Conceptualizing and Validating Complexity in Decision Making for Cloud Computing Adoption: A Mixed Method Approach

Abstract

This research paper conceptualizes and then validates the notion of complexity in cloud computing adoption, using the context of the local government sector in Australia. The research utilized both cloud computing adoption literature and an Information Systems Complexity Framework to propose a complexity assessment model for cloud computing adoption. A mixed method approach was used in this research. Firstly, we conducted 21 in-depth interviews with IT managers in the local governments in Australia to obtain their insights into the complexity of cloud computing adoption. Secondly, a quantitative method is used in which 480 IT staff from 47 local governments responded to an online survey to validate the proposed assessment model. The findings provide interesting insights. In particular, the results indicate that structural complexity of an organization (i.e., knowledge management), structural complexity of technology (i.e., technology interoperability, and data processing capability), dynamic complexity of an organization (i.e., business operations), and dynamic complexity of technology (i.e., systems integration, IT infrastructure update, and customization resources) are critical complexity aspects to be considered during adoption of cloud computing within organizations. These findings provide important implications for both researchers and managers that are trying to understand the complexity involved in cloud computing adoption.

Keywords: *Cloud computing; complexity; adoption; Information Systems Complexity Framework; local government.*

1. Introduction

Cloud computing has the potential to help companies remain competitive in the marketplace and optimize their operations (Sultan, 2010; Attaran, 2017). Following new technological innovation such as cloud computing leads to a significant reduction in cost in government organizations (Saeed et al., 2011; Ali et al., 2018), reduced infrastructure requirements for

Information Technology (IT) (Marston et al., 2011), and improved organizational performance that results in better and cost-effective quality of service delivery to customers (Sharma et al., 2012; Ali et al., 2018). The adoption of cloud computing is undoubtedly assisting regional governments in reducing the challenges they face in relation to maintenance (Saeed et al., 2011). Moreover, the cloud computing network redundancy has seen a decrease in problems and risks linked to disaster recovery and associated expenditures (Rajkumar et al., 2011). However, despite being one of the most important and evolving developments in computing history and IT applications, cloud adoption has not been a smooth ride for all enterprises, especially governments that find it particularly complex to make cloud adoption decisions. In fact, the rate of cloud computing adoption in rural local governments is relatively low (about 14 per cent) compared to urban areas (Department of Innovation Industry Science and Research, 2011; Ali et al., 2016). Existing research frequently highlights that the technical complexity of cloud computing is related to issues of security and privacy, connectivity, reliability and interoperability (Avram, 2014). However, factors related to organisational barriers are still not sufficiently integrated into those woks. Indeed, there are limited studies regarding conceptualization of the complexity of cloud adoption from an organizational perspective. Therefore, the main objective of this research paper is *to conceptualize the concept of complexity of cloud computing adoption* using a case study of Australian local governments for validation purposes.

Complexity analysis essentially articulates the various constraints between the various constituting elements through the life-cycle of a system (Leising et al., 2013; Young et al., 2010). Indeed, complexity analysis is frequently utilized in a modern setting to consider the effort required to build-up a system (Leising et al., 2013; Young et al., 2010). IT adoption is challenging to analyse due to the dual role of technological issues and organizational factors that makes adoption complex to manage (Mir, 2015; Welch & Feeney, 2014; Liang et al., 2017). One of the significant challenges of IS researchers and managers is to manage the complexity of adopting new technologies (Welch & Feeney, 2014; Liang et al., 2017). Before researchers can formulate effective strategies to manage and control the complexity involved in adopting any new technologies, the types of key characteristics that make the technology complex must be understood and this is also important to evaluate complexity levels (Xia & Lee, 2005). However, to date, there is no research that has addressed in-depth how to assess cloud adoption—or the factors that might be used to assess—the complexity within organizations' information systems (ISs) (Salado & Nilchiani, 2015). Therefore, further empirical research into the critical factors is needed to assess the complexity of cloud computing adoption (Opara-Martins et al., 2016). To address this gap in the literature, this research paper uses cloud computing adoption literature and an Information Systems Complexity Framework to answer the following research question: *What are the critical factors towards assessing cloud computing adoption complexity in local governments*? To answer this question, we used a mixed method approach. Specifically, we conducted a total of 21 in-depth interviews with IT managers in the local governments in Australia to obtain their views about the complexity of cloud computing adoption. Additionally, we used a quantitative method in which 480 IT staff from 47 local governments responded to an online survey to validate the proposed assessment model.

This research study also aims to assist local governments in adopting cloud computing, as well as charting a direction on how the complexity of cloud computing adoption can be assessed. The results of this research could be relevant to government organizations in different countries—particularly in those countries that have similar socio-economic conditions. This research provides new insights into the IS management literature by developing an approach to manage IS complexity which will help in understanding cloud computing characteristics that constitute IS complexity.

The next section outlines related research regarding cloud computing and complexity. A background is also provided on the methodology and research model before presenting results, analysis and discussions, and recommendations for future research.

2. Literature review

2.1. Cloud computing complexity

Cloud computing is defined by Buyya et al. (2009) as a system of inter-connected computers with dynamic provisioning of resources so that a consistent service-level agreement can be arranged between the service provider and its consumers. Major cloud computing service providers in the market today are Microsoft Azure (Chappell, 2009; Calheiros et al., 2011), Amazon EC2 (Vecchiola et al., 2009), and Google Cloud (Calheiros et al., 2011). The worldwide market for cloud computing is rapidly growing across all segments by about 21 per cent and reaching a market size of U.S. $186.4.4B in 2018—up from U.S $153.5B in 2017 (Moore & van der Meulen, 2018). Despite the operational and strategic benefits, cloud computing adoption is not moving as fast as originally expected (Goscinski & Brock, 2010; Avram, 2014; Okai et al., 2014).

Some researchers, such as Rogers (2003), describe complexity as the extent that IT such as cloud computing is seen as difficult to comprehend and utilize. Also, Davis (1987, p. 2) describes complexity by using the term *ease of use* explained as *"the degree to which an individual believes that using a particular system would be free of physical and mental effort"*. Despite key differences between Rogers' and Davis' definitions of complexity, Rogers focuses on the organizational perspective while Davis presents the unit of analysis from an individual perspective. However, both used the terms *complexity* and *ease of use* to represent the perceptions of individuals.

According to research conducted by Oliveira et al. (2014), adoption complexity is defined as the perceived difficulty to learn to adopt, use and understand new or advanced technologies. This implies that the easier it is to integrate innovation into operational activities, the more likely is the success of technology adoption (Oliveira et al., 2014). A recent study by Kinsella (2017) which reviewed about 451 research articles related to cloud computing found a substantial increase in the operational complexity of IT infrastructure management. According to studies conducted by Bosch-Rekveldt et al. (2011) and Mir (2015), one of the significant reasons that leads to IT adoption failure is adoption complexity, intertwined with time delays and cost blowout. Further exploratory research directed by KPMG (2011) identified complexity as an underlying significant issue for organizations worldwide. The research outcome demonstrates that 94 percent of executives think controlling complexity is imperative in embracing any new innovation inside organizations.

A cloud computing environment provides the capability to provide seamless access to required resources to deliver required services. However, cloud computing adoption often leads to unforeseen challenges and obstacles (Crump, 2012). For instance, integrating existing IT into a particular cloud environment may need specialist IT expertise that is unavailable within the organization (Luna-Reyes et al., 2007). In a research conducted by Sonnenwald et al. (2001), they recommend understanding the complexity of a system in terms of usability of the system, perceived ease of use, and ease of learning a new system. In other research conducted by Tiat and Vessey (1999) on system complexity, they identify the struggle to determine relevant information of the organization system, the complexity of processing data, and the overall system design complexity as the main factors in measuring system complexity. Furthermore, complexity also refers to how difficult predictions can be, which are decided based on three factors: the system itself; the observer's abilities; and the behaviour that the observer is looking to predict (Wade & Heydari, 2014; Sillitto, 2009; ESD Symposium Committee, 2007). Many firms have faced challenges in how to integrate advanced technology such as cloud computing into the workplace (Premkumar & Roberts, 1999). The perceived complexity of implementing new technology can also act as a barrier in enhancing firm outcomes (Lee et al., 2013; Low et al., 2011).

2.2. Information systems complexity framework

According to a review study on system complexity literature conducted by Baccarini (1996), the complexity of the system is characterized as the presence of various interacting components and the interdependency between those components. With a view to determining the meaning of complexity, the author suggested two main types of complexity:

1. Organizational complexity: This aspect refers to different components and the interdependency between those components, such as management levels.
2. Technological complexity: This aspect refers to the number of connections between inputs, outputs, activities and technologies within the system (Mir, 2015; Helbig et al., 2009; Yildiz, 2007).

In other research directed by Xia and Lee (2005, p. 54), IS complexity is characterized as "*the IS's state of consisting of many varied organizational and technological elements that are interrelated and change over time*". According to this definition, and as described in Figure 1, Xia and Lee (2005) built a conceptual framework of IS complexity with key metrics. The first metric of the research conceptual framework determines whether IS complexity relates to the structural outlook or the dynamic aspects of the organization system. The second metric determines whether complexity relates to the organizational or technological features of the organization system. Each metric comprises two dimensions of IS complexity as illustrated in Figure 1.

Organizational	Structural Organizational Complexity	Dynamic Organizational Complexity
Technological	Structural IT Complexity	Dynamic IT Complexity
	Structural	**Dynamic**

Figure 1: IS complexity framework (Xia & Lee, 2005)

The first metric defined by the differences between structural and dynamic complexity is also supported by previous research (Ribbers & Schoo, 2002; Tatikonda & Rosenthal, 2000). Based on previous studies, this research characterizes *structural complexity* as (1) variety, multiplicity and differentiation of the system components (Pich et al., 2002; Williams, 1999); and (2) coordination, interaction, interdependency and integration of the system components (Tatikonda & Rosenthal, 2000; Pich et al., 2002; Ribbers & Schoo, 2002). IS normally includes various organizational and technological components. These components include the current systems, advanced technology, infrastructure, stakeholders, and service providers. As the system tasks expands, it becomes very difficult to control and monitor the system. Interdependencies among these tasks make it harder to foresee the system's procedures and results. As indicated by Leveson (1997), issues in implementing complex systems regularly emerge in the interfaces between the different components, for example, hardware, software and human elements. According to previous studies, this research characterizes *dynamic complexity* as uncertainty, variability, and dynamism (Meyer & Curley, 1991; McKeen et al., 1994; Ribbers & Schoo, 2002) potentially caused by differences in organizational and technological environments.

The difference between organizational and technological complexity—which is the second metric —is well-informed by the IS literature (McKeen et al., 1994; Meyer & Curley, 1991; Xia & Lee, 2004). *Organizational complexity* refers to the complexity in organizational settings while using the system in study. Organizational components of IS incorporate client gatherings, decision-makers, team, external users and vendors, business processes, and organization hierarchical structure (Xia & Lee, 2005). *Technological complexity* refers to the technological complexity surrounding IS (Xia & Lee, 2005). As per the survey research conducted by McKeen et al. (1994), technological complexity (refer to the complexity of the organization system) incorporates the complexity of technology platform, planning strategies and programming, advancement methodology, and system integration. Furthermore, other research by Meyer and Curley (1991) recommended that the technological complexity with regards to effective systems comprises of such innovative factors as assorted platform varieties, database intensity, technological variety and systems integration effort.

As suggested by previous studies, the major objective in promoting the adoption of cloud computing is to improve reliability and access whilst decreasing IT expenses and processing time (Hayes, 2008). The current review of the IS literature suggests a lack of studies explaining the complexity of cloud computing adoption. This research aims to utilize the IS complexity framework to investigate and understand the main critical factors to measure and evaluate complexity in cloud computing adoption within government organizations.

3. Research methodology

A sequential mixed methods approach is used in this research. Researchers define mixed approach as a method in which the findings from one study inform the other (Venkatesh et al., 2013). Many IS scholars have adopted a mixed method approach in various prior studies (Grimsley & Meehan, 2007; Hackney et al., 2007; Soffer & Hader, 2007; Venkatesh et al., 2013). An ideal mixed research method usually begins with an exploratory study (e.g. qualitative research method), followed by a confirmatory study (e.g. quantitative research method) (Venkatesh et al., 2013; Walsham, 2006; Bhattacherjee & Premkumar, 2004). During exploratory qualitative research, researchers adapt trade-offs between choices of factors from discussions with the relevant stakeholders of the research (Teddlie & Tashakkori, 2009; Venkatesh et al., 2013). In this context, quantitative research is also relevant to explore the relevant factors as proposed in (Hanson & Grimmer, 2005). After the exploratory journey, a quantitative research method can be applied with a formal questionnaire (survey) to validate the factors. In order to follow this research protocol, a mixed approach was used to meet the objectives of: (1) identification of factors to assess the complexity of cloud computing from the literature, using a qualitative method; and (2) development of a conceptual model, using a quantitative method (Song et al., 2005). We initially employed qualitative research because a primary goal of our research is to clearly understand the occurrence of a phenomenon – complexity in cloud computing adoption (Zikmund et al., 2012). Secondly, a quantitative research method based on an online survey is useful to test the factors of the conceptual framework proposed in this research. The adoption of such mixed methods approach is not new in the area of technology adoption, and IS researchers have used this approach for similar purposes (Becerra-Fernandez & Sabherwal, 2001; Grimsley & Meehan, 2007).

Table 2 illustrates the four main phases towards the development and validation of the conceptual framework.

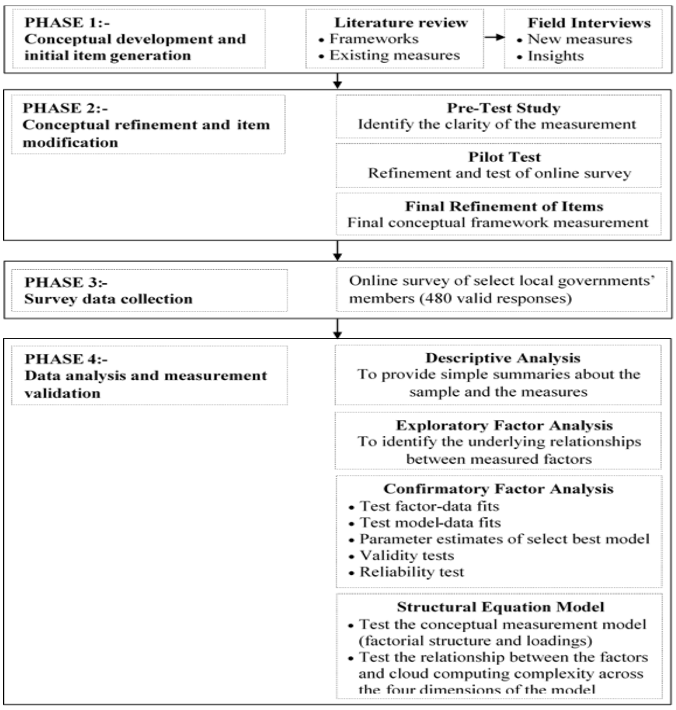


Figure 2: Process of developing, validating, and measuring the framework

3.1. Study 1: Qualitative method

In this research, in-depth interviews were carried out with 24 local government IT staff in senior management positions over a period of four months. Interviewees were selected based on representational factors related to cloud computing. They also represented local governments from a broad geographical perspective. The key point of this exploratory stage was to explore and determine factors that were overlooked as noted during our literature review towards evaluating the complexity of cloud computing; and to refine and confirm the conceptual research framework (Myers & Avison, 1997). An additional purpose of this exploratory stage was to identify possible measurement items for complexity of cloud computing factors (Zikmund et al., 2012).

Three steps were followed in the research approach, including preparation of the interview structure and style, and invitations to participants (Gaskell, 2000). Five central questions formed the foundation of the interview. While the first question sought to determine the duties of the respondents' position, the second question sought to understand participants' educational background and their skills and comprehension regarding cloud computing. Participants were then required to advise their relevant work experience and their workforce capacity in understanding cloud computing. In the fourth question, interviewees were asked to identify the factors that they thought are relevant to measure the complexity of cloud computing adoption. Finally, the fifth question concerned descriptions of specific complexity impacts on cloud computing adoption. This interview design and approach allowed the interviewer to explore and follow up the responses.

The questions were created for the purpose of eliciting in-depth answers and discussions, and portraying personal opinions on the topic (Carson et al., 2001). The questions were Open-ended, resulting in interview lengths of approximately 30 to 50 minutes. Out of the original 24 interviews, only 21 interviews were considered due to participant reliability. The three interviews were excluded since it was determined that the three IT managers did not have sufficient experience and knowledge related to the adoption and use of cloud computing based on their interview responses.

3.1.1. Data analysis

Interview outcomes were analysed using manual content analysis (Miles et al., 2014). Three steps were followed: data minimization; display of information; and verification of results (Hsieh

& Shannon, 2005; Miles et al., 2014). Each interview was transcribed immediately after completion of the data and used to draw up conclusion tables for each participant (Rao & Perry, 2007). These consisted of central themes, main concerns, issues and responses to each question. Subsequently, data was then recorded as a final summary (Schilling, 2006). Codes for the interview data were then devised, followed by arranging the information categorically and sequentially in order to identify findings and necessary paths of action (Miles et al., 2014).

3.1.2. Study 1 results

The literature review found that all previous studies on cloud computing adoption identified complexity as the perceived difficulty of learning to adopt, use, and understand a new systems or advanced technologies. Some of these studies argued the operational complexity of using cloud computing. Moreover, some studies identified the organization system's complexity as a result of the lack of cloud technical expertise. Also, there are some researchers who identified integration of cloud computing as a factor of complexity within the system. However, none of the previous research—and in particular cloud computing adoption studies— presented any factors useful to assess complexity in decision making regarding cloud computing adoption. Therefore, the exploratory stage of this research investigated new factors to assess the complexity of cloud computing adoption as identified by the participants, including: (1) change management; (2) business operations; (3) knowledge management; (4) data processing capability; (5) technology interoperability; (6) systems integration; (7) vendors multiplicity; (8) IT infrastructure updates; (9) IT architecture revisions; and (10) customization resources. Each of these factors is discussed next.

Change management: Participants suggested change management as a major factor that impacts measuring complexity in cloud computing adoption. About sixty percent of the research participants confirmed the role of change management within the organization and change-related information is needed to reduce the level of complexity of using cloud computing. Comments included: *"The more informed the users are on what they expect to what their expectations are, how they are going to work. They are always easy to handle change if they know what that effect is going to be. So yes, certainly a move to the cloud if they understood what that is that going to be* *about and what their end-user experience would be, it would be a positive to have that"* (C45-RAV). Information availability has been proven to greatly reduce users' resistance in using a new technology (Kebede, 2002). When information regarding change is not adequate, this leads to restricted IT use and less benefits from the technology. Thus, information availability impacts the adoption rate of cloud computing as sharing relevant information about changes amongst users is important (Ghobakhloo, et al., 2010; Egbu et al., 2005).

Business operations: The qualitative analysis also showed business operations impacts assessing complexity of cloud computing adoption: about seventy-five percent of the research participants responded that using cloud computing system is not seen as complex for business operations in their organizations. Comments included: *"We do not see any more complex than what we currently have now. Because we are only taking that application and that server functionality and it is just running off-site. The only link in between them is the connectivity so we do not see the complexity"* (C11-RAV). *"It will make new processes and that a lot more available to businesses quicker so businesses will be able to adopt new functionality within applications a lot quicker than they have been able to in the past"* (C40-UDV). Although there are efficiency gains with cloud computing, these can only be achieved by integrated business operations that promote organizational productivity. Expenses can be lowered and availability can be improved within the value chain through service management, and the cost reductions can be used to enhance company operations (IBM, 2010a). The business operations make clear which service is input or output and highlights demand cycles. Service architecture is vital for design purposes and clear boundaries are essential in terms of understanding workloads required for cloud computing adoption (Phaphoom et al., 2013; Roy et al., 2011).

Knowledge management: Participants also suggested that knowledge management is a key factor that impacts understanding complexity in cloud computing adoption: approximately forty-five percent of the research participants suggested the knowledge required for cloud computing adoption is not complex for employees in their organization. Comments included: *"Employees' skills and knowledge that needed, I believe it is not complex. If the employees and the end users* *were familiar with using cloud computing, they would be a lot quicker to pick up on it and to use it"* (C19-RTL). Commonly, external services are utilized owing to a lack of knowledge within in-house employees (Al-Qirim, 2012; Rajendran, 2013). When existing staff do not possess knowledge conducive to the job, IT can be poorly managed and the adoption process is difficult (Rajendran, 2013). Once shortfalls in knowledge have been identified, changes should be implemented (Goles & Chin, 2005; Grover et al., 1995). Using effective knowledge transfer strategies, employees must enhance their knowledge through training in cloud operations; and appropriate sourcing and risk assessments would also ease the process (Rajendran, 2013).

Data processing capability: The findings also indicated data processing capability as another factor for assessing complexity in cloud computing adoption: about seventy percent of the research participants responded that data processing capability of the cloud would not be complex or different from in-house IT resources. Comments included: *"The data processing would not be any complex or different on what we have in-house. Because, the data would be maintained by us, it is only ensuring that the link, Internet link and connectivity is, once again, 99.9 percent reliable and available because if it goes down, you would have, in our case, say you have got an application that is being used by a hundred employees internally, they would not have access to the data because it is off-site"* (C11-RAV). Using redundant frameworks that include mirrored data processing so that the system users are better able to access resources and set up programs (Warneke & Kao, 2009) are useful methods to mitigate this complexity factor. There are platforms available to programmers to start processing applications with virtually unlimited and constant data supply (Neumeyer at al., 2010). These are scalable platforms that can be used for numerous purposes and are largely fault-tolerant (Hashem et al., 2015). One example of data processing within a cloud is MapReduce, which enables vast sets of data to be located in the cluster (Dean & Ghemawat, 2008). Cluster computing typically has advantageous productivity across different contexts such as connection systems, strength and storage (Hashem et al., 2015).

Technology interoperability: The results of the exploratory phase of this research also showed that technology interoperability is another factor that influences examining complexity of cloud computing adoption: fifty-five percent of the research participants stated that despite a variety of technology platforms that are increasingly more interoperable, cloud computing is still less complex than other types of technologies. Comments included: *"The nature of IT is pretty much complex. But cloud computing complexity is not an issue, because Amazon and Microsoft made it very easy to migrate the cloud and also having a more modular, huggable software solution"* (C52-UFM). *"Comparing to other type of technologies cloud computing is less complex"* (C55-URS). *"I would probably say it would be probably not much more complex than it is at the moment it is definitely going to be less requirement to having an understanding of your servers"* (C55-URS). It has been argued that organizations may be apprehensive about adopting cloud computing if the technology platform is regarded as complex (Rogers, 1983; Thong, 1999). Other studies have indicated that there is no correlation between adoption and perceived complexity of the variety of technology platforms (Kendall et al., 2001; Seyal & Rahman, 2003). Borgman et al. (2013) argued that cloud computing is no more complex than other IT solutions and will be no more difficult to adopt and use than routine IT management challenges.

Systems integration: Systems integration is another important factor that impacts assessing complexity in cloud computing adoption: sixty-five percent of the research participants responded that integration of cloud computing with the organization's existing IT system does not present any problem for their organizations. Comments included: *"A complex integrated environment becomes a real risk for organisations like us"* (C68-URL). But, *"because it is based on the cloud service providers and most of the cloud providers find solution to the integration with the existing technologies"* (C19-RTL). Research indicates that organizations are looking for cloud service providers (CSPs) to assist them with complexity and integration issues. With the exception of price, almost all the answers were associated with the reduction of perceived complexity related to cloud implementation (Gangwar et al., 2015).

Vendors' multiplicity: The findings also suggested vendor multiplicity as an important and critical factor that affects assessing complexity in cloud computing adoption: seventy-five percent of the research participants pointed out that the availability of different providers makes it difficult for organizations to choose high-quality cloud services. Comments included: *"We need to ensure that we have an effective network, and convinced that the network that we have in place is going to have a higher level of up-time. In other words, being able to access our cloud resources will be very important. So, effective networking is a challenge. It is also potentially is a barrier to us moving there. Essentially, in our area, there is only one provider offering business grade data solutions and data network solutions. The diversity and availability of more than one provider will make the market less complex in choosing the right vendor and more competitive, and consequently, lead to high quality of services and reduction in the cost of these services"* (C15-RAL). There is a need to ensure all decision-makers are provided with transparent information surrounding the services and capabilities of the vendors (Kepes, 2010). When the choice of vendors is limited, competition is minimal and the organizations may not receive the best value for their investment (Whitten & Wakefield, 2006; Soo Han et al., 2013). This problem is prominent in regional areas compared to metropolitan areas where cloud vendors offer more services due to the critical mass and Internet connectivity (Soo Han et al., 2013).

IT infrastructure updates: Participants also argued that IT infrastructure update is a key factor that impacts measuring the complexity of cloud computing adoption: ninety percent of the research participants believe that by adopting cloud computing, organizations make drastic updates to their IT infrastructure leading to less complexity than when IT infrastructure is in-house. Comments included: *"The major benefits of adopting cloud computing in the organization is to reduce IT infrastructure, and this reduction means that change the IT infrastructure within the organizations"* (C72-URS). *"If there were proper communication, then lesser needs for local infrastructure. No expensive service, local signs or backups; everything be done from the cloud. That would be an advantage"* (C74-RTM). Cloud computing has enabled the reduction of IT infrastructure (Subashini & Kavitha, 2011; Nicho & Hendy, 2013), and it allocates the increased usage of mobile technology and broadband Internet services which, in turn, improves system accessibility for users (Gupta et al., 2013). Cloud computing is perceived to have transformed IT services from an investment-based infrastructure to a service received through the Internet which facilitates customers to benefit from the respective services regardless of time and place. An increased demand for quicker delivery of services is likely to persuade organizations to adopt this technology for improved IT agility (Oliveira & Martins, 2011).

IT architecture revisions: IT architecture revision is also suggested as a factor that impacts evaluating complexity in cloud computing adoption: half of the research participants indicated that the organization's IT architecture will undergo significant revisions after adopting cloud computing. They expressed the view that the revisions result in a less complex IT architecture than what they have with in-house IT infrastructure. Comments included: *"All the changes come around being able to entering and use the software as a service and infrastructure as a service, that quick response bring the system quickly without spending much time or wait for service to arrive and installation of the processes, and this change make the business process run very smoothly"* (C61-URM). The entire IT architecture can be studied as the management of three layers of the core stack in IT. The three layers that comprise the core stack are: resources, platforms, and applications (Shawish & Salama, 2014). Resources are made up of connection systems, storing of data and both virtual and tangible computing. Platforms are more complex and are therefore regarded in sub-layers. For example, within a platform there is a structure which controls tasks, timings, and transactions. Another sub-layer may be a storage layer enabling caches and unlimited data. Finally, the applications back up existing systems, yet with more advanced versatility and functions that enable greater ability to address higher demands—thus not seeing systems slow or cease (Qian et al., 2009).

Customization resources: Participants also suggested customization resources as being a key factor that impacts assessing complexity in cloud computing adoption: ninety percent of the research participants believed that customization resources to adapt cloud services to the organizational context must be provided by vendors (but still operated by the organization) who set up the functions and the features that are needed locally. Compared to in-house software development, the cloud customization resources provided by vendors were seen as less complex. Comments included: *"A lot of government organization software development is provided by* *vendors, not a great deal of in house software development so most of the innovation has to be worked by level government representation to the vendors to say this is a function or feature set or value add that we want to add to that out of the particular piece of software we are using, so I think local government in general is a little big hamstrung by the vendors and does not to many level governments that would put on you know five or ten developers to you know redevelop or to start a software development project"* (C42-URL). In the traditional model, software vendors design and develop the applications and then they sell these application packages to customers (Singh et al., 2004). Typically, customers purchase licences for these application packages; and these licences give customers the right to adopt and use this software under specific terms (Singh et al., 2004). The Software as a Service (SaaS) is one of the cloud computing deployment models in which an application is hosted as a service provided to customers over the Internet. SaaS is expected to reduce the customer's needs related to software maintenance, operation, and support (Benlian & Hess, 2011; Tilley & Rosenblatt, 2016).

According to our initial findings from the literature review and results from Study 1 (qualitative method), the following ten factors were identified to assess the complexity in cloud computing adoption: *change management*; *business operations*; *knowledge management*; *data processing capability*; *technology interoperability*; *systems integration*; *vendors multiplicity*; *IT infrastructure updates*; *IT architecture revisions*; and *customization resources*. These factors formed a cloud complexity conceptual framework, which is discussed next.

3.2. Cloud computing complexity assessment model

Using the literature review and the theoretical background presented thus far, the cloud computing complexity assessment model was developed. In particular, it is underpinned by a combination of factors from (Premkumar & Roberts, 1999; Li & He, 2007; Broberg et al., 2011; Gangwar et al., 2015; Wade & Heydari, 2014; Sallehudin et al., 2015) and from IS complexity frameworks (Schmidt et al., 2001; Scott & Vessey, 2002; Barki, 2001; Jiang & Klein, 2001). Factors identified from the qualitative study (discussed above) involving IT staff in senior management positions in local government were also incorporated. The resultant initial model is shown in Figure

3 to guide the assessment of the complexity of cloud computing adoption within a quantitative study (discussed next) which encapsulates study 2 of this research. The model is a multi-dimensional construct that has four main components: (1) structural complexity of organization; (2) dynamic complexity of organization; (3) structural complexity of technology; and (4) dynamic complexity of technology (see Figure 3); and a number of underpinning factors.

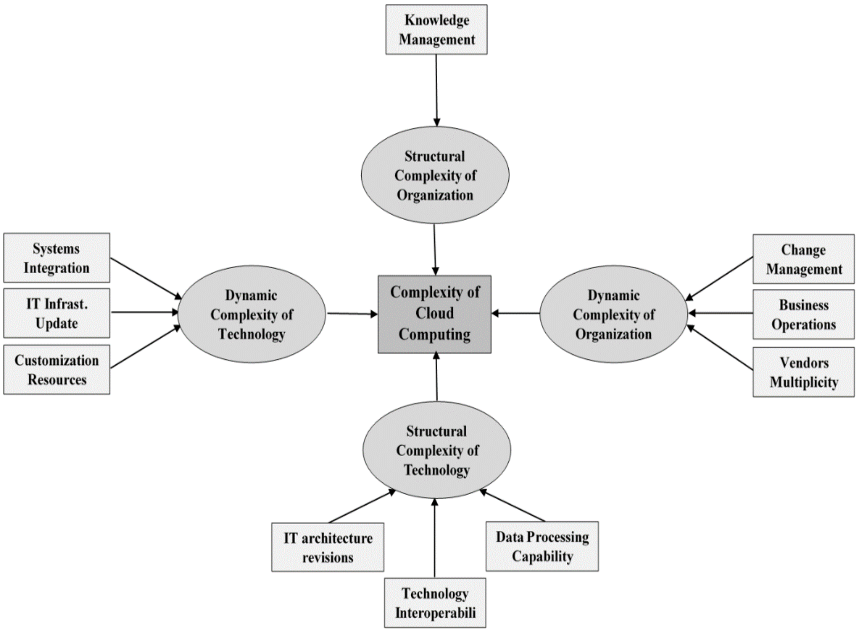


Figure 3: Cloud computing complexity assessment model.

In our model, the structural complexity of an organization refers to current knowledge stock within the organization that reflects the relationship between the knowledge source and an organization's knowledge management capacity (such as level of employees' skills). Likewise, the dynamic complexity of an organization refers to the level of change within organizational management, business processes, and vendors within the organizational environment. More importantly, it reflects the dynamic nature of the organizational environment. Similarly, the structural complexity of technology defines the complexity in the interfaces between the IT components and refers to the technical complexity elements such as data processing capability, technology interoperability, and IT architecture. Lastly, the dynamic complexity of technology refers to the level of changes in the IT environment within the organizations that is measured in terms of integration, infrastructure, and customization.

3.3. Study 2: Quantitative method

The research instrument implemented in study 2 was a questionnaire (Zikmund, 2012; Zikmund et al., 2013). The purpose of the questionnaire (research survey) was to empirically test the cloud computing complexity assessment model. An online survey was the chosen approach, ensuring ease of input by the research participants. A provider was sought to ensure 24/7 access to the survey; and a link was provided to the respondents for a three-month period.

To identify the main critical factors used to evaluate and measure the complexity of cloud computing, a 7-point Likert scale was used with 1 meaning ‘strongly disagree’ and 7 representing ‘strongly agree’. The first version of the questionnaire was adjusted following feedback from university staff and local government IT managers. The pre-study was effective in highlighting problems and advancing the survey structure (Waters, 2011). An essential component in implementing a questionnaire is to perform a pilot study (Shaughnessy et al., 2012; Waters, 2011). We recruited 30 IT managers during our pilot study. Cronbach’s alpha was used to evaluate the reliability of the research instrument items in the conceptual framework (Field, 2009). The acceptable value required for Cronbach’s alpha subsisted on a trustworthy degree between 0.7 and 0.8 (Field, 2009; Stafford & Turan, 2011).

3.3.1. Data

After the pilot study was completed, the main study was conducted. The 77 Queensland local governments supply numerous services to their local constituents (citizens) and regional companies and have an interest in IT research (LGAQ, 2013). All 77 regional local governments had access to the online survey and the research had a response rate of sixty-one percent. A total of 480 staff participated and returned the survey.

The demographics comprised the participants’ occupations within the IT department, their level of comprehension surrounding cloud computing and their total length of time working in IT.

The majority held authoritative positions at 49.6 per cent, while 28.8 per cent worked as programmers, analysts or developers. Twenty-one per cent of the participants were either in supporting positions, administration or operators. The majority of respondents held knowledge and experience in managerial positions. ‘Good knowledge’ was the highest rating and this was attributed to 49.6 per cent of the respondents (238); and ‘some knowledge’ related to 23.1 per cent of the respondents (111). These findings point to vast perceived knowledge differences by regional staff.

4. Results

Commented [GB1]: Perhaps a statement of how 4.1. and 4.2 are complementary can be added.

4.1. Measurement model

Numerous analytical methods of the data were utilized to ascertain the reliability, validity and assessment of information regarding the main critical factors towards measuring the complexity in cloud computing adoption. Validity was first tested using Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA). To ascertain how constant the internal factors were, the reliability and validity of the categorizations were then tested.

Exploratory Factor Analysis: EFA is an extensively utilized and largely implemented statistical methodology in IS, education, and social science (Williams et al., 2010). In this research study, the survey items employed to determine the major constructs of the research model included some items adopted from previous studies, and others were taken from IT managers in the qualitative phase by developing the scale using the 4 steps approach espoused by Moore and Benbasat (1991). According to Chong et al. (2009), the purpose of implementing EFA within the research is to evaluate the construct validity. Zhang et al. (2000), conducted a research study which confirmed that the main aims of applied principal component analysis is to evaluate the link of the items to their underlying factors. Based on Hair et al. (2005), the factor loadings were applied to explain these relations. They also identified that factor loadings greater than 0.50 are very significant, which was applied in this research. In this research, the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was also applied. The value on each of the 10 factors ranged from 0.756 (for change management) to 0.943 (for customization resources). In summary, each factor loading was greater than the suggested 0.50 (Hair et al., 2005), which is considered to be very significant and acceptable.

CFA is basically employed to assess a suggested theory and is an arithmetical methodology. CFA is also a type of Structural Equation Modelling (SEM) (Swisher et al., 2004). Contrary to EFA, CFA has suppositions and prospects established on priori theory regarding the number and appropriateness of factors (Swisher et al., 2004). In this research, CFA was conducted using AMOS Graphics 22. The research first tested the one-factor congeneric measurement to each factor in the cloud computing complexity conceptual model. This test can help to evaluate the uni-dimensionality and appraisal of data set through the verification of basic structure as per the theoretical framework (Mueller, 1996). For the evaluation of the theory and analyzing the level of fit, it additionally recommends alteration, simplification and any essential modification in the measurement model (Byrne, 2001; Holmes-Smith et al., 2006). The model fit statistics have been categorized into three measurement types: absolute fit indices; comparative fit indices; and indices of model parsimony (Byrne, 2001; Cunningham, 2008; Hair et al., 2006). It is very significant to note that for suitability there are several fit indices and different rules of thumb regarding the minimum range of value in these types of measurement (Byrne, 2001). In this research, CMIN/DF, GFI, AGFI, RMR, IFI, TLI, CFI and RMSEA are taken into account for this analysis as these are employed frequently and are mentioned in the literature (Byrne, 1998; Hulland et al., 1996). All 10 factors in the research model were evaluated individually using this technique, and the best fit of each congeneric measurement model was achieved. In this process, 12 items have been removed from the individual models. The objective of removing these 12 items was to accomplish an enhanced fit to the data in this procedure wherein 34 items were assessed in the overall measurement model (see Table 1).

Table 1:
One-factor congeneric measurement results.

Factors	Fit Indices								Items Input	Items Output
	CMIN	**GFI**	**AGFI**	**RMR**	**IFI**	**TLI**	**CFI**	**RMSEA**		
Knowledge Management	.698	.999	.991	.020	1.002	1.000	1.000	.000	4	4
Change Management	1.286	.998	.984	.024	.999	.998	.999	.023	3	2
Business Operations	.819	.999	.988	.017	1.000	1.002	1.000	.000	5	3
Vendors Multiplicity	4.087	.998	.982	.003	.996	.996	.992	.080	4	2
Systems Integration	2.306	.923	.949	.027	.988	.989	.999	.028	5	4
IT Infrastructure Update	.864	1.000	.971	.006	1.003	1.008	1.000	.000	6	5
Customization Resources	4.001	.947	.999	.022	.999	.958	.994	.080	5	4

Data Processing Capability	1.245	.949	.974	.008	.991	.999	.980	.052	6	4
Technology Interoperability	4.065	.986	.994	.011	.997	.947	.920	.080	5	3
IT Architecture Revisions	1.234	.920	.905	.019	.994	.991	.997	.026	3	3
Total Items									**46**	**34**

Reliability and validity: To test for model reliability and validity, the study employed *Cronbach's Alpha* using the recommended acceptance score of ≥ 0.70 (Stafford & Turan 2011). Each of the factors in the cloud computing complexity model exceeded the acceptance score by falling within the range of 0.845 and 0.968. This study also considered the *Squared Multiple Correlation* (SMC) (Holmes-Smith, 2011) using the suggested value of SMC being > 0.30. The large majority of items (26 items out of 34 items) in the final model exceeded 0.50, and the remaining 8 items were above 0.30, with 0.346 being the lowest value. In summary, the value of SMC suggests that all the measurement items used in the research conceptual framework are dependable. The study also tested for convergent validity using *Standardized Regression Weights* (SRW) to check for construct consistency and the measurement limits of each of the items. The recommended factor loading to suggest the significant validity of each item is an approximated value of ≥ 0.50 (Holmes-Smith, 2001; Hair et al., 2006). The SRW loading values of the factors in the final model were found to be between 0.743 and 0.971. Finally, the *Critical Ratios* (CR) of the research model items were between 11.216 and 26.976, which were more than the standard value of 1.96 suggested by Holmes-Smith (2006). This indicates that the cloud computing complexity model retains significant regression validity.

4.2. Structural equation model

The cloud computing complexity conceptual model was designed to determine the critical factors to evaluate and measure the complexity of cloud computing adoption in local governments. As earlier described, 10 factors were included in the research conceptual framework designed for evaluating the complexity of cloud computing. According to research by Byrne (1999), a SEM allows researchers to identify those factors that have a direct or indirect effect on the values of other latent variables. The principle of the research structural model in the study is to evaluate the links via major paths between latent variables, as well as to examine the fundamental hypothesis for providing answers to the highlighted research question. As shown in Table 2, the results of the structural model fit confirmed that the research measurement model achieved a good fit and most of the different indicators that were reported in this research meet the recommended levels.

Table 2:
Overall measurement of fit indices from SEM test results

Indices	Structural Model Fit	Conclusion
Normed Chi Square (CMIN)	2.619	Good
Root Mean Square Residual (RMR)	.058	Good
Goodness of Fit (GFI)	.915	Good
Adjusted Goodness of Fit (AGFI)	.799	Acceptable
Incremental Index of Fit (IFI)	.917	Good
Tucker-Lewis Index (TLI)	.897	Acceptable
Comparative Fit Index (CFI)	.935	Good
Root Mean Square Error of Approximation (RMSEA)	.060	Good

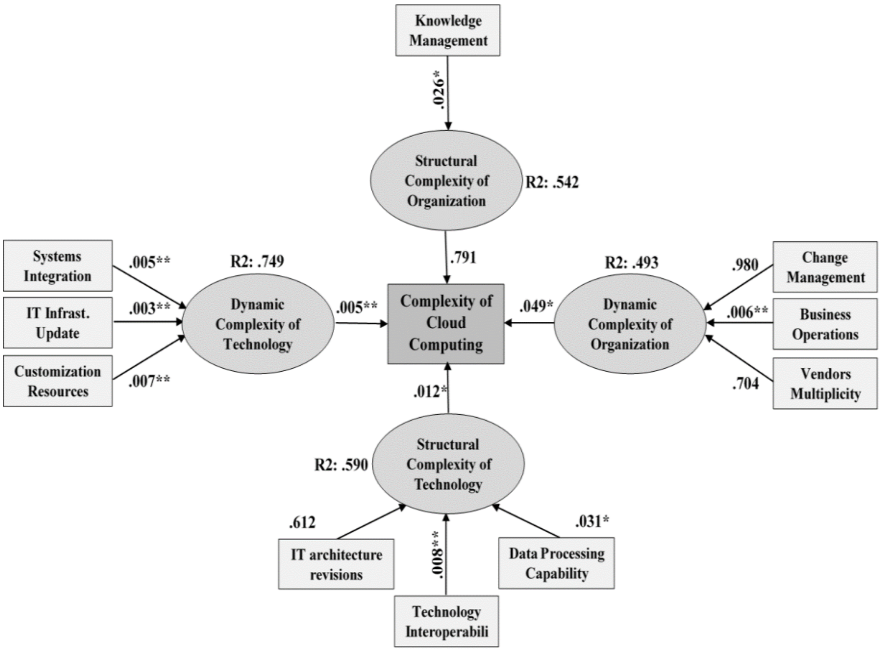
The SEM findings presented in Table 3 are measured on the basis of estimated path coefficient (β) value with the critical ratio (t-value), p-value, and R square (R^2). According to Byrne (2001) and Holmes-Smith (2006), the standard decision rules of t-value greater than 1.96, and the p-value is at least ≤ 0.05 or ≤ 0.01 are applied.

Table 3:
Regression weights of the SEM and results of the hypothesized path relationships

Paths [#]			Structural Model					Results
			Standardized (β)	S.E.	C.R. (t)	P	R2	
KM	→	Complexity of Cloud	.156	.073	3.314	.026*	.539	Supported
SCO	→	Complexity of Cloud	.159	.098	3.257	.025*	.542	Supported
CM	→	Complexity of Cloud	-.092	.232	-.046	.980	.387	Not supported
BO	→	Complexity of Cloud	.218	.167	2.823	.006**	.736	Supported
VM	→	Complexity of Cloud	.111	.085	.165	.704	.395	Not supported
DCO	→	Complexity of Cloud	.289	.218	4.921	.049*	.493	Supported
DPC	→	Complexity of Cloud	.133	.086	4.918	.031*	.519	Supported
TI	→	Complexity of Cloud	.256	.163	2.723	.008**	.670	Supported
ITAR	→	Complexity of Cloud	.059	.192	.250	.612	.462	Not supported
SCT	→	Complexity of Cloud	.287	.152	1.948	.012*	.590	Supported
SI	→	Complexity of Cloud	.274	.189	2.911	.005**	.754	Supported
ITIU	→	Complexity of Cloud	.104	.205	2.502	.003**	.762	Supported
CR	→	Complexity of Cloud	.587	.264	2.680	.007**	.706	Supported
DCT	→	Complexity of Cloud	.101	.179	2.742	.005**	.749	Supported

KM: Knowledge management, SCO: Structural complexity of organization, CM: Change management, BO: Business operations, VM: Vendors multiplicity, DCO: Dynamic complexity of organization, DPC: Data processing capability, TI: Technology interoperability, ITAR: IT architecture revisions, SCT: Structural complexity of technology, SI: Systems integration, ITIU: IT infrastructure update, CR: Customization resources, DCT: Dynamic complexity of technology.

The results of the regression tests presented in Table 3 indicate and confirm that seven out of ten measurements that were developed for testing in the SEM have been accepted as significant and having a positive impact as critical factors used to measure the complexity of cloud computing adoption. These major factors are knowledge management, business operations, data processing capability, technology interoperability, systems integration, IT infrastructure update, and customization resources. The other three factors in the research structural model have been rejected. These factors are change management, vendors' multiplicity and IT architecture revisions. Figure 4 depicts the path diagram for these final relationships.



* $p < 0.05$ ** $p < 0.01$

Figure 4: Cloud computing complexity SEM test.

5. Discussion

Based on the findings thus far, we next discuss the ten factors to understand complexity in decision making regarding cloud computing adoption.

5.1. Structural complexity of organization

There was a direct correlation between *knowledge management* in terms of comprehension of IT and the perceived complexity of cloud computing. As shown in Table 3, the standardized coefficient was 0.156 with t-value is 3.314, R^2 is 0.539 and p value is < 0.05 level .026*. When there is a shortfall in knowledge, adopting cloud computing is regarded as complex and challenging

(Rajendran, 2013). Organizations evidently need to incorporate effective knowledge transfer strategies under such circumstances (Goles & Chin, 2005; Grover et al., 1995; Sharma & Yetton, 2007). An implication of this research is that local governments can reap huge benefits by assisting staff through training and providing information when adopting cloud and, as a result, the rate of adoption will likely improve.

5.2. Dynamic complexity of organization

This section includes a discussion on change management, business operations, and vendors' multiplicity. Each of these factors is discussed in turn.

Change management: Table 3 indicates that change management does not have a significant correlation with complexity of cloud computing adoption. As shown in Table 3 the standardized coefficient was -0.092 with t-value is -0.046, R^2 is 0.387 and p value is 0.980. Prior literature has shown contrasting findings suggesting that better quality information should be accessible for users in order to provide ease of access with the systems. This, in turn, would increase opportunities to utilize such systems, thereby reducing change management efforts (Porter & Miller, 1985; Yap, 1990). When change management is compromised, complexity becomes a greater issue and the ability to experience the advantages of the IT systems is hindered. If organizations demonstrate poor communication and a lack of system knowledge, adoption becomes less of a possibility (Ghobakhloo et al., 2010; Egbu et al., 2005). This research study challenges previous findings and suggests that this may be the result of 'early adopters' where offices/departments were more conventional and bureaucratic—in such an organizational culture, communication and adoption surrounding new IT can become more problematic. Cloud computing is very much a new IT service delivery mechanism and still not considered 'mainstream'. Once such systems are accepted more as the norm, findings related to change management are expected to be more positive regarding adoption.

Business operations: In this study, substantial connections between adoption and company processes were found, illustrating a positive trend. As shown in Table 3 the standardized coefficient was 0.218 with t-value is 2.823, R^2 is 0.736 and p value is < 0.01 level .006**. The opportunities with cloud computing are significant but, in order to maximize these opportunities, specific factors need to be considered. These include a greater capacity for enhanced services, a blend of IT, and redefined business models (IBM, 2010b). This research findings concur with previous research in this field that highlight the opportunities for enhanced productivity by combining cloud computing with in-house IT. In this light, cloud computing adoption is not regarded as complex.

Vendors' multiplicity: Table 3 indicates that having choice of vendors does not have any bearing on the rate of adoption. As shown in Table 4 the standardized coefficient was 0.111 with t-value is 0.165, R^2 is 0.395 and p value is .704. This research study suggests that with such a range of vendors, this does impact on decision-makers regarding adoption. In a study by Kepes (2010), the author points out that to ease the decision-making process, issues relating to cost, productivity and privacy need to be clearly outlined to potential consumers. A variety of vendors is vital to ensure the best quality IT and maximum potential service value. The factors highlighted herein might aid both vendors and consumers in their search for new cloud services to both offer and utilize.

5.3. Structural complexity of technology

This section includes a discussion on data processing capability, technology interoperability, and IT architecture revisions. Each of these factors is discussed next.

Data processing capability: The research conceptual framework indicated that there is a very significant and positive relationship between data processing and complexity of cloud computing adoption. As shown in Table 3 the standardized coefficient was 0.133 with t-value is 4.918, R^2 is 0.519 and p value is < 0.05 level .031*. In the context of cloud computing, data processing is related to the degree to which cloud is perceived as being easy to use and to process data from one system to another. As in other fields of computer systems, data processing is one of the critical factors in accepting the adoption of any new systems or advanced technologies (Paquette et al., 2010; Wang & Lo, 2016). CSPs have integrated parallel data processing frameworks into their services to help their customers to access cloud resources more effectively (Warneke & Kao, 2009), for example, a scalable streaming system for real time data processing tools (Neumeyer et al., 2010). Our research study findings are consistent with the previous literature. Based on the research findings, data processing would be no more complex in cloud than in-house IT.

Technology interoperability: The research conceptual framework established that there is a significant and positive relationship between the variety of technology platforms and the complexity of cloud computing adoption. As shown in Table 3 the standardized coefficient was 0.256 with t-value is 2.723, R^2 is 0.670 and p value is < 0.01 level .008**. According to previous studies, some researchers have generalized that complexity in having a variety of technology platforms is an issue for organizations when adopting new technology such as cloud computing (Rogers, 1983; Thong, 1999), while other studies indicate that there is actually no concern regarding complexity in having a variety of technology platforms (Seyal & Rahman, 2003; Kendall et al., 2001). According to our research findings, cloud computing is less complex to adopt as compared to other types of technologies, even though they are highly interoperable.

IT architecture revisions: Changes in IT architecture and the complexity of cloud computing adoption did not reveal any specific relationship within this study. As shown in Table 3 the standardized coefficient was 0.059 with t-value is 0.250, R^2 is 0.462 and p value is .612. The core stack in IT architecture consists of resource, platform, and application—with the platform layer posing the most challenges (Shawish & Salama, 2014). For this reason, it is broken down into sub-layers whereby technological structures manage smaller components, processes, and timing. A storage sub-layer would deal with caches and levels of data. These are aspects that local administrations need to consider when commencing cloud computing, although this poses fewer challenges than existing IT.

5.4. Dynamic complexity of technology

This section includes a discussion on system integration, IT infrastructure update, and customization resources. Each of these factors is discussed in turn.

Systems integration: The findings showed a positive link between integration and cloud computing adoption, which is consistent with previous studies (Daylami et al., 2005; Yildiz, 2007; Layne & Lee, 2001). As shown in Table 3 the standardized coefficient was 0.274 with t-value is

2.911, R^2 is 0.754 and p value is < 0.01 level .005**. Based on the research findings, local governments would benefit from focussing on integration factors to decrease the complexity level of cloud computing adoption. This attention might involve the IT manager and senior IT staff engaging in conversations with local government bodies, networking with other councils, engaging external consultants or attending relevant conferences to become informed and educated about the integration between their present systems and cloud computing technology.

IT infrastructure updates: Changes in IT infrastructure and the complexity in adopting cloud computing were found to have a pertinent relationship. As shown in Table 3, the standardized coefficient was 0.104 with t-value is 2.502, R^2 is 0.762 and p value is < 0.01 level .003**. Prior studies have indicated how decreased IT infrastructure is an advantage in cloud computing, which leads to a greater adoption rate (Subashini & Kavitha, 2011; Nicho & Hendy, 2013). This study concurs with previous literature and suggests that local governments change existing technology to an Internet service. This would enable consumers to access data regardless of location or time, thus making the process less complex than the current investment-based infrastructures.

Customization resources: The research conceptual framework demonstrate a significant and positive relationship between the customization resources and the complexity of cloud computing adoption. As shown in Table 3 the standardized coefficient was 0.587 with t-value is 2.680, R^2 is 0.706 and p value is < 0.01 level .007**. This finding is similar to previous studies that have reported that the majority of customization resources for cloud services are provided by vendors, but operated by the organization to set up the functions and the features that they need in the cloud. In a highly competitive market, the main vendors are constantly seeking to provide contemporary and enhanced solutions for organizations (Tilley & Rosenblatt, 2016). It is suggested that cloud computing adoption strongly relies on the role of the IT staff within local government and that they need to become the innovation 'champions' for cloud computing in their local government organization. As part of championing the innovation, the IT staff will need to outline the functions and the features of the cloud services.

Some researchers such as Hong and Kim (2002) argue that successful operations rely on accepting up-to-date IT and the changing world of technology. By accepting this, companies also respond and become aware of the implementation processes. Cloud computing can lead to decreased IT complexity through shared functions which are understood by all users (Bhattacharya, 2011). In research conducted by Borgman et al. (2013), cloud computing grows in its entirety and it does not pose any more challenges than the existing IT that already does. Nonetheless, complexity due to innovative features is a factor that influences adoption of cloud computing in the local government sector.

6. Implications for theory and practice

We concur with the premises of the research by Xia & Lee (2005) that IS project complexity will continue to increase despite the relative advantages of the new technology, that is, cloud computing in this research. Limited cloud computing adoption, despite its anticipated benefits and attractiveness, highlights the need to further investigate the factors associated with complexity in using cloud computing. This research paper extends the growing literature on cloud computing by presenting the complexity dimension in decision-making regarding the adoption of cloud computing. This research study found ten empirically-validated factors that contribute towards fully understanding the complexity of cloud computing adoption. The factors were encapsulated within the IS project complexity framework by Xia and Lee (2005) that provided an opportunity to measure IS complexity on organizational and technological aspects driven by structural and dynamic composition of the IS—which is cloud computing in this case.

6.1. Implications for theory

Regarding structural complexity of organizations, Xia and Lee (2005) originally presented three measurement items: cross-functionality; involvement of vendors; and coordination of users. Our research consolidated this view from a knowledge management perspective using cloud as an enabler for knowledge transfer (Goles & Chin, 2005). Likewise, in terms of structural IT, the technology features of real-time data processing, multiple software and technology platforms and systems integration were proposed in the original theory (Xia & Lee, 2005). While data processing and technology interoperability features were retained in our study, our study did not find multiple software environments as a key complexity issue since cloud computing provides the underpinning technology to support different software environments. More importantly, we moved systems integration from a structural complexity component to a dynamic component since recent studies on system integration emphasize its role on not just technical collaboration, but also collaboration across different domains—including architecture and engineering (Shen et al., 2010). This move recognizes the importance of measuring cloud computing complexity on a broader perspective than just technology collaboration. Likewise, revisions in IT architecture shifted from a dynamic IT complexity to structural IT complexity issue in our study. This is because the major complexity associated with IT architecture is now outsourced to the CSP and only the cloud services are interfaced by the organization that adopts cloud computing (Dikaiakos et al., 2009). Therefore, with cloud computing, the complexity of revisions in IT architecture is one of the risks that are transferred to the CSP, thereby providing a level playing field for any organization to have a stable IT architecture and to concentrate on their core business operations.

Likewise, the original theory proposed measurement items for dynamic complexity of the organization in terms of variations in the organizational structure as well as business processes before and after the technology project, as well as changes in users' information needs. Our research encapsulated all these change factors into a single general item of 'change management' that reflects the organization-wide nature of change impacted by cloud computing that enables disruptive innovations (Sultan, 2013). The business process management principles extend business operations enabled by IT to five other organizational aspects, namely strategic alignment, governance, methods, people and culture (Rosemann & vom Brocke, 2015; Janssen & Estevez, 2013). Recognizing the role of cloud computing in business process management, we included the factor of 'business operations' to measure the complexity of cloud computing given the dynamic nature of organizations. We also considered 'vendor multiplicity' as a dynamic complexity of an organization to measure complexity of cloud computing adoption. This aspect was originally considered as a measurement item for structural complexity of an organization by Xia and Lee

(2005). However, typical cloud service level agreements are arranged across organizational boundaries with multiple stakeholders (e.g. Internet service provider, document services, storage services, enterprise systems, etc.) on the cloud. Therefore, we believe these attributes fit into the dynamic complexity of organizations in terms of cloud computing. Finally, in terms of dynamic complexity of IT, we retained the measurement item of IT infrastructure updates since this impacts cloud computing services, even though it may be managed by the CSPs and beyond the direct control of organizations themselves. We changed the measurement item of 'software development tools' as required in IS development projects in the original study into what we refer to as 'customization resources', which is a collection of tools that CSPs offer to organizations in order to manage and monitor their cloud services. The results show these resources have a very critical impact on cloud computing complexity.

Using the IS complexity framework espoused by Xia and Lee (2005) as a starting point, this research has operationalized the framework by developing a model for cloud computing complexity assessment. Furthermore, the assessment model offers an empirically-validated instrument to investigate complexity associated with any new technology from an organizational perspective. In this way, our findings extend the application of the IS complexity dimension from the original IS development context to IS adoption in terms of cloud computing. The cloud complexity assessment framework is expected to assist researchers to use the provided assessment items to generate and/or test theories that explain the cause and impact of cloud computing complexity. Since we grounded our complexity assessment model on the IS complexity framework, we believe that the assessment results can be generalized or applied across other studies on IS complexity, such as large data complexity assessment or cyber security adoption complexity assessment within an organization.

6.2. Implications for practice

The results of our research study have practical implications for IT and senior managers. While the role of assessment of cloud complexity is widely recognized, organizations lack strategies to undertake such assessments. Using structural and dynamic complexities across technology and organizational aspects, this research provides an empirically-validated cloud computing complexity assessment model to better understand and communicate cloud adoption decisions in terms of complexity. By using this assessment model, it will enable IT managers to clearly select the specific factors of cloud complexity that are relevant to their business contexts very early in their cloud adoption decision-making process. Without this type of assessment model, it would be very arduous for IT managers to identify priorities for cloud computing adoption. Previous researches have confirmed the role of complexity in making adoption decisions on cloud computing (Opara-Martins et al., 2016). Hence, accurately assessing cloud computing complexity would allow organizations to make effective use of the cloud services being offered.

This research offers important guidelines for managers to aid them in the provision of cloud services based on impartial and correct assessment of their cloud computing requirements. The current state of cloud computing models is such that challenges with adoption cannot always be understood clearly by users. Using the cloud computing complexity assessment model, employees would be able to interpret the disparate complexity issues so as to manage any potential and existing problems in adopting cloud computing. Moreover, using the complexity assessment model would provide an organization with an evidence base of their cloud decisions to learn from their experiences; and provide an excellent resource for knowledge transfer while managing cloud complexity issues from different CSPs. These assessments can potentially be used to compare several CSPs to ascertain best value for services. The assessments also help to identify specific complexity areas, thus allowing IT managers to review the most important complexity aspects during cloud adoption. By considering such factors and assessment as outlined in this research study, organizations are expected to be better equipped to manage cloud-computing complexity.

7. Limitations and future studies

This research, akin to other similar studies, have important limitations to be highlighted. We identify three salient limitations: The first limitation is related to the geographical scope: this research study is based on regional local governments in the state of Queensland, although the findings could be generalized to Australia based on the government structure. The second limitation of this research study is related to the definition of complexity or cloud computing complexity, which may be considered to be very narrow. Future research directions could extend this research study by exploring additional critical factors that might assist in determining the complexity of cloud computing adoption from domains beyond organization and technology aspects (such as policy and external environments). Finally, another future work would involve applying this research proposed framework to other countries and to different technologies or adoption into different industry settings.

8. Conclusion

Cloud computing offers improved productivity, enhanced services, decreased potential IT issues and lower costs. It is expected that cloud computing adoption will continue to grow and also adapt to organizational demands and suggestions. It is also expected that adoption complexity will be present continued challenges as the adoption of cloud computing becomes more widespread. This research paper aimed to investigate the major critical factors in determining the complexity of cloud computing adoption in the context of local governments. Factors found to have a statistically significant and positive result relating to the complexity of cloud computing adoption in Australian regional local governments were: business operations; knowledge management; data processing capability; technology interoperability; systems integration; IT infrastructure updates; and customization resources. Using the introduced framework, managers and decision-makers can outline the relevant aspects of complexity that they must consider during the various stages of cloud computing adoption.

The findings of this research indicate that complexity is a key aspect in the decision to adopt cloud computing within organizations. Surprisingly, a low level of complexity will lead to a positive and significant impact on adopting cloud computing and other advanced technologies. The results highlighted by this research study can further inform future research in cloud computing adoption, as well as provide guidelines for the design and implementation of IS projects in cloud computing.

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