & Jeyaraj 2018).

Tatikonda and Rosenthal (2000) refer to project complexity as relating to the uniqueness and novelty of the product or service, including its development process, performance objectives and interdependence in terms of its technological advancement and difficulty. According to this definition, CC qualifies as a complex project due to its novelty, interdependence in terms of its technological advancement and difficulty. This is confirmed by Hür Bersam and Gül Tekin (2019), stating that Industry 4.0, which CC is a part of, brings complexity and uncertainty. This also means that a CC project is inherently an IT project. Therefore, before the complexity brought about by CC projects can be understood, it is important to explore and understand the complexity brought about by IT projects.

2.5 IT project complexity

Complexity is a well-researched area in project management (Botchkarev & Finnigan 2015; Daniels & LaMarsh 2007; Murray 2002; Wallace, Keil & Rai 2004; Whitney & Daniels 2013; Xia & Lee 2004). Project complexity is defined by Baccarini (1996) as "consisting of many varied interrelated parts and can be operationalised in terms of differentiation and interdependency". Baccarini (1996) further indicates that this definition of project complexity is applicable to any type of project. Wood and Ashton (2010) define project complexity as a "single or a combination of factors that affect the responses/actions taken to achieve the project outcomes". Tatikonda and Rosenthal (2000) refer to project complexity as relating to the uniqueness and novelty of the product or service, including its development process, performance objectives and interdependence in terms of its technological advancement and difficulty. (Lu, Luo, Wang, Le & Shi 2015) define project complexity as "consisting of many varied interrelated parts, and … dynamic and emerging features".

Based on an extensive literature review, IT project complexity can be categorised into (i) organisational, (ii) technical, (iii) uncertainty, (iv) size, (v) project management itself, (vi) people management, (vii) environmental and (viii) dynamics (Bakhshi, Ireland & Gorod 2016; Botchkarev & Finnigan 2015; Marnewick, Erasmus & Joseph 2017; Merali 2006; Mitleton-Kelly & Land 2005; Murray 2002; Poveda-Bautista, Diego-Mas & Leon-Medina 2018; Williamson 2011; Xia & Lee 2004).

- Organisational complexity deals with and consists of factors which affect the organisation at large, such as organisational parts, structure, units and the changes brought about by their related factors (Bakhshi *et al*. 2016; Botchkarev & Finnigan 2015; Marnewick *et al.* 2017; Mitleton-Kelly & Land 2005; Poveda-Bautista *et al*. 2018; Williamson 2011; Xia & Lee 2004; Murray 2002).
- Technical complexity deals with factors dealing with technology and its related processes (Bakhshi *et al*. 2016; Botchkarev & Finnigan 2015; Marnewick *et al.* 2017; Merali 2006; Murray 2002; Poveda-Bautista *et al*. 2018; Williamson 2011; Xia & Lee 2004).
- Environmental complexity deals with the context in which projects are executed, which includes economic, social and legal factors (Botchkarev & Finnigan 2015; Marnewick *et al.* 2017; Mell & Grance 2011; Merali 2006; Poveda-Bautista *et al*. 2018; Williamson 2011; Xia & Lee 2004).
- Uncertainty involves the current and future states of different areas of the project factors which can be difficult to predict. It is about the present and the future: triple constraints, activity, goals, technology, stakeholders, among others (Bakhshi *et al*. 2016; Botchkarev & Finnigan 2015; Marnewick *et al.* 2017; Mitleton-Kelly & Land 2005).
- Dynamics is about project change management, i.e. the changes both internal and external to the project (Bakhshi *et al*. 2016; Botchkarev & Finnigan 2015; Marnewick *et al.* 2017; Merali 2006; Mitleton-Kelly & Land 2005; Murray 2002; Xia & Lee 2004).
- Size deals with the number and significance/magnitude of all project-related factors (Bakhshi *et al*. 2016; Botchkarev & Finnigan 2015; Marnewick *et al.* 2017).
- Project management complexity per se deals with all project-related factors such as scheduling, scoping, methods, tools and techniques (Bakhshi *et al*. 2016; Botchkarev & Finnigan 2015; Marnewick *et al.* 2017; Murray 2002; Williamson 2011;).
- People management involves all the people-related factors which affect the project (Bakhshi *et al*. 2016; Botchkarev & Finnigan 2015; Poveda-Bautista *et al*. 2018; Marnewick *et al.* 2017; Williamson 2011).

Table 3 shows the various IT project complexity categories.

Table 3: Information technology project complexity categories

IT Project Complexity Categories	(Murray 2002)	(Xia & Lee 2004)	(Mitleton-Kelly & Land 2005)	(Merali 2006)	(Williamson 2011)	(Botchkarev & Finnigan 2015)	(Bakhshi *et al.* 2016)	(Marnewick *et al.* 2017)	(Poveda-Bautista *et al.* 2018)
Organisational	x	x	x	x	x	x	x	x	x
Technical	x	x		x	x	x	x	x	x
Environmental				x.	x	x	x	x	x
Uncertainty			x			x	x	x	
Dynamics	x	x	x	x		x	x	x	
Size						x	x	x	
Project management	x				x	x	x	x	
People management					x	x	x	x	x

Source: Authors' own analysis

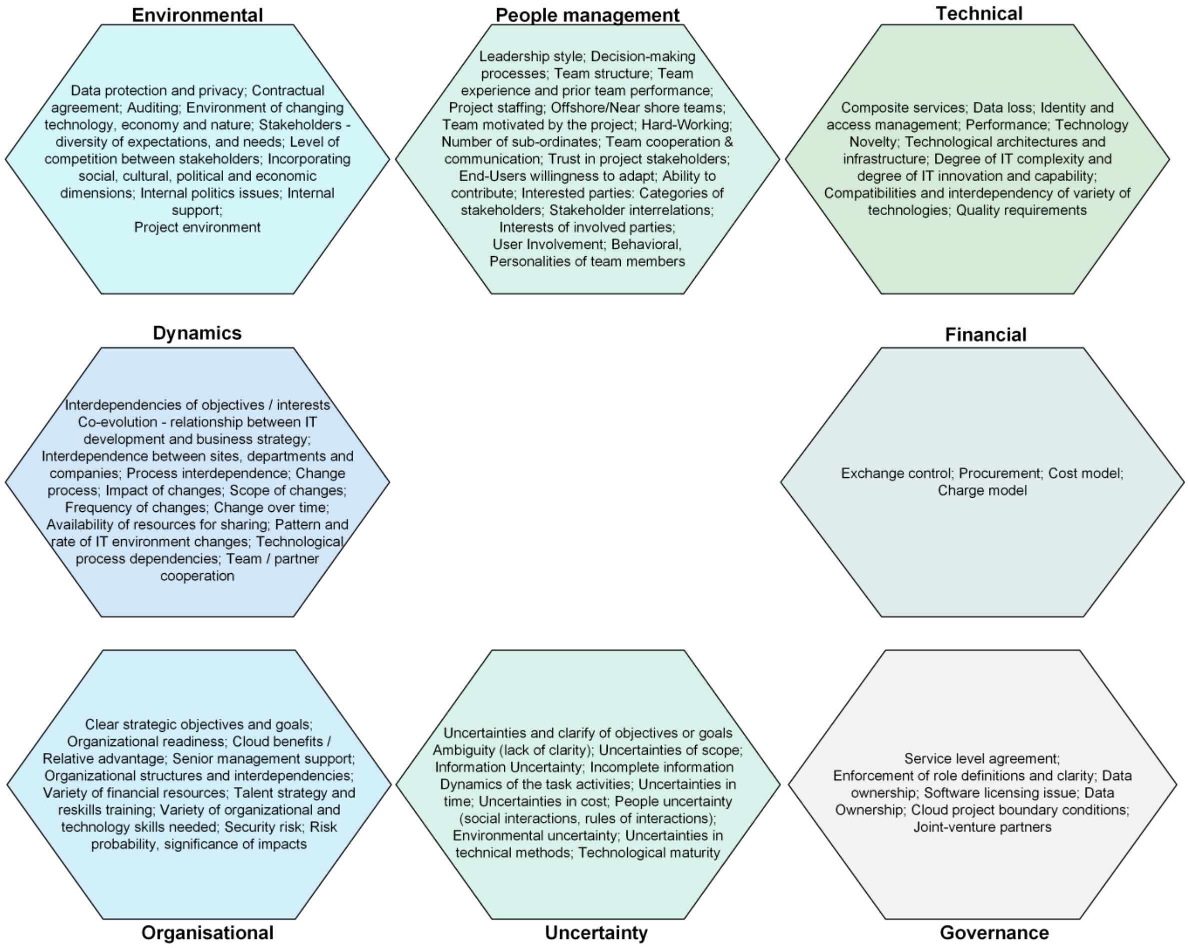
2.6 Cloud computing project complexity as a sub-set of information technology

2.6.1 Project complexity

To realise the benefits of CC and to mitigate the risks associated with it, it is important to determine whether CC projects should be managed differently from traditional IT projects. The literature shows that there are specific CC project complexities which can be categorised as organisational, financial, governance, compliance, legal and technical project (Akar & Mardiyan 2016; Almubarak 2017; El-Gazzar *et a*l. 2016; Rai, Sahoo & Mehfuz 2015). Cloud computing projects by default would inherit IT project complexities. Cloud computing project complexity categories are therefore incorporated into IT project complexity categories to create a full list of CC project complexity categories. The full, consolidated CC project complexity categories are organisational, financial, governance, technical, environmental, uncertainty, dynamics and people management.

The full details of the CC project complexity categories and its associated 97 factors are indicated in Figure 1.

Figure 1: Cloud computing IT project complexity types



Source: Joseph (2017) and Joseph and Marnewick (2020)

As CC is still relatively new, current project management best practices are not yet adopted or developed to manage CC projects (El-Gazzar *et al.* 2016; Stendal & Westin 2018). There are multiple references which detail CC in terms of its capabilities, characteristics, benefits and architecture, but there are still relatively few references describing how to manage CC projects (Conway & Curry 2012; Wang *et al*. 2016). Current project management references are not ready and prepared to be regarded as a solution to managing CC projects in terms of transitioning from on-premises to the cloud (Wang *et al.* 2016). For this reason, project management will be explored in the next section.

2.6.2 Project management

The overall goal of this section is to explore the project management knowledge and skills required to implement CC. The PMBOK Guide (Project Management Institute 2017) defines project management as *"the application of knowledge, skills, tools, and techniques to project* *activities to meet the project requirements".* In the literature on project management, two themes and their relationships are found to be critical when managing projects, namely the adoption and application of (i) project approaches and (ii) project management standards and methodologies (Iivari, Hirschheim & Klein 2000; Project Management Institute 2017; Zandhuis & Stellingwerf 2013;).

- Project management approach: This approach is defined as the principles and guidelines of defining the manner in which a project should be managed (Iivari *et al.* 2000; Introna & Whitley 1997). The choice of approach is important because it helps to structure and organise the project work. This will help to choose the approach's associated life cycle to match the approach. These approaches range from highly predictive methods where there are assumptions that the knowledge about the context is known, to those approaches where the environment is highly adaptive, uncertain and volatile (Kuruppuarachchi, Mandal & Smith 2002). Waterfall and Agile approaches are the most popular. Agile is more focused on adaptation and innovation than the Waterfall approach, which is focused on prediction and control (Cockburn & Highsmith 2001; Vinekar, Slinkman & Nerur 2006).

Project management standards and methodologies: Vukomanović, Young and Huynink (2016) describe a standard as a "document, established by consensus and approved by a recognised body, which provides for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context". The Project Management Institute defines a standard as "a formal document that describes established norms, methods, processes, and practices" (Project Management Institute 2017). Even though it is reported that standards are rarely used within project management (Ahlemann, Teuteberg & Vogelsang 2009), they are perceived as contributing to project success and improving communication within the project environment because they harmonise the terminology and the understandings of processes and methods (Vukomanović *et al.* 2016; Grau 2013).

3. RESEARCH METHODOLOGY

The literature review provided the basis for the development of the conceptual CC project management framework. This study followed a theoretical (non-empirical) approach proposed by Mayring (2014). More specifically, a systematic literature review was conducted with the aim to identify the current state of empirical research in respect of cloud computing projects. Systematic literature reviews are inductive in nature and, according to Mayring (2014), an important criterion to assess the quality of the review.

A comprehensive and well-integrated literature Review is essential to any study (Blumberg, Cooper & Schindler 2008; Flick 2014). Such a review provides a good understanding of issues and debates in the area of research, current theoretical thinking and definitions, as well as previous studies and their results. Cloud computing has become an important research topic in recent years. A systematic search process was conducted on four databases that have a specific focus on information technology as well as project management. The search focused on all published journal fitting the search criteria as per Table 4.

Table 4: Results from database search

	Search Phrases	
	CC project management	**IT project management**
ACMDL	1	118
IEEE Explore	17	106
Science Direct	2	78
Springer	1	480
Total	**21**	**782**

Source: Authors' own analysis

The results from Table 4 highlight that limited research has been done on CC project management in relation to IT project management.

- In each relevant reviewed article, the process of identifying the key concepts in the text was followed by marking and underlying the relevant information needed.
- A spread sheet for systematically recording information from the reviewed literature was created by ensuring that all information was relevant to answer the research question.
- The recorded information was linked to the research questions to establish the relationship between different concepts in order to make sense of them.

These processes were used to develop the conceptual framework.

4. DEVELOPING THE CONCEPTUAL FRAMEWORK

In this section, the proposed conceptual framework is presented. The conceptual framework formulated in this study links CC project complexities, the project management knowledge areas and the project approach.

4.1 Cloud computing project complexity and knowledge areas

Project management standards and methodologies (PMBOK Guide, ISO, APM, P2M, AIPM and PRINCE2) provide insight into the various knowledge areas (Akar & Mardiyan 2016; Ohara 2005; Zandhuis & Stellingwerf 2013). Project management knowledge areas are business case, integration management, scope management, schedule management, cost management, risk management, quality management, communication management, stakeholder management and procurement management.

In Table 7 (Annexure A), CC project complexity factors are mapped to their respective knowledge areas. The mapping was done by determining which CC project complexity factors are related to each of the knowledge areas. For example, all the CC project complexity factors involving stakeholders are mapped to stakeholder management. The aim was to determine how CC project complexity factors can integrate with project management knowledge areas to be used to address CC. It shows that all project complexity factors are applicable to all the knowledge areas. In cases where the block intersecting between CC project complexity category and knowledge area is empty, this means that no relationship was established

Table 5 summarises the number of CC project complexity category factors in each of the respective knowledge areas.

Table 5: Number of CC Project Complexities per Knowledge Area

	CC Project Complexity Factors								
Knowledge Area	People Management	Environmental	Technical	Dynamics	Organisational	Uncertainty	Governance	Financial	Total
Risk Management	1	10	13	2	2	3	1	1	**33**
Stakeholder Management	7	6		1		1	1		**16**
Resource Management	7			1	2		1		**11**
Integration Management	1			5	2	1			9
Business Case				1	7		1		9
Scope Management				1		4	2		7

CC Project Complexity Factors									
Knowledge Area	People Management	Environmental	Technical	Dynamics	Organisational	Uncertainty	Governance	Financial	Total
Schedule Management				2		2			4
Cost Management						1		2	3
Communication Management	1					1			2
Procurement Management							1	1	2
Quality Management			1						1
Total	**17**	**16**	**14**	**13**	**13**	**13**	**6**	**4**	**96**

Source: Authors' own analysis

Environmental, people management, technical, dynamics, organisational and uncertainity CC project complexity categories are extremely important categories, given the higher number of project complexity factors they each have. The governance category is regarded as of high importance due to its number of project complexity factors, and the financial category is regarded as moderately important due to a lower number of project complexity factors.

Risk management, stakeholder management, resource management and intregation management are extremely important knowledge areas which project teams need to give attention to because of the higher number of CC project complexity factors related to them. Risk management's focus should be on technical and environmental project complexity risks. Stakeholder management's focus is on people management and enviromental project complexity factors. Resource management should focus more attention on people management project complexity factors. Integration management should focus more on dynamics project complexity factors.

Buisiness case and scope management are very important given the high number of associated project factors. The business case should focus on organisational project complexity factors. Scope management should focus on uncertainty and governance complexity factors. Schedule, cost, communication, quality and procurement management are moderately important, given the lower number of project complexity factors each has. Schedule should focus on uncertainity and dynamics project complexity factors. Cost management should focus on financial and uncertainty project complexity factors. Communication management should focus on people management and uncertainty project complexity factors. Quality management should focus on technical complexity factors, whereas procurement management should focus on governance project complexity factors.

4.2 Project approach and process groups

The relationship between process groups and project approach is explained in this section. Process groups are repeated in each of the project life cycle phases. Every phase may have initiating, planning, executing and closing process groups, whereas monitoring and controlling is a continuous process group. The application of these process groups is dependent on the size of the project and organisational context (Kuruppuarachchi *et al*. 2002; Project Management Institute 2017)

The project phases are performed within the project life cycle as part of the project approach. The project life cycle helps to show the beginning and the end of the project. Project phases can vary and have several phases depending on the industry or the choice of project approach (Agile and/or Waterfall) the organisation adopts (Iivari *et al.* 2000; Kuruppuarachchi *et al.* 2002). Examples of project phases are conception, requirements gathering, planning, analysis, design, implementation, testing, deployment and maintenance. Each phase has deliverables (Tatikonda & Rosenthal 2000).

Project life cycles describe the processes for project delivery. There are three (3) project life cycles (Cockburn & Highsmith 2001; Kuruppuarachchi *et al.* 2002):

- Predictive linear (plan driven): Project management uses the predictive linear life cycle when the project requirements (scope), cost and time are known in advance and easily predictable. The phases of this life cycle can be sequential or overlapping from planning, analysis and design and implementation phases. It bears the most stable products and is easier to manage.
- Iterative/incremental approach: Like the predictive life cycle, the phases can be sequential. But the requirements are not unknown in advance and defined in detail. This life cycle repeats phases, in iterations, and each iteration completes all the project phases, namely planning, analysis, design and implementation phases.

- Adaptive (change-driven): This is different from the iterative approach because the iteration slots, called sprints, are kept shorter.

4.3 Proposed theoretical Cloud Computing Project Management Framework

It has been established that a CC project can be perceived and managed as a special type of IT project. This implies two (2) aspects. The first aspect is that a CC project inherit all the characteristics and complexities of an IT project. The second aspect is that a CC project is also different from a traditional IT project and that there are specific characteristics that sets the management of a CC project apart from the management of a traditional IT project.

Figure 2 (Annexure B) shows the proposed theoretical CC project management framework. It is essential to consider all the components of the framework during CC projects. The omission or underestimation of any one component can cause the CC project to be unsuccessful.

The best approach to implement a CC project is an agile approach. An agile approach allows for the various iterations and various changes to the final solution and product. Only five knowledge areas are specifically applicable to a CC project as per Figure 2 (Annexure B). Of the various complexity factors, only 14 are specific to a CC project ranging from data ownership to legal liabilities.

It is important for the project manager and the team to consider and understand all the CC project complexity categories - most importantly, how they will affect the project and how they will be mitigated. It is important to take into account the organisational context and the industry in which the organisation operates when applying the CC project complexity categories into knowledge areas.

The following propositions are made with regards to the core cloud computing project complexity factors as shown in Table 6.

Table 6: Core Cloud computing project complexity factors propositions

Category	Factors	Proposition
Governance	Software licensing	**Proposition 1:** Organisations need to understand the impact on licenses when moving from on premise to cloud. **Proposition 2:** Organisations need understand and know if their current applications can be hosted and licensed on cloud computing environment.
	Data ownership	**Proposition 3:** Organisations need to understand fully the cloud providers' agreements in terms of how cloud providers' handles that data on cloud. Organisations may involve their legal team to assist

Category	Factors	Proposition
		them to comprehend the contracts. **Proposition 4:** Organisations need to know which data to put on cloud and on premise. They need to employ ways to protect those data. They need to have backups and where possible only index data on cloud, and full data stored on premise
	Cloud boundary	**Proposition 5:** Organisations need to invest on their stakeholder engagements to strengthen their relationship with business. It is for IT department to ensure that all stakeholders are engaged at all times when discussing a cloud strategy for the organisation.
Financial	Charge model (pricing strategy)	**Proposition 6:** Organisations should experiment cloud services before they can fully subscription to cloud services because subscription charge model allows organisations to easily experiments and makes it easier to discontinue with the services at any time they wish without incurring substantial costs. Organisations need to invest time and resources to understand cloud providers' pricing as there are not clear across cloud platforms. **Proposition 7:** Organisations need to have monitoring tools to monitor their usage and cost when using cloud services. Because of subscription based, the usage and cost may fluctuate and it may be difficult to budget. **Proposition 8:** Organisations need to form consortiums where possible in order to negotiate better deals (e.g. prices) with cloud providers.
	Cost model	**Proposition 9:** Organisations should be aware that on cloud projects, the cloud services are financed differently compared to on premise because on premise you buy an asset (capital expense) and on cloud assets are accessed and consumed by subscription (Opex expense). Cloud computing do not require substantial upfront cost (capital) as compared to on premise.
Organisational	Cloud providers going out of business	**Proposition 10:** Organisation should look for the cloud providers with financial stability when considering going to cloud. **Proposition 11:** Organisations should investigate the cloud providers with necessary cloud skills and experiences when considering to go to cloud.
	Job security	**Proposition 12:** Senior management of the organisations need to show committed by alleviating the fears of affected employees. **Proposition 13:** Organisations also should explain and paint the picture of why the organisations are undergoing the cloud project and where the market in which they operate in is heading to.
Environmental	Subpoena and electronic discovery	**Proposition 14:** Organisations need to understand fully the agreements with cloud providers' agreements in terms of legal liabilities, for any damages or lawsuits, that happened when they use cloud computing services. **Proposition 15:** Organisations should understand their right in terms of cloud providers and law enforcement of their data on cloud computing.
	Legal liabilities	
	Non-compliance with industry standards	**Proposition 16:** Organisations need to invest time and resources to do compliance homework, need to train their people to understand the compliance requirements. **Proposition 17:** It was emphasised that applications not

Category	Factors	Proposition
		automatically or immediately comply with industry or governmental standards like POPI act, they still need to put logic to ensure they comply. Organisations are still required to pay attentions when it comes to compliance.
	Law and regulations discrepancies	**Proposition18:** Organisations need to understand the laws and regulations of different countries especially in the countries where they intend to host their cloud services. By design, cloud providers are having several data centres across the world. **Proposition 19:** Organisations need to investigate which laws and regulations their cloud providers comply with.
	Data location/ residency	**Proposition 20:** Organisations need to know the different locations their preferred cloud providers have data centres and select the location(s) which are suitable to host their cloud services.
	Lack of cloud standards	**Proposition 21:** Organisations should understand the limitations that come within Standardizations of systems and processes
Technical	Cloud migration	**Proposition 21:** Organisation need to assess and identify certain applications which are suitable to move to cloud. **Proposition 22:** Organisations should employ piece / incremental approach when they migrate their applications to cloud.
	Limited flexibility/ customization	**Proposition 23:** Organisations are required to do their homework and research on the type of services they need to implement. Interviewees mentioned that cloud providers have many options of services to choose from.
	Multitenancy	**Proposition 24:** Organisations should look at their applications and use cases to decide whether they intend to use shared resources (multitenancy) or not. **Proposition 25:** Organisations have options to have their separate (not shared) cloud resources but they will need to consider the cost implications.
	Vendor-in	**Proposition 26:** Organisations to understand the functionalities and capabilities and their limitations of cloud services which assist them to be aware of potential lock in. **Proposition 27:** Organisations need to use multi-cloud strategy to address vendor lock in concerns. **Proposition 28:** Organisations should use open technologies, which can be easy to manage and can avoid vendor lock in.
	Insider access	**Proposition 29:** Organisations should have non-disclosure agreements with cloud providers among others.

Source: Authors' own analysis

5. DISCUSSION AND FINDINGS

Cloud computing projects can be managed as traditional IT projects but it opens then the door for potential failures. CC projects are very specific IT projects and should be managed as such.

Project managers and project teams should know and understand CC project complexities to implement CC effectively. It is critical to address organisational, financial, governance, environmental and technical project complexity categories when implementing a CC project.

It is important not to study these project complexity factors and their associated risks in isolation because their integration is vital.

Although all the knowledge areas are important, project managers implementing CC solutions should focus on the knowledge areas of risk, cost, procurement and resource management. The business case for a CC project should clearly address the needs of such a project and how it addresses the organisational strategies.

More attention needs to be given to environmental (including legal and compliance issues), people management and technical CC project complexities, because from literature it appears that they have the most project complexity factors to consider. Risk management, stakeholder management and resource management are the areas which are important for project teams to focus on because most CC project complexity factors are related to these areas. It is also recommended that organisations embrace Agile as the preferred project approach when implementing CC projects, irrespective of the type and nature of the project. It is important to ensure that all the risks relating to project complexity factors are identified, mitigated and addressed throughout the project.

The developed conceptual framework shows that it can be used as a guide to manage CC projects by organisations, IT project managers and IT professionals.

This study identified the key project complexity factors influencing the implementation of CC projects. The findings can guide organisations to make better decisions in this regard. For academia, this study adds to the knowledge in the field of CC and project management. Researchers can depend on this study’s results when conducting new studies and applying new theories in these fields.

6. MANAGERIAL IMPLICATIONS

The conceptual framework derived in this study enables IT project managers and other senior management to focus on the key CC project complexity factors. This conceptual framework also helps to determine the key CC project complexities, project management and project approach required to achieve the project objectives. These criteria, once followed, will bring about project success in a CC project context.

7. CONCLUSION

In conclusion, the reviewed literature provides an understanding of CC project complexity as well as the required project management knowledge areas to manage cloud projects. A conceptual framework is proposed that should be used to manage cloud projects in order to improve adoption of CC by organisations. The conceptual framework was developed based on the various concepts as highlighted by the literature review. These concepts include project complexity factors, the project management knowledge areas as well as the different implementation approaches. This framework suggests that project management knowledge areas should be applied to CC project IT complexity factors to ensure that all the risks relating to them are identified, mitigated and addressed throughout the project. An Agile project approach should be adopted to cater for the iterative nature of cloud computing implementations. However, further validation of the conceptual framework is required through data collection from both the private and public sectors. The main idea is to achieve validity by interviewing project managers and IT professionals with experience in implementing CC projects.

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ANNEXURE A

Table 7: Mapping of CC complexity factors to knowledge areas

	CC Project Complexity Factors							
Knowledge Area	People Management	Environmental	Technical	Dynamics	Organisational	Uncertainty	Governance	Financial
Risk Management	Project staffing	Data protection and privacy; Contractual agreement; Subpoena and electronic discovery; Legal liabilities; Law and regulations discrepancies; Data residency; Auditing (licences, infrastructure and applications); Non-compliance with industry standards; Lack of cloud standards; Environment of changing technology, economy and Nature	Cloud migration; Vendor lock-in; Multitenancy; Composite services; Insider access; Data loss; Identity and access management; Limited flexibility/ customisation; Performance; Technology novelty; Technological architectures and infrastructure; Degree of IT complexity and innovation; Compatibilities and interdependency of variety of technologies	The pattern and rate of IT environment changes; Technological process Dependencies	Security risk; Risk probability; Significance of Impacts	Environmental uncertainty; Uncertainties in technical methods; Technological Maturity	Service level agreement (SLA)	Exchange Controls

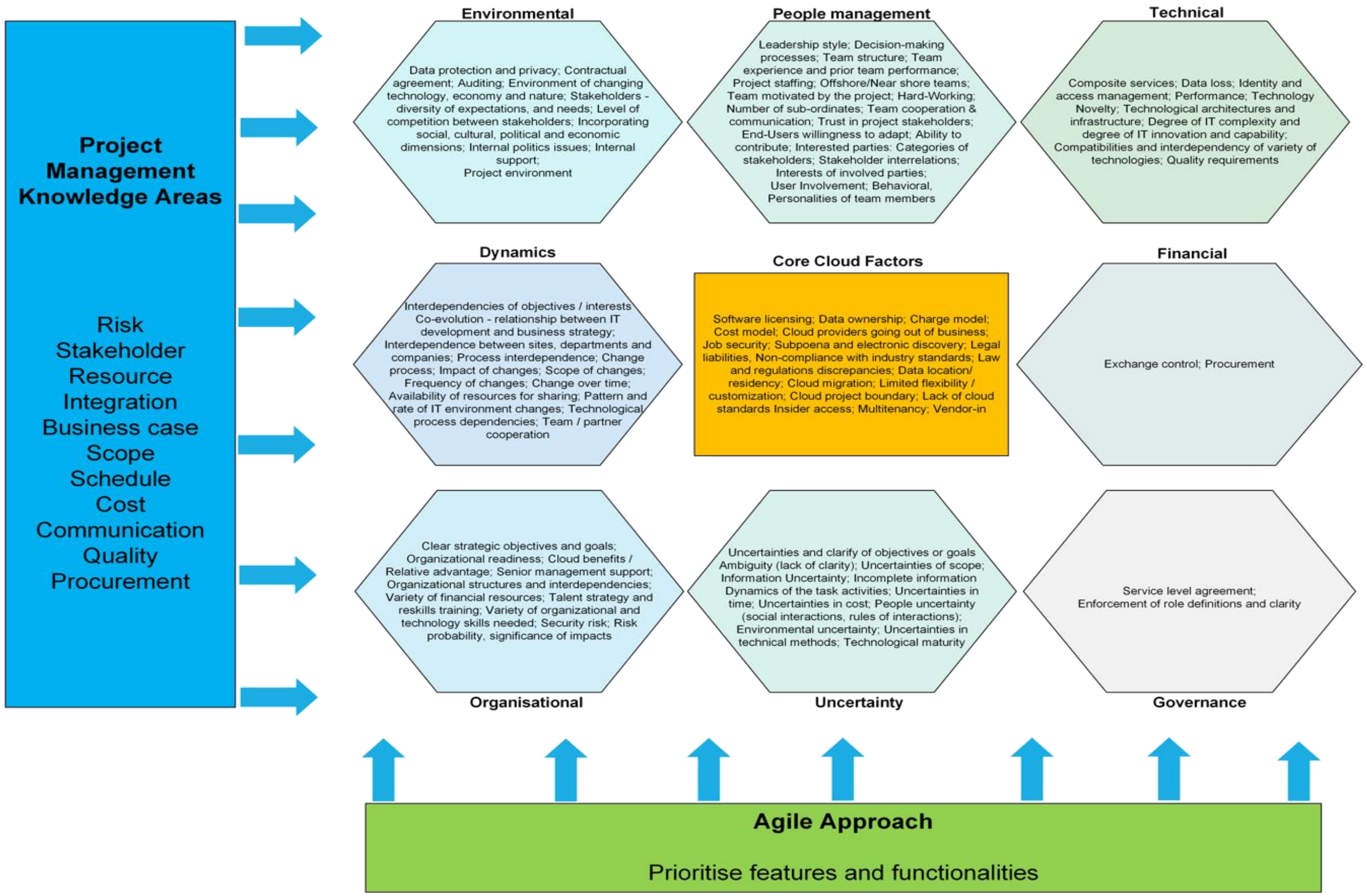
Stakeholder Management	Trust in project stakeholders; End- users' willingness to adapt; Ability to contribute; Interested parties: Categories of stakeholders; Stakeholder interrelations; Interests of involved parties; User involvement	Stakeholders - diversity of expectations and needs; Level of competition between stakeholders; Incorporating social, cultural, political and economic dimensions; Internal politics issues; Internal support; Project environment: political importance, strategic importance, external Dependencies		Team/partner cooperation		Undisclosed participants	Joint-venture partners (parties/ contractors)	-
Resource Management	Team structure; Team experience and prior team performance; Team motivated by the project; Hard- working; Number of subordinates; Offshore teams; Behavioural, personalities of team members			Availability of resources for sharing (people, material and others)	Talent strategy and reskills training; Job security; Variety of organisational and technology skills needed		Poor enforcement of role definitions	

Integration Management	Leadership style			Co-evolution - relationship between IT development and business strategy; Interdependence between departments and companies; Process interdependence; Change process; Impact of changes	Organisational change (processes and effect); Decision-making processes	Uncertainties and clarity of objectives or goals		
Business Case				Interdependencies of objectives/interests	Clear strategic objectives and goals (organisational); Cloud providers going out of business; Organisational readiness; Cloud benefits/Relative advantage; Senior management support; Organisational structures and interdependencies; Variety of financial Resources		Data ownership	
Scope Management			-	Scope of changes		Ambiguity; Uncertainties of scope; Information uncertainty; Incomplete Information	Cloud project boundary conditions	
Schedule Management				Frequency of changes; Change over time		Dynamics of the task activities; Uncertainties in time		
Cost Management						Uncertainties in cost		Charge model; Cost model

Communication Management	Team cooperation & communication					People uncertainty		
Quality Management			Quality requirements					
Procurement Management							Software licensing Issue	Procurement

ANNEXURE B

Figure 2: Conceptual CC Project Management Framework



Source: Authors' own analysis