2016

# Technical and Environmental Factors Affecting Cloud Computing Adoption in the South African Public Sector

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## *Abstract*
Cloud computing can bring many benefits to organisations and countries. However there are technical and environmental factors that could hinder the adoption of these technologies in developing countries. The purpose of this paper is to explore the extent of these factors in the public sector in developing countries such as South Africa. A detailed literature review revealed several factors to cloud computing adoption and these were empirically validated using a survey approach. Fifty one respondents from forty public sector organisations in South Africa completed the survey. The findings revealed that the majority of the respondents showed concern regarding the availability and privacy of data. The environmental factors that were of the most importance to respondents were adoption strategies of cloud computing implementations as well as the provision of usage guidelines and regulatory requirements in organisations.

## *Keywords*
Cloud Computing, Adoption, Environmental Factors, and Technical Factors.

## 1. Introduction
Cloud computing has redefined the computing paradigm by providing dynamically scalable resources on demand over the internet (Foster, Zhao, Raicu & Lu 2008). These resources are a combination of Service Oriented Architecture and virtualisation techniques (Papazoglou 2003). Cloud computing allows organisations to focus on their core business activities since they do not have to worry about maintaining their Information Technology (IT) and other infrastructure (Berman, Kesterson-Townes, Marshall & Srivathsa 2012; Garrison, Kim & Wakefield 2012). The removal of infrastructure requirements changes the competitive landscape and allows companies that have innovative ideas but no capital to invest, to deploy their software and succeed (Berman et al., 2012). Jangra and Bala (2011) argue that cloud computing is an enabler for many different services due to its dynamic scaling capability, pay-per-use business model and the various other business models available. These software deployment models include Infrastructure as a Service (IaaS), Software as a Service (SaaS), and Platform as a Service (PaaS). Cloud computing is scalable with business agility and results in less capital expenditure (Jangra & Bala 2011). However, Feuerlicht and Margaris (2012), in their comparative study about cloud adoption in Australia and Czechoslovakia, reported that the primary reason for cloud adoption is the improved support for business processes rather than cost savings.

Marston, Li, Bandyopadhyay, Zhang and Ghalsasi (2011) claim that cloud computing is a disruptive way in which public sector enterprises can consume data, communicate, deploy and deliver services to their constituents. Governments are eager to adopt cloud computing; however, a survey in 2012 found that only 12% of the respondents had spent more than 10% of the total IT resources on cloud services (Sahu & Tiwari 2012). According to a 2015 survey report, 93% of the respondents are using cloud computing out of which only 11% is from the public sector (Weins 2015). Australia ranked second amongst the countries that support the growth of cloud computing (Business Software Alliance 2012; Feuerlicht & Margaris 2012). This is confirmed by the Busch et al. (2014) survey in Australia which reported a high interest in cloud computing in that country; however it was found to be still a new and emerging concept in the Australian public sector. A study in the United States reported that cloud computing has been adopted to some extent in several government divisions such as the National Aeronautics and Space Administration, the Census Bureau and the White House (Phillips 2015).

Sultan (2011) argues that the developing world is not yet taking full advantage of cloud computing adoption to catch up with the developed world. In a more recent study, Adam and Musah (2015) also argue that the situation in the developed world is better than the developing world as far as the adoption of cloud computing by small and medium enterprises is concerned. This is in spite of the fact that in Africa, India, China, and Taiwan innovations brought by cloud computing initiatives are the leading reasons for economical and societal changes (Chang et al. 2012; Kshetri 2012, 2013; Lee & Yen 2012; Lian, Yen & Wang 2014). Cloud adoption provides developing countries with an equal opportunity with respect to applications, IT infrastructure and data centres so that they can compete with developed countries (Kshetri 2010). The scenario in South Africa, according to Schofield and Abrahams (2015) is that the adoption of cloud computing is extensive at the informational level. Departments such as primary education, health, science and technology, and government, which share information with the public, have shown interest in adopting cloud computing for their own needs (Kshetri 2010). However, there is still a need for further improvements in the area of e-education, e-health, and sharing business processes across governmental departments, which require extensive data sharing. There is a gap in cloud computing research in Africa and specifically in South Africa. In particular, there is a lack of research on the level of cloud computing adoption in the public sector in South Africa. There are also no existing comprehensive studies that focus on the environmental factors of the public sector in South Africa to adopt cloud computing. However, developing countries like South Africa may have additional challenges such as electric grid outages (Cruz, 2012) and internet connection speed problems (Leavitt 2009; Schofield & Abrahams 2015; Xi & Mitrovic 2014) amongst others. All the existing reviewed research on public sector technology adoption in South Africa has been limited to interview based qualitative studies on a few public sector organisations within specific provincial regions.

The purpose of this paper is to investigate the technical and environmental factors influencing organisations in the public sector for adopting cloud computing. The structure of this paper is as follows: Section 2 describes the background to cloud computing and the research problem addressed in this paper. Section 3 describes the factors that may hinder the adoption of cloud computing by organisations. The research methodology is shown in Section 4 and Section 5 is

concerned with the results from the study undertaken. The paper is then concluded and recommendations are made for future work.

## 2. Background to Cloud Computing

Cloud computing is the large-scale provision of services as a utility, using remote servers and shared resources to store and process data rather than local servers so as to obviate the necessity of owning and maintaining the computing infrastructure (Cai et al. 2009). Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell & Grance 2011). Enterprise systems such as Enterprise Resource Planning (ERP) systems and Customer Relationship Management (CRM) systems are now also offering models where they can be hosted onsite or offsite using servers in the cloud (Grubisic 2014). These are known as cloud ERP and cloud CRM respectively. In these models, the end user is required to pay for the right to use the software as with SaaS and the host servers need not be stored physically at the end user's premises and this is referred to as cloud ERP.

A survey of 38 countries worldwide reported that cloud computing is gaining increasing momentum (North Bridge 2015). However the public sector at 45% adoption is still lagging behind the private sector at 48%. Schofield and Abrahams (2015) proposed several factors that can affect cloud adoption in the public sector in South Africa, as well as the enablers, benefits and risks of adoption. The study reports that the current cloud adoption in South Africa is mostly from an information perspective and not from an IT standpoint. This situation can change once there is clarity of purpose, all regulations have been framed and a central authority is tasked with creating a private government cloud. It is true that, due to a lack of alternatives, some of the departments have been utilising commercial private or public cloud services currently; however if the South African government wants cloud computing adoption to increase, it should create a private cloud platform. This platform will help integrate all the various departments' efforts and utilisation of data by all departments and will reduce duplication of efforts. Building on country-internal cloud facilities is fraught with risks such as capacity constraints and bureaucratic decision-making processes resulting in loss of agility to scale on demand and access to government data. Schofield and Abrahams (2015) argue that there has been no work done yet to achieve this readiness. The individual departments are not working on formulating a strategy to address the risks, nor are there any overarching guidelines being produced.

Mvelase, Dlamini, Macleod, Dlodlo and Sithole (2014) propose a cloud model, which can be used by the South African government and is based on different models and implementations worldwide. Gupta (2015) hypothesises that the lack of development with regards to cloud computing in Africa is a blessing in disguise since it means the country can directly advance to Industry 4.0 which encompasses cloud computing, as it has no legacy applications to hold it back.

## 3. Factors Affecting Cloud Computing Adoption

Technical factors affecting the adoption of cloud computing include the availability and privacy of data since cloud infrastructure could reside in a different area when related to the area where the data is produced which could mean that the data production, storage and consumption could

all be in different jurisdictions (Reed 2010). Questions arise as to who owns the data, how to enforce intellectual property rights, how to maintain confidentiality, integrity and availability of data and who is responsible if there is a failure to do so. Legal rights pertaining to contractual obligations are also difficult to resolve.

Xi and Mitrovic (2014) identified three groups of readiness indicators, which can also be viewed as factors in adopting cloud computing. These three groups are infrastructure, environmental and organisational. The Xi and Mitrovic (2014) study however focused on non-technological factors. This study focuses on the technical and environmental factors that influence cloud computing adoption and therefore the organisational factors are not included in the proposed framework. The environmental factors proposed by Xi and Mitrovic (2014) can be extended since cloud computing can address two areas of sustainability, namely energy and resource efficiency by utilising technologies such as the virtualisation of resources and workload consideration (Priya Pilli & Joshi 2013). The sustainability of a cloud data centre involves both its energy consumption as well as its carbon footprint. Garg, Yeo and Buyya (2011) therefore argue that cloud computing is not environmentally sustainable since the release of $CO_2$ emissions would only increase if economical energy, such as coal, is used to power cloud data centres.

A framework of factors, which are either technical or environmental, that can affect the adoption of cloud computing identified in literature, is therefore proposed (Table 1). One of these factors is the lack of reliable electricity supply since the electric grid is lacking in capacity as well as reliability resulting in companies wary of building data centres in South Africa (Abrahams et al. 2015; Cruz, 2012; Wyld 2010). On the other hand, these electric grid outages are an opportunity for companies to pursue the cloud computing route, especially for delivering services through mobile applications, as there are five times as many mobile users as there are internet users. This has spurred the success of mobile applications such as M-Pesa, which has very high usage statistics. The mobile internet bandwidth is not a problem for deploying as it is easier and since mobile phones can be recharged through generator or solar cells, it is not necessary for them to be always connected to a power outlet (Cruz 2012). Cruz (2012) proposes that this is where Africa can excel in the use of cloud computing. While it is true that mobile applications may have better chance of success in Africa, not everything can be done with a mobile application and organisations need scalable resources available at a low cost to compete. The Abrahams et al. (2015) study identified several environmental factors as preventative to the rapid adoption of technology. Critical to the efficient usage of cloud computing is the requirement for a strong and reliable internet connection and without it cloud services are inaccessible to the user. The connection speed is also critical to enabling smooth usage of certain services. A slow connection can lead to frustrated users and reduced satisfaction of customers (Leavitt 2009; Miller 2008). The financial outlay for improving bandwidth and broadband speed can offset the financial benefits of cloud computing and is a factor in cloud computing adoption (Leavitt 2009; Schofield & Abrahams 2015; Xi & Mitrovic 2014).

# 4. Methodology

The primary research question of the study is *"What are the technical and environmental factors faced by the South African public sector in adopting cloud computing?"*. This study employs an exploratory research design. The study will allow for insight into the adoption of cloud computing by the South African public sector. A theoretical framework of the factors to cloud

computing is derived as a result of the literature review. The framework is then empirically validated through means of a survey research strategy (Saunders & Goulding 2005). An online questionnaire was used in the survey and was based on the theoretical framework of factors. The study took place across the South African public sector and included all government, local, provincial and national departments and agencies. The research endeavoured to attain a minimum target of 50 respondents comprising of government CIO, government senior IT management and IT decision makers.

| | Factor | Reference |
|---|---|---|
| TECHNICAL | The availability of data | Tweneboah-Koduah, Endicott-Popovsky and Tsetse (2014) |
| | The privacy of data | Abrahams, Ophoff and Mwalemba (2015) |
| | Lack of control of data | Garfinkel and Abelson (1999) |
| | Multitenancy (different organisations' data hosted on the same server) | Assyne and Riungu-Kalliosaari (2014) |
| | Cyber attacks | Chou (2010) |
| | System performance | Tian and Zhao (2015) |
| | Difficulty to integrate with in-house system | Xi and Mitrovic (2014) |
| | Not enough ability to customise | Xi and Mitrovic (2014) |
| | Difficult to bring back in-house | Reed (2010) |
| | Lack of support from vendors | Leavitt (2009) |
| | Lack of compatibility with proprietary software | Goldsmith (2015) |
| | Poor IT infrastructure currently in place | Tian and Zhao (2015) |
| ENVIRONMENTAL | Lack of approved cloud standards | Schofield and Abrahams (2015) |
| | No national cloud computing policy in place | Schofield and Abrahams (2015) |
| | No national, local, departmental or agency cloud adoption strategy or guidelines in place | Schofield and Abrahams (2015) |
| | Regulatory requirements | Xi and Mitrovic (2014) |
| | Trans-border information flow | Gunasekara (2007) |
| | Lack of specialist public sector local vendors | Schofield and Abrahams (2015) |
| | Electricity availability | Abrahams et al. 2015;, Leavitt (2009); Miller (2008) |
| | Broadband connectivity | Leavitt (2009); Miller (2008) |
| | Sustainability and carbon efficiency | Xi and Mitrovic (2014) |

**Table 1:** Framework of Technical and Environmental Factors for Cloud Computing Adoption

# 5. Results

## 5.1 Demographic and Organisational Information

Fifty one completed questionnaires were received and analysed from all nine South African provinces (Table 2), with the majority of responses coming from Gauteng (41%) followed by KwaZulu-Natal (18%). Less than a third (31%) of the respondents was female, while 69% were male (Table 3). All respondents had some form of formal tertiary educational qualification, with nearly a third (31%) having Masters degrees and 8% with PhDs. The respondents were given an option to reveal the public sector department or agency they were employed at. Of the 51 completed responses, 40 identified their organisation (Table 4). Of these 21 were South African local municipalities and 19 were South African national departments.

| Province | n | % |
|---|---|---|
| Gauteng | 21 | 41 |
| KwaZulu Natal | 9 | 17 |
| Western Cape | 6 | 12 |
| Mpumalanga | 4 | 8 |
| Limpopo | 3 | 6 |
| Eastern Cape | 2 | 4 |
| Free State | 2 | 4 |
| Northern Cape | 2 | 4 |
| North West | 2 | 4 |
| **Total** | **51** | **100** |

**Table 2:** Regional Distribution of Respondents

| Gender | n | % |
|---|---|---|
| Male | 34 | 66.67 |
| Female | 15 | 29.41 |
| Unspecified | 2 | 3.92 |
| **Total** | **51** | **100.00** |
| **Education** | **n** | **%** |
| Diploma | 8 | 16 |
| Undergraduate degree | 9 | 18 |
| Honours | 14 | 27 |
| Masters | 16 | 31 |
| PhD | 4 | 8 |
| **Total** | **51** | **100** |

**Table 3:** Demographic Profile of Respondents (n = 51)

| Department/municipality | n |
|---|---|
| Ekurhuleni Metropolitan Municipality | 1 |
| Merafong City Local Municipality | 1 |
| Department of Social Development | 1 |
| eThekwini Metropolitan Municipality | 1 |
| Lesedi Local Municipality | 1 |
| Msunduzi Local Municipality | 1 |
| Abaqulusi Local Municipality | 1 |
| Agriculture, Forestry and Fisheries | 1 |
| Arts and Culture | 1 |
| Basic Education | 1 |
| City of Cape Town Metropolitan Municipality | 2 |
| City of Tshwane Metropolitan Municipality | 1 |
| Department of Science and Technology | 1 |
| Department of Water Affairs | 1 |
| Energy / Power Generation | 1 |
| eThekwini Metropolitan Municipality | 1 |
| Finance | 1 |
| Frances Baard District Municipality | 1 |
| Gert Sibande District Municipality | 1 |
| Home Affairs | 1 |
| Human Settlements | 2 |
| Information Technology | 1 |
| Kynsna local municipality | 1 |
| Labour | 1 |
| Lejweleputswa District Municipality | 1 |
| Midvaal Local Municipality | 1 |
| Mkhambathini Local Municipality | 1 |
| National Research Foundation of South Africa | 1 |
| Provincial Legislature | 1 |
| Sedibeng District Municipality | 1 |
| Sisonke District Municipality | 1 |
| Statistics South Africa | 1 |
| Umdoni Local Municipality | 1 |
| uMhlathuze Local Municipality | 1 |

| | |
|---|---|
| Water and Sanitation | 1 |
| West Rand District Municipality | 2 |
| Women | 1 |
| **Total** | **40** |

**Table 4:** Departments and Municipalities that responded

The respondents' management status ranged from middle management to senior management to executive management (Figure 1). None of the respondents was junior or senior. All respondents who were in the middle management group were also employed in their organisation from one to four years in total. The majority of respondents in senior management (57%) were in their organisation for five to ten years and the majority of respondents in executive management (67%) were in their organisation for over 10 years.

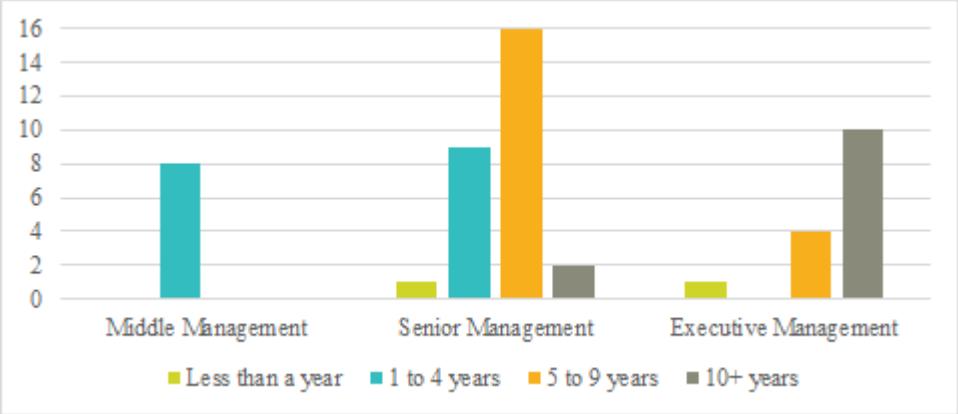



**Figure 1:** Company Status vs Tenure

## 5.2 Adoption of Cloud Computing

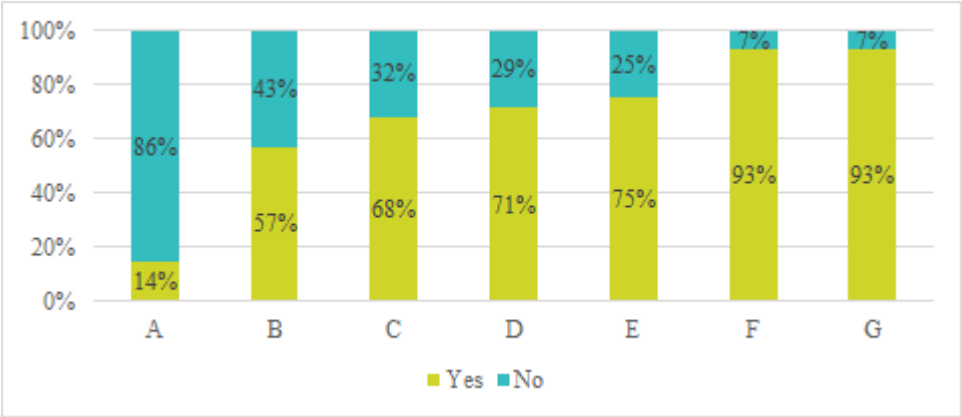
Whilst 47% of respondents agreed that their organisations are willing to adopt new technology to save money, 41% of respondents disagreed that their organisations prefer to cut back on new technology to save money and 43% of the respondents considered their organisations as early adopters of new technology. Of the organisations surveyed, 54% (n = 27) uses some form of cloud computing compared to 46% (n = 23) who do not. However, a one sampled t test of these two groups show that the t-statistic was not significant at the 0.5 critical alpha level, T (51) = 0.573, p = 0.569. In the organisations using cloud computing, the extent of use of certain major cloud technologies and models were measured (Table 5). IaaS and PaaS appear to be the most extensively used cloud computing models amongst respondents ($\mu$ = 3.82). SaaS was the next most utilised technology, followed by cloud analytics and human resources modules in the cloud. CRM in the cloud was the second least utilised technology ($\mu$ = 2.43) and cloud ERP systems are the least utilised ($\mu$ = 1.89).

The questionnaire also measured the respondents' activities and intentions towards adopting cloud computing (Figure 2). 40% of the respondents rely solely on cloud computing for their systems' activities, 93% utilised a combination of cloud computing and internally owned IT systems. Of the respondent organisations, 71% is currently assessing the cloud, while 75% is currently developing a cloud strategy. Finally 57% of respondents stated that their organisations

are testing a proof of concept, 68% are currently implementing and 93% plans to increase their use of cloud computing.

| Technology | Minimum | Maximum | Median | Mean | Standard Deviation |
|---|---|---|---|---|---|
| IaaS –Infrastructure as a Service | 1.00 | 5.00 | 4.00 | 3.82 | 0.80 |
| PaaS – Platform as a Service | 1.00 | 5.00 | 4.00 | 3.82 | 0.80 |
| SaaS – Software as a Service | 2.00 | 5.00 | 4.00 | 3.39 | 0.82 |
| Cloud Analytics – On demand Business Intelligence solutions | 1.00 | 5.00 | 3.00 | 3.39 | 0.94 |
| Cloud HRM – Human Resource Management | 1.00 | 5.00 | 3.00 | 2.86 | 0.99 |
| Cloud CRM | 1.00 | 5.00 | 2.00 | 2.43 | 1.02 |

**Table 5:** Utilisation of Cloud Computing Technologies (n = 51)




A – Rely solely on cloud computing technologies for their ICT needs
B – Testing a proof of concept
C – Currently implementing
D – Currently assessing the cloud
E – Developing a cloud strategy
F – Utilise a combination of cloud computing and internally owned IT systems
G – Plans to increase your use of cloud

**Figure 2:** Move towards Cloud Adoption Activities (n = 51)

Of the companies that have not adopted any cloud computing, 70% say that their company trust their internal IT systems over cloud based technologies (Figure 3). For the statement "It's too soon to adopt cloud computing", the largest percentage (36%) of responses were neutral. The majority (78%) agree and strongly agree that cloud computing is a viable technology option.

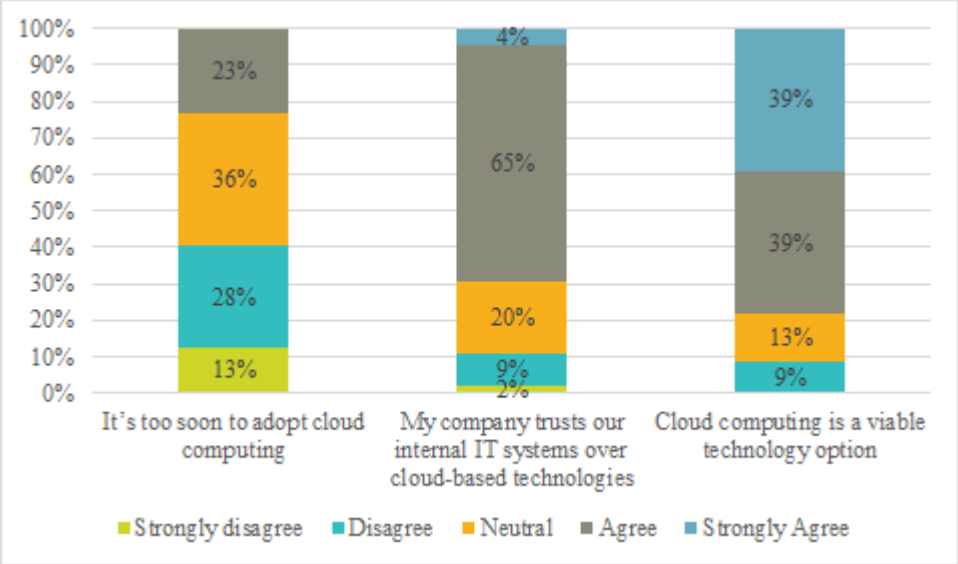



**Figure 3:** Cloud Computing Intention (n = 51)

To establish a timeline to cloud adoption for those organisations surveyed who don't have any form of cloud computing, they were asked when they plan to integrate some form of cloud computing. The majority of the respondents (43%) said that they planned to do so in the next 12 to 24 months. On the other hand, 30% said they planned to do so in the next 24 to 36 months, whilst 15% said in the next 12 months. Less than one tenth (6%) of respondents stated that they planned to integrate cloud computing in the next 36 to 49 months, 4% planned to do so in the next 48 to 60 months and only 2% claimed that they will not implement cloud computing at all.

To further derive detail regarding actual and planned cloud computing adoption environments/models all respondents were asked which specific cloud computing environment they have adopted or would consider adopting in future (Figure 4). The cloud computing environments included private cloud, public cloud, hybrid cloud and community cloud. Over a third (35%) of respondents said that they already use a private cloud, 51% confirmed that they will adopt a private cloud in the next year, 14% claimed that they would not adopt technology in the next year. A total of 22% of respondents already have public clouds in place, with 37% saying they will adopt public clouds in the next year and 41% will not adopt in the next year. Of all the respondents, 20% already have a hybrid cloud in place, 41% say they will in the next year and 39% stated they would not in the next year. Of all the respondents, 14% already have a community cloud in place with 33% adopting in the next year and 53% stated that they would not in the next year.

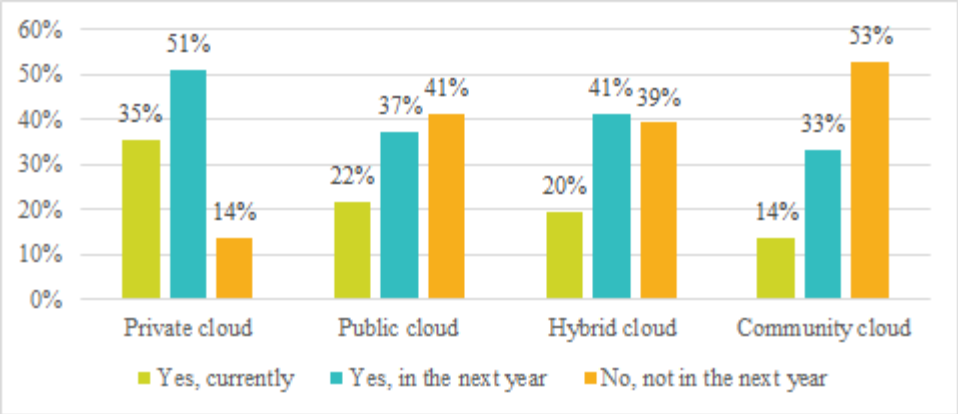



**Figure 4:** Short Term Adoption of Different Cloud Environments (n = 51)

## 5.3 Factors to Cloud Adoption

### *5.3.1 Technical factors*

Respondents were asked, on behalf of their organisation, to assess the importance of technical concerns to their organisations' current technological landscape. Being strong or having ample resources in a particular area meant that aspect was a low concern (not important) whereas having weakness or little recourse in an area meant high concern (very important). A scale of 1 to 4 was used with 1 meaning not important and 4 meaning very important. The 12 technical factors all scored a mean of above 3 reflecting that in general all respondents have a high concern for technical factors (Table 6). The highest rated technical barrier was "system performance" ($\mu$ = 3.29) and the second highest was "privacy of data" ($\mu$ = 3.27). The lowest rated barrier was "difficult to bring back in-house" ($\mu$ = 2.92).

| Barrier | Minimum | Maximum | Median | Mean | Standard Deviation |
|---|---|---|---|---|---|
| The availability of data | 2.00 | 4.00 | 3.00 | 3.20 | 0.59 |
| The privacy of data | 2.00 | 4.00 | 3.00 | 3.27 | 0.77 |
| Lack of control of data | 1.00 | 4.00 | 3.00 | 3.14 | 0.77 |
| Multitenancy | 1.00 | 4.00 | 3.00 | 3.10 | 0.77 |
| Cyber attacks | 2.00 | 4.00 | 3.00 | 3.06 | 0.73 |
| System performance | 1.00 | 4.00 | 3.00 | 3.29 | 0.75 |
| Difficulty to integrate with in-house system | 1.00 | 4.00 | 3.00 | 2.98 | 0.83 |
| Not enough ability to customise | 1.00 | 4.00 | 3.00 | 3.16 | 0.75 |
| Difficult to bring back in-house | 1.00 | 4.00 | 3.00 | 2.92 | 0.79 |
| Lack of support from vendors | 1.00 | 4.00 | 3.00 | 2.96 | 0.79 |
| Lack of compatibility with proprietary software | 1.00 | 4.00 | 3.00 | 3.04 | 0.82 |
| Poor IT infrastructure currently in place | 1.00 | 4.00 | 3.00 | 3.04 | 0.84 |

**Table 6:** Technical Factors to Cloud Adoption (n = 51)

Of all the respondents, 90% expressed that the availability of data is either important or very important to their organisation. The privacy of data was a concern to 90% of respondents as it was rated important or very important. Of all the respondents, 84% of respondents indicated that the lack of control of data is either an important or very important concern to their organisations. Multitenancy was an important factor for 78% of respondents. More than three quarters of respondents (76%) acknowledge cyber-attacks as an important to very important concern. System performance is a major concern as indicated by 86% of respondent who rate it as either

important or very important. Also, 76% of respondents noted that *"integration difficulties of cloud systems with in-house systems"* is an important/very important concern. Lack of support from vendors proves to be a concern as indicated by 79% of respondents who rated this as either an important or a very important concern. 78% of respondents voiced concern over the current poor IT infrastructure in place, rating it as either an important or very important technical barrier to the adoption of cloud computing.

### *5.3.2 Environmental factors*

Environmental factors indicate how the business environmental factors can hinder the adoption of cloud computing by the South African public sector. Nine environmental factors were tested on a five-point scale with 1 being extremely unimportant and 5 extremely important (Table 7). The overall mean for all nine factors was 3.84 and the average median was 4 with an average standard deviation of 0.86, which indicates that on average that the identified environmental factors are of important concern to the respondents' organisations.

| | Minimum | Maximum | Median | Mean | Standard Deviation |
|---|---|---|---|---|---|
| Lack of approved cloud standards | 2.00 | 5.00 | 4.00 | 3.71 | 0.75 |
| No national cloud computing policy in place | 3.00 | 5.00 | 4.00 | 3.71 | 0.64 |
| No national, local, departmental or agency cloud adoption strategy or guidelines in place | 2.00 | 5.00 | 4.00 | 4.04 | 0.86 |
| Regulatory requirements | 2.00 | 5.00 | 4.00 | 4.08 | 0.79 |
| Trans-border information flow | 2.00 | 5.00 | 4.00 | 3.90 | 0.85 |
| Lack of specialist public sector local vendors | 2.00 | 5.00 | 4.00 | 3.80 | 0.86 |
| Electricity availability | 1.00 | 5.00 | 4.00 | 3.69 | 0.96 |
| Broadband connectivity | 1.00 | 5.00 | 4.00 | 3.86 | 1.03 |
| Sustainability and carbon efficiency | 1.00 | 5.00 | 4.00 | 3.76 | 1.04 |

**Table 7:** Environmental Factors to Cloud Computing (n = 51)

Of all the respondents, 65% stated that the lack of approved cloud standards is of important to extremely important concern. Of all the respondents, 61% of respondents believed that no national cloud computing policy in place was of important to extremely important concern. More than three quarters of respondents (76%) voiced concern over no national, local, departmental or agency, cloud adoption strategy, or cloud adoption guidelines currently being in place. Regulatory requirements were an issue of concern by 76% of respondents. Trans-border information flow was indicated as an important to extremely important concern by 70% of respondents. Of all the respondents, 63% of respondents indicated that there is a lack of local vendors who specialise in the public sector. Electricity availability and broadband connectivity was of concern to 67% and 68% of respondents respectively. Concern for sustainability and carbon efficiency was shown by 64% of respondents.

## 6. Conclusions and Future Research

The purpose of this paper was to investigate the technical and environmental factors involved in adopting cloud computing in the South African public sector. The literature review revealed the background of cloud computing and explored the factors involved in cloud computing adoption based on previous studies conducted. A synthesis of literature enabled a distinction to be made between the technical and environmental factors of adoption. These factors were used to propose a theoretical framework. An exploratory research study in the form of a survey was used to

gauge the adoption levels of government, local, provincial and national departments and agencies. The results of the survey validated the technical and environmental factors of cloud computing identified in the theoretical framework. The most prominent technical factors that were of importance to the respondents were the availability and the privacy of data. The environmental factors that were of the most importance to respondents were cloud adoption strategies and usage guidelines provided as well as regulatory requirements. The public sector should prioritise the way in which data is handled with cloud computing implementations and then also ensure that appropriate rules and guidelines are in place in order to regulate the usage of such a technology. The theoretical framework and the survey results provide a valuable contribution to the field of cloud computing. The main research question was answered by determining what the technical and environmental factors of cloud computing adoption are, specifically in the South African public sector. One limitation of the study is the relatively small sample size of 51 respondents. Alternative contexts of this study could be considered for future work, such as investigating cloud computing factors of adoption in universities or schools.

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