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Hybrid cloud approach to data platforms: A South African perspective

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Background: An effective data platform is essential for fostering data-driven organisations and enhancing decision-making. A review of the literature shows that cloud computing and modern data platforms, which include cloud-based data platforms are well investigated by researchers. However, based on the analysis of the literature, there is limited research focusing on the impact of cloud computing on data platforms with a focus on the perspective of developing countries such as South Africa.

Objectives: This research sought to unravel the contextual nuances of hybrid cloud deployments and unearth the factors with a significant influence on organisations operating in the financial services sector (FSS) and adopting hybrid data platforms (HDPs) as a contemporary paradigm for information management.

Method: This study adopted an exploratory sequential mixed method. This methodology employs two sequential phases of data collection and analysis where the results of one stage are used to achieve analysis of research results from two vantage points.

Results: The study found that security is a critical driver for the hybrid cloud. In addition, the study identified that the contextual nuances of hybrid cloud architecture significantly influence organisations in the FSS to implement HDPs.

Conclusion: The study concluded that the findings would make significant contributions by addressing challenges related to cloud computing and hybrid cloud in South Africa.

Contribution: The result of the study provided a foundation for further exploration of the design, deployment and implementation of the hybrid cloud and HDP solutions in the South African FSS and similar contexts in developing nations.

Keywords: hybrid data warehouse; financial services sector; South Africa; information management; cloud computing.

Introduction

Managing data across various applications, databases and diverse environments, including on-premises and cloud solutions, presents a significant challenge (Kerner 2020). The advent of cloud computing has led to a surge in organisations across South Africa transitioning their applications and data to the cloud. This transition has given rise to the need for effective strategies in managing hybrid cloud data platforms, such as hybrid data warehouse (HDW) platforms or what Gartner (2019) also refers to as logical data warehouse (DW) platforms. Merging heterogeneous data platforms, often from different vendors, into a unified information management system capable of handling data with multiple dimensions and scales poses considerable challenges for numerous organisations (Bauer et al. 2018). Particularly, medium- to large-scale organisations in developing world contexts grapple with establishing robust data handling and information management approaches and seek cost-effective, sustainable solutions. Achieving ideal data warehousing systems necessitates addressing the core issues that impede their widespread adoption.

A preliminary literature analysis highlights that while cloud computing offers many advantages, it also introduces new challenges. For instance, Barhate and Dhore (2018) noted that many organisations have numerous business applications that cannot be migrated to the cloud because of concerns such as security and privacy, necessitating integration and interoperability between on-premises and cloud-resident data. Even though data warehousing has been extensively researched, certain issues continue to hinder smooth implementation within organisations. The absence of global consensus on various aspects of data platforms can be partially attributed to the limited research on hybrid data platforms (HDPs) (Nambiar & Mundra 2022; Newman

2023). This gap in global knowledge is further exacerbated within the context of South Africa's financial services sector (FSS). Research conducted by Muriithi and Kotzé (2013) reveals that research into the architecture of HDPs remains in its infancy and constitutes one of the less explored domains in information systems (IS). This study considers HDW as an example of an HDP, using the two terms interchangeably.

This study endeavours to explore the contextual intricacies of the hybrid cloud, which influence information-intensive organisations in adopting HDPs. Given the pursuit of data accessibility at all times for sustainable competitiveness, many organisations operating in data- or information-intensive environments have adopted cloud computing solutions. For this study, the South African FSS has been selected as a case study. Employing a pragmatic philosophical stance, this research utilises an exploratory sequential mixed method study, incorporating case studies and survey research strategies. It leverages the technology-organisation-environment (TOE) framework and the DeLone and McLean information systems (D&M IS) success model as research lenses to investigate how the contextual nuances of hybrid cloud architecture contribute to, and impact modern data platforms. The study involves data collection from key stakeholders within companies, including data management department managers, cloud solution architects, data providers and consumers.

Background

According to Brutnell (2023), a data platform 'provides several key advantages for organisations, including data integration and consolidation, scalability and performance, enhanced data analytics and insights, improved collaboration and data sharing, and data security and compliance'. Organisations today thrive because of the investment made and continue to make on data and data platforms. Data are used to derive new insights, uncover hidden trends, enable new services such as artificial intelligence (AI), and improve company competitiveness.

However, because of rapid growth in data, and the increased demand for data by the business, organisations including those in FSS are faced with different data challenges. These challenges include ageing information technology (IT) and data platform infrastructure, security, cost optimisation and data platform optimisation. Therefore, the escalating demand for information in today's business landscape has rendered traditional data platforms incapable of meeting business requirements and alleviating these challenges. This inadequacy primarily stems from the inability to connect, analyse and manage the diverse data sources necessary to generate the required information (El-Seoud et al. 2017; Forrester 2017; Ji et al. 2012; Steer & Milburn 2017). An effective data platform is a crucial component in the business to drive organisations to being data-driven and to improve decision making by organisation leaders and managers. Consequently, organisations embark on a strategic journey to migrate business applications, including existing data platforms such as DWs, to cloud-based computing platforms. This shift is motivated by the pursuit of improved system performance, system availability, cost reduction and other factors.

A review of the literature shows that cloud computing and modern data platforms which include cloud-based data platforms are well investigated by researchers. However, based on the analysis of the literature, there is limited research focusing on the impact of cloud computing on data platforms with a focus on the perspective of developing countries such as South Africa. Many researchers such as Mudzamba, Van der Schyff and Karen Renaud (2022), Sithole and Ruhode (2021) and Mohlameane and Ruxwana (2020) have studied cloud focusing on cloud adoption impact on South African small, medium and micro enterprises (SMMEs). However, it is our view that understanding the impact of cloud computing on data platforms will assist organisations, big or small, to implement relevant strategies to enhance the quality of data platforms.

The increasing demand for information in today's business landscape has exceeded the capabilities of traditional data platforms, leading to challenges in connecting, analysing and managing diverse data sources (El-Seoud et al. 2017; Forrester 2017; Ji et al. 2012; Steer & Milburn 2017). Organisations are therefore migrating existing data platforms like DWs to cloud-based computing to enhance performance, availability and reduce costs, resulting in the adoption of hybrid data architectures (451 Research 2019; Russom 2019). However, research indicates a significant oversight in understanding the complexities of data management in hybrid cloud environments, particularly in South Africa, where cloud-based computing is relatively new. This research gap is notable in modern information architectures such as hybrid or multi-cloud architectures, especially concerning HDW platforms (Muriithi & Kotzé 2013).

Therefore, to close the research gap and to enrich the IS theory and knowledge, this research article aims to explore the contextual nuances of hybrid cloud architecture that influence organisations in the FSS to adopt HDPs as a contemporary information management paradigm using the exploratory sequential mixed methods research choice.

Therefore, it is asserted that this study's findings will make significant contributions by addressing challenges related to cloud computing and hybrid cloud. In particular, the study aims to bridge the research gaps in the information management domain by exploring the contextual nuances that affect HDPs in the FSS. To achieve the research aim, some of the research questions explored include identifying the drivers of the hybrid deployment model in the realm of cloud computing, exploring the contextual challenges and opportunities for hybrid cloud data management in a developing world context, and investigating the critical success factors for implementing hybrid clouds.

Literature review

An effective literature review serves not only as a robust foundation for expanding knowledge but also as a guide to identify areas necessitating further research (Webster & Watson 2002). Literature review assists to conceptualise a study, grasping design parameters, and comprehend the existing body of knowledge to glean insights from previous research (Saunders, Lewis & Thornhill 2009). Therefore, this section presents the definition and benefits of hybrid cloud computing, an overview of modern data platforms and a summary of research work related to the impact of cloud computing on data platforms.

Cloud computing and data platforms

The concept of cloud computing can be traced back to the visionary thinking of John McCarthy and Leonard Kleinrock in the 1960s when they predicted that computing and networks would eventually become a 'public or computer utility' (in 1961 and 1969, respectively). Today, it has become central to the strategies of nearly every organisation. Cloud computing, as defined by the National Institute of Standards and Technology (NIST), is a model that enables ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage, applications and services).

Depending on their needs and strategic objectives, organisations can deploy different cloud computing models. The public cloud presents a situation where computing resources are shared and accessible to the public over the Internet without any limitations. The private cloud is where computing resources are dedicated to and consumed by a specific organisation, either hosted by a specific provider or on-premises. The community cloud presents an opportunity where computing resources are shared by a community of organisations to meet specific needs such as security or compliance. The final model is the hybrid cloud which is a combination of public, private or community cloud computing models.

Cloud computing services can be classified into different service models such as infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS), among others. In IaaS, computing infrastructure resources such as processing and storage are offered as services via a virtual machine on a per-use and demand basis. Users have no control over the underlying hardware but can control the applications deployed on it. Platform as a service is an extension of IaaS, which provides a platform for designing, developing, running and managing applications. Users have control over the applications they deploy but not over the underlying infrastructure. SaaS service model grants users access to complete software over the Internet, which is hosted on the cloud and delivered to users via the Internet.

Financial institutions, for example, have traditionally relied on in-house applications, which can hinder innovation because of security concerns and legacy systems. Cloud computing provides a way for financial institutions to rapidly develop new applications, including data-intensive applications like AI and data analytics, which are critical to their success (Burke 2019). The advantages that cloud computing offers are particularly relevant to DW platforms. It provides on-demand virtualised resources, parallel processing, security and flexible data service integration (Hashem et al. 2015).

In South Africa, Google, AWS, IBM and Microsoft are the key players in the cloud space (Gillwald et al. 2013; Kshetri 2011). Both Microsoft and AWS have set up data centres in the country, enhancing the local cloud landscape (Amazon 2019). Other local companies, including Internet Solutions, MTN Solutions and Business Connexion (now part of Telkom) are also actively involved (Gillwald et al. 2013). According to the MyBroadband Cloud Survey, around 77% of South African companies are using cloud services (MyBroadband 2019).

Related studies

Understanding the landscape of cloud computing in South Africa is crucial as it forms the backbone of an HDW. Although the primary focus here is on recent studies, it is essential to reflect on the historical context to gauge the growth of this field. In South Africa, pivotal articles such as those by Gillwald, Altman and Moyo (2012) and Chavula, Phokeer and Calandro (2018) shed light on the journey of cloud computing research.

Gillwald et al.'s study in 2012 examined cloud computing in South Africa, delving into its prospects and challenges. Many of the challenges identified in their study, such as policy gaps in data protection, cybersecurity and privacy, have since been addressed, thanks to recent research and regulatory frameworks in the country. The issues of data security and privacy continue to be crucial factors affecting the adoption of public cloud services in South Africa.

Another early study by Chavula et al. (2018) focused on cloud computing from a latency perspective. They aimed to measure Internet latency as a barrier to the adoption of cloud computing services in the South African public sector. Their findings pointed to the need for cloud service providers (CSPs) to establish data centres in Africa to reduce latency and enhance cloud service performance.

A study by Sithole and Ruhode (2021) adopted the TOE framework to determine opportunities and challenges influencing the adoption of cloud computing by SMMEs in South Africa. This study revealed that government and regulatory support is perceived as a barrier to cloud adoption by SMMEs. On the other hand, another study focusing on cloud computing in South Africa by Mohlameane and Ruxwana (2020), when exploring the impact of cloud computing on existing South African regulatory frameworks,

found that the existing policies are generic. As a result, the study identified a subject-specific policy which is future-proof as a need to foster the adoption of cloud computing. Their study employed a qualitative multi-method approach. Both studies demonstrate that secure access to the data is paramount when dealing with data from the cloud environment. Interestingly, Khan et al. (2014) found that cloud computing impacts secure access to the data in the cloud, which coincides with the observation of Sithole and Ruhode (2021) and Mohlameane and Ruxwana (2020).

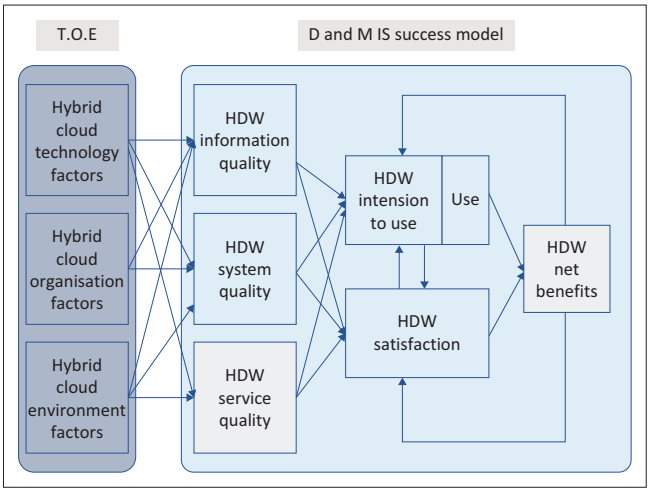
Based on these previous studies, it is observed that the examination of cloud computing in South Africa reveals a dynamic landscape shaped by both historical precedents and recent research endeavours. These studies investigated critical issues, such as cloud security, latency and barriers to cloud adoption, prevalent to the success and adoption of cloud computing in South Africa. Studies by Gillwald et al. in 2012 and Chavula et al. in 2018 as an example laid foundational insights into the challenges and opportunities surrounding cloud adoption, particularly regarding data security, latency and regulatory frameworks. The overarching theme resonating across these studies is the critical importance of secure data access within the cloud environment, highlighting the ongoing imperative for robust security measures to underpin the continued growth and success of cloud computing initiatives in South Africa. Therefore, it becomes important for organisations to prepare for any cloud deployment, including hybrid cloud.

Theoretical and conceptual framework

The role of theoretical and conceptual frameworks in research is pivotal, as they inform the study's design approach. A theoretical framework provides the essential structure for research, guiding and supporting the entire study. Grant and Osanloo (2014) aptly liken the theoretical framework to the blueprint of a house. Just as when constructing a building, meticulous planning and critical thinking are essential in crafting a blueprint for a research project.

This study's conceptual framework was developed from the two classical theories, the TOE framework and the D&M IS success model. A conceptual framework as depicted in Figure 1 is named the HDP research model, and it was used to investigate the state of cloud computing and its impact on data platforms in the FSS in South Africa.

The combination of the TOE framework and D&M IS success model in research is not uncommon. A study by Aoun, Vatanasakdakul and Chen (2011) used these two frameworks to investigate factors influencing the success of IT governance adoption. With that said, the author found no published articles within the South African context using both frameworks in their research. This demonstrates that there is limited research using this approach. However, Irakoze



Source: Adapted from TOE framework and DeLone, W.H. & McLean, E.R., 2003, 'The DeLone and McLean model of information systems success: A ten-year update', *Journal of Management Information Systems* 19(4), 0–30

T.O.E., technology-organisation-environment; HDW, hybrid data warehouse; D&M IS, DeLone and McLean information systems.

FIGURE 1: The first version of hybrid data platform research model.

(2016) did employ a combination of the D&M IS success model and the TOE framework in a Master's thesis conducted at the University of Cape Town to explore an enterprise resource planning (ERP) implementation success framework for developing countries using a case study of South African small and medium enterprises (SMEs).

The framework has played a pivotal role in shaping the problem statement, structuring and organising the literature review, and devising the research methodology. This aligns with the importance of having a theoretical framework guide a dissertation study, as elucidated by Grant and Osanloo (2014).

Technology-organisation-environment framework

The TOE framework, developed by Tornatzky and Fleischer in 1990, serves as a valuable tool for comprehending technology adoption and use at the organisational level. It has garnered consistent empirical support regarding the factors affecting IS (Hoti 2015). This framework primarily focuses on assessing technology acceptance in organisations by considering TOE factors (Jiang, Chen & Lai 2010). Bakkabulindi (2014) noted that the TOE framework finds its roots in Rogers' Innovation Diffusion Theory (IDT) and aims to elucidate the determinants of user acceptance of technology.

The TOE framework divides these determinants into technological, organisational and environmental factors. Technological factor pertains to internal and external technology, encompassing both new and existing technologies necessary for enhancing organisational productivity and supporting various business functions. Organisational factors deal with factors such as the organisation's size, scope, managerial structure, quality and financial resources, among others. Environmental factor encompasses considerations related to the industry

within which the organisation operates, interactions with business partners, competitive conditions and regulatory issues.

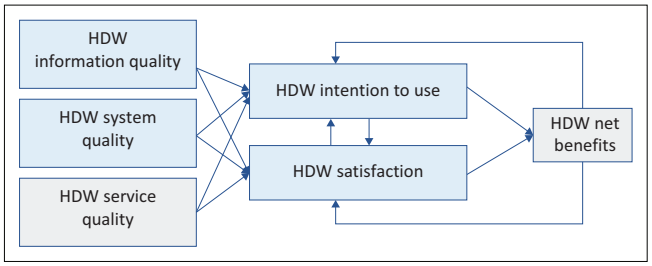
This framework's versatility allows it to be adapted to various domains within the IS sphere, including Business Intelligence (BI) and data warehousing. For example, Johnston and Lautenbach, as well as Lautenbach, Johnston and Adeniran-Ogundipe (2017) employed the TOE framework to explore factors influencing the use of BI and analytics in South African organisations. Similarly, Walker and Brown (2019) used this framework to gain insights into factors relevant to the big data adoption model.

Despite its successes in adoption research, the TOE framework has not been without criticism. Some have argued that it has remained static, perceived as a 'generic' framework rather than a competing alternative to other adoption theories like the DOI theory (Baker 2012). Another critique, as highlighted by Bakkabulindi (2014), is that the TOE framework appears biased towards technological innovation, overlooking the fact that not all innovations are technological. However, this critique may not be applicable in this study, as the focus is on the novel technology of hybrid data warehousing.

DeLone and McLean information systems success model

The D&M IS success model was originally developed in 1992 as a means to measure the multifaceted variables associated with an IS (DeLone & McLean 2003). Although the model was published in 1992, it was based on research conducted during the 1970s and 1980s (DeLone & McLean 2003).

Approximately a decade after the model's initial publication, subsequent to extensive criticism, evolving IS landscapes and the emergence of new challenges (Lian 2017), it was updated by its original authors. The revised model, depicted in Figure 2, incorporates empirical work to validate its propositions (DeLone & McLean 2003; Urbach & Mueller 2011). This revision addresses various issues, including process versus causal models, system use as a success measure, role of context, and independent versus dependent variables (DeLone & McLean 2003).



Source: Adapted from DeLone, W.H. & McLean, E.R., 2003, 'The DeLone and McLean Model of information systems success: A ten-tear update', *Journal of Management Information Systems* 19(4), 0–30

HDW, hybrid data warehouse.

FIGURE 2: Updated DeLone and McLean information systems success model.

This revised model assesses the success of IS through six dimensions: information quality, system quality, service quality, (intention to) use, user satisfaction and net benefits. The model posits that for an IS to be deemed successful, its use (or intention to use) and user experiences should generate specific benefits for individuals and organisations. The nature of these benefits depends on the quality of information, system and service quality. Notably, net benefits may or may not influence further use (or intention to use) and user satisfaction with the IS (Urbach & Mueller 2011). By delineating the six dimensions of IS success, the model provides a comprehensive and solid framework to explore the contextual intricacies of the hybrid cloud, which influence information-intensive organisations in adopting HDPs.

The DeLone and McLean (2003) model has been extensively employed in empirical research pertaining to IS success (Mudzana & Maharaj 2015), including the study by Mudzana and Maharaj (2015), which used the updated model to assess business information system (BIS) success. This choice was made because the model was the most widely cited IS model in the IS literature at that time. Another quantitative study by Donovan et al. (2018) explored the impact of factors such as the free flow of information, IT infrastructure flexibility, cloud system quality, IT security and cloud privacy concerns on the increased net benefits of cloud computing. They extended the updated D&M IS success model by adding constructs related to information security concerns, privacy, free flow of information and cloud flexibility of IT infrastructure. However, the authors acknowledged that this study's reliance on survey data could have been complemented by other data collection methods (Donovan et al. 2018).

Research methods

The study leverages the TOE framework and the D&M IS success model as research lenses to investigate the state of cloud computing and its impact on data platforms in South African FSS. Given the aim of this study, it was critical to collect reliable data from individuals with deep knowledge in data platform and cloud computing. To achieve this, data were collected from participants in a natural setting, enabling them to express their interpretations of the data management and integration capabilities necessary for the success of data platforms (Saunders et al. 2009). Therefore, the study adopted the exploratory sequential mixed methods research choice to collect data necessary to assess the state of cloud computing and its impact on data platforms from the perspective of data professionals in the FSS.

An exploratory sequential mixed method is a research choice that allows one to combine qualitative and quantitative research strategy into a single study, but the qualitative data are collected first (first phase) and then followed by the quantitative data (second phase) (Creswell 2009). The outcomes of the first phase serve as the foundation for designing data collection instruments used in the second phase. Adopting the exploratory sequential mixed methods research choice was not only a pivotal choice to allow for a

deep understanding of the phenomena, but it also allowed the authors of this article to corroborate the findings of the qualitative data with data from the quantitative phase.

Qualitative data collection and analysis techniques

The first phase of the study delved into qualitative data collection, conducted via in-depth interviews with seven managers and leaders of data platform teams hailing from organisations operating within the FSS in South Africa. As such, the organisations examined in this study operate within the banking and insurance sectors. Consequently, in-depth interviews were conducted with managers employed either as full-time staff or consultants within these organisations. An in-depth, semi-structured interview was selected because it involves a dynamic exchange between the interviewer and the interviewee, aiming to extract valuable information through a question-and-answer format (Longhurst 2009). This method was employed as a deliberate approach to gather reliable and relevant insights from senior data managers in the FSS in South Africa. The participants with extensive knowledge of data platforms were purposefully selected and interviewed via Microsoft Teams.

The participants in the in-depth interviews were purposively selected based on their roles and experience in the data platform domain. At the time of the interviews, they occupied leadership positions within data platform teams and were actively involved in DW cloud migration within their respective companies. Out of the seven participants, two were consultants offering services to companies in the FSS in South Africa, while the remaining five were employed directly by companies. The two consultant participants held senior positions within their organisations and possessed extensive experience in data-related tasks, including projects related to cloud computing. For example, one consultant had accumulated 6–7 years of experience in cloud computing, during which they led multiple cloud migration projects and held certifications in data warehousing and cloud solutions:

> 'Yeah, I've got, yeah, altogether cloud experience until the end of well, altogether now about six to seven years cloud experience. Certified DW architect, certified cloud solutions architect. And like I said, you know I've led, from an advisory capacity, as well as owning a good number of cloud migration or migrations of cloud data estates, so data estates into the cloud.' (Participant 6, Solution Architect, Consulting industry)

Qualitative data analysis employed the 2006 Braun and Clarke six-step framework as depicted in Box 1.

The first step of the six-step framework is crucial for the entire analysis process. It demands a thorough understanding of the data and is time-consuming. Braun and Clarke (2006) strongly advise against skipping this step, as it provides a solid foundation for data analysis (Braun & Clarke 2006). To become familiar with the data, the researcher listened to the recordings of each interview. The interviews were recorded using Microsoft Teams and were transcribed using the Microsoft Teams transcribe feature.

BOX 1: Six-step framework by Braun and Clarke (2006).

Six-step framework	
Step 1: Familiarising yourself with your data	Step 2: Generating initial codes
Step 3: Searching for themes	Step 4: Reviewing themes
Step 5: Defining and naming themes	Step 6: Producing the report

Source: Adapted from Braun, V. & Clarke, V., 2006, 'Using thematic analysis in psychology', *Qualitative Research in Psychology* 3, 77–101. https://doi.org/10.1191/1478088706qp063oa

Steps 2–5 of the six-step framework of the qualitative data analysis were facilitated by the QDA Miner Lite software (version 2.0.9) and Microsoft Excel. Figure 3 shows the use of QDA Miner Lite software to define codes and categories from the interview transcribed data.

The results of the qualitative analysis of interview data were used to update the HDP research model on Figure 1, to formulate the hypotheses and to guide the design of quantitative data collection instrume. Figure 4 shows the study's research framework updated with the data from results of the qualitative data.

As depicted in Figure 4, the framework outlined 14 hypotheses derived from the analysed data in phase 1. This questionnaire was designed to test the following hypotheses:

- $\mathbf{H_1}$: Hybrid cloud technology factors are likely to have a positive impact on HDP information quality.
- $\mathbf{H_2}$: Hybrid cloud technology factors are likely to have a positive impact on HDP system quality.
- $\mathbf{H_3}$: Hybrid cloud technology factors are likely to have a positive impact on HDP service quality.
- $\mathbf{H_4}$: Hybrid cloud organisational factors are likely to have a positive impact on HDP information quality.
- $\mathbf{H_5}$: Hybrid cloud organisational factors are likely to have a positive impact on HDP system quality.
- $\mathbf{H_6}$: Hybrid cloud organisational factors are likely to have a positive impact on HDP service quality.
- $\mathbf{H_7}$: Hybrid cloud environment factors are likely to have a positive impact on HDP information quality.
- $\mathbf{H_8}$: Hybrid cloud environment factors are likely to have a positive impact on HDP system quality.
- $\mathbf{H_9}$: Hybrid cloud environment factors are likely to have a positive impact on HDP service quality.
- $\mathbf{H_{10}}$: Meeting HDW information quality is likely to increase the HDW platform user experience.
- $\mathbf{H_{11}}$: Meeting HDW system quality is likely to increase the HDW platform user experience.
- $\mathbf{H_{12}}$: Meeting HDW service quality is likely to increase the HDW platform user experience.
- $\mathbf{H_{13}}$: Having a positive HDW user experience will improve the HDW net benefits.
- $\mathbf{H_{14}}$: Improved net benefits will increase the HDW user experience.

Quantitative data collection and analysis techniques

The second phase centred on quantitative data collection, achieved through an online questionnaire targeting data

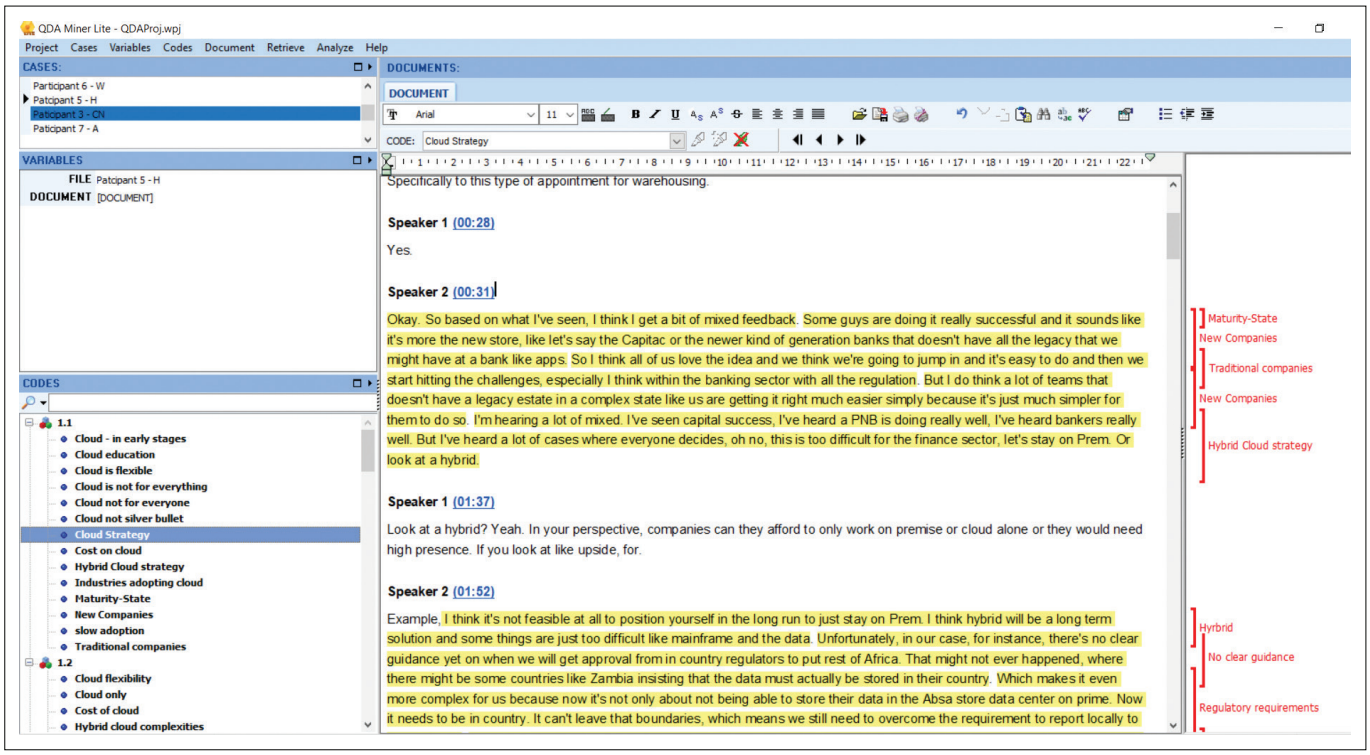
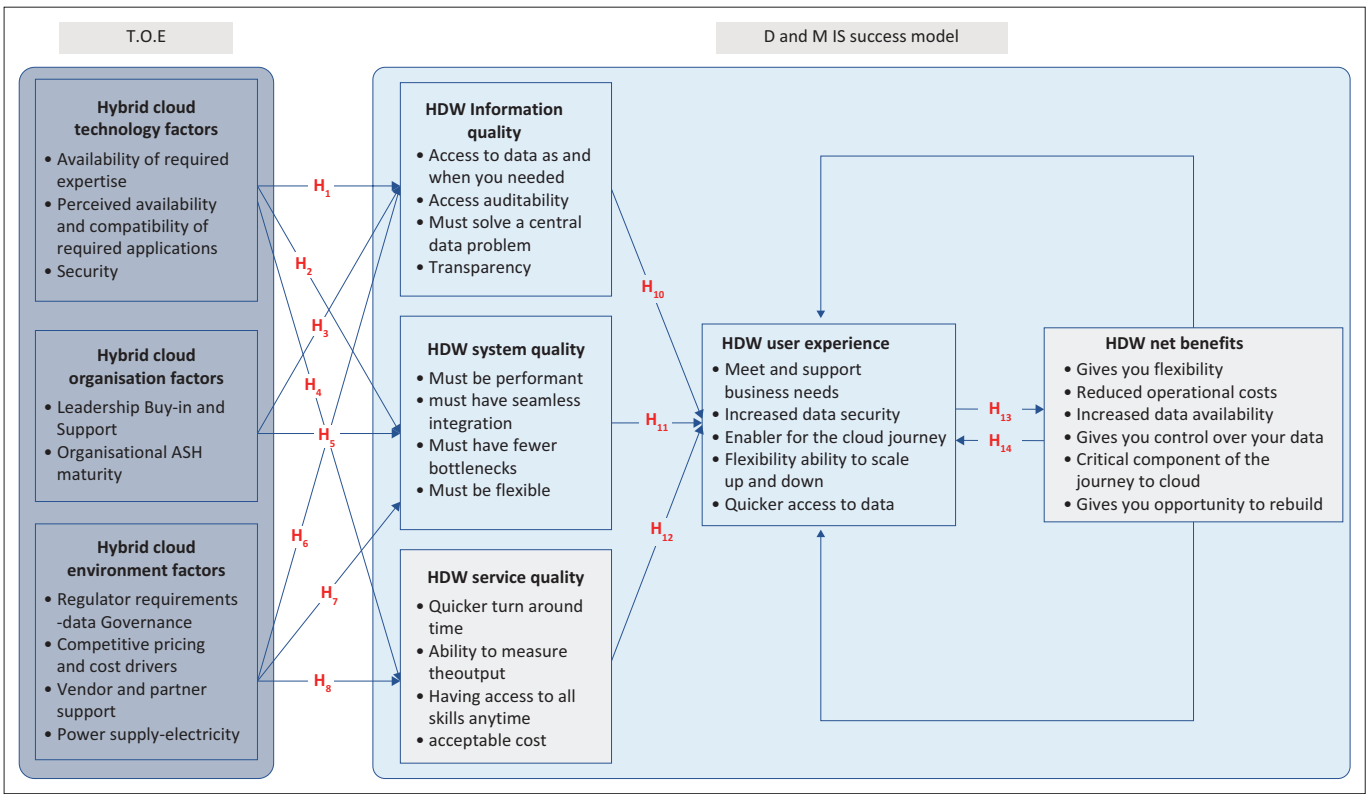


FIGURE 3: Categories and codes.



Source: Adapted from TOE framework and DeLone, W.H. & McLean, E.R., 2003, 'The DeLone and McLean model of information systems success: A ten-year update', *Journal of Management Information Systems* 19(4), 0–30

T.O.E., technology-organisation-environment; HDW, hybrid data warehouse; D&M IS, DeLone and McLean information systems.

FIGURE 4: Updated hybrid data platform research model.

professionals within the FSS of South Africa. A questionnaire was selected because it is a well-suited instrument for posing structured questions, ensuring that each participant responds to the same set of questions (Saunders et al. 2009). At the conclusion of the first phase (qualitative phase), the findings from the literature review and semi-structured interviews were employed to create quantitative data collection instruments. A total of 258 data professionals participated in

this phase. The questionnaire aimed to allow participants to express their views on the competencies required for the success of a hybrid environment, complementing the insights obtained from the in-depth, semi-structured interviews. Using IBM SPSS version 28.0.1, the quantitative data underwent descriptive analysis, exploratory factor analysis (EFA) and OLS regression analysis.

Descriptive statistical analysis is used to summarise and describe research data, providing valuable insights. It is recommended as the first analysis to be conducted before any inferential analysis (Yellapu 2018). After descriptive analysis, the second statistical analysis conducted in this study was EFA. Exploratory factor analysis, often referred to as factor analysis, is a statistical technique used to reduce data to a smaller set of summary variables and explore the underlying theoretical structure of phenomena (StatisticsSolutions.com 2023). It is a multivariate statistical method widely employed for the development and validation of theory and for identifying latent constructs (Watkins 2018).

Exploratory factor analysis can be performed using various software tools, such as datatab.net, Jamovi, R, and IBM SPSS. In this study, IBM SPSS Statistics Version 28.0.1 was chosen because of its widespread use among researchers and the availability of multiple analysis functions. Additionally, the author had a full licence for IBM SPSS through the university, making it a convenient choice for phase 2 data analysis. Several considerations must be considered when conducting an EFA, including assessing the appropriateness of the data, understanding the difference between principal component analysis (PCA) and common factor analysis (CFA), determining the number of factors to retain and selecting a factor rotation method.

Regression analysis is used to measure the effect of one or more variables on another variable or predict a variable using one or more variables. In this study, we used simple linear regression, where a single independent variable predicts the dependent variable, aligning with the research model. Multiple linear regression, which involves multiple independent variables, was considered unsuitable for this study.

For each hypothesis, a correlation analysis was performed before regression analysis. Both Pearson and Spearman correlation tests were used on dependent and independent variables, and the relationships were depicted in scatter plots. This was essential to detect any correlations between variables and determine the viability of regression analysis.

To conclude the hypothesis tests, the study also assessed the OLS regression assumptions. Checking these assumptions was crucial to ensure the reliability of the results (Williams, Grajales & Kurkiewicz 2019). The assumptions tested included linearity, independence of variables, homoscedasticity, multivariate normality and multicollinearity (Poole & O'Farrell 1971; Williams et al. 2019).

Ethical considerations

Ethical principles were meticulously adhered to at every stage of the research process, from topic selection, research design, data collection, and analysis, to results interpretation and reporting. Ethical clearance was obtained from the University of Johannesburg Ethics Committee, facilitated by the School of Consumer Intelligence and Information Systems. The protection of the identities of the participating companies and individuals was a top priority, ensuring that participants were not exposed to any harm, embarrassment, pain or disadvantage. Personal information was not collected, and all participants were given the opportunity to provide informed consent to participate in the research – 2020SCiiS09.

Research results

Cloud maturity

The findings from the qualitative data in phase 1 reveal critical insights related to the state of cloud maturity in South Africa. It is evident from the qualitative data that cloud computing adoption in South Africa is still in its early stages. The slow acceleration of cloud adoption is attributed to factors such as the absence of local data centres from major CSPs in the African region. Furthermore, the results suggest that the technology sector and tech companies are at the forefront of cloud adoption. Older organisations, which were established before the cloud era, tend to have a higher proportion of their data and IT resources on-premises, causing them to lag in cloud adoption compared to newer companies founded during the cloud era. See interview extract from participants 2 and 6:

> 'Your newly started company, they started up in the cloud. They didn't really migrate anything legacy wise to the cloud. So like your payment providers that you would see, or Yoko, and they've built on top of cloud providers already. They started out like that … especially companies like Investec and standard bankers that's really old. I mean, standard banks are 150 years old.' (Participant 2, BI Architect and Administrator, Banking industry)

> 'Yeah, yeah. So there's one bank, Time Bank, yes, which started off as a digital bank and they started off as cloud-based so they, you know, they launched in the cloud. So for them that answer is, you know they're always going to be cloud and then they in in in that sort of aspect. You know they have had a clear strategy from day one I believe. Probably before day one.' (Participant 6, Solution Architect, Consulting industry)

Additionally, the results also indicated that a hybrid cloud model is more efficient than relying solely on public or private cloud deployment. Organisations often opt for a hybrid approach because of factors like legacy data and the practical challenges of transitioning all data to a single deployment model. For example, one participant said:

> 'OK, then, in terms of your more traditional organisations, you're going to find quite a heavy on-premises footprint and a lot of them have invested quite heavily because of regulations. A lot of them have invested very heavily in those traditional on-premises data centres that they have. They have had over the years, you know they've bought into, or you know, they've been, yeah. They've bought into long-term licensing and hardware software also, so you will find that they will need a hybrid strategy for a couple of years, more than a couple, for a few years in order to allow their migration journey.' (Participant 6, Solution Architect, Consulting industry)

The study found that organisations seeking to adopt cloud must evaluate cost differences between on-premises and cloud computing, address regulatory and security considerations, view the hybrid model as a short-term strategy and understand the complexities of the cloud.

The results from quantitative data in phase 2 corroborate and enhance the understanding of cloud maturity in South Africa. The quantitative data show that 63.8% of participants believe there is increasing interest in cloud adoption within the FSS in South Africa. Only 32.8% perceive cloud adoption as being in the infancy stage. However, it is noteworthy that the majority of participants lack significant cloud knowledge. The rate of cloud adoption within organisations is mixed, with 35% considering it fast over the past 2 years, 33% moderate and 32% slow. A significant percentage (48.3%) of participants reported that less than 25% of their DW or data platform workload runs in the cloud in their respective organisations. Interestingly, the majority (52 out of 58) view the hybrid cloud approach as the future of computing and data platforms in the FSS in South Africa over the next 10 years.

Drivers of the hybrid cloud deployment model

The drivers of hybrid cloud architecture, as identified in phase 1, are categorised into three groups: technological, organisational and environmental. The findings regarding the drivers of hybrid cloud architecture, as identified in phase 1, indicate several critical factors influencing the adoption of a hybrid cloud. These factors include the availability of cloud resources and services in the customer's preferred region, security concerns, leadership buy-in, organisational maturity, regulatory compliance, resilience during power outages and trust in technology partners. For example, one participant had this to say about the availability of cloud resource in South Africa:

> '[*O*]ne of the reasons is that not all the offerings are yet available in South Africa. So for example, you can't run snowflake locally as best I understand, you know, that with Cloud pack for data for example, which would be a good hybrid warehouse, but that is only recently available here.' (Participant 4, Managing Director, Consulting industry)

These drivers shape the decision-making process for adopting a hybrid cloud strategy and ensure the successful implementation of data platform projects. Another important factor prevalent in South Africa is that of resilience during power outages. Following is the extract from the in-depth interview:

> 'And as we know, especially in the country like South Africa, energy is a big problem. And our footprint, our carbon footprint is important … So in a country like South Africa, if have three AZ's, only one of them can use Eskom as a primary source of electricity. Yeah, OK, and the other two can use Eskom as a secondary or tertiary, as a backup source. Yes, but only one of them can use as the primary one, then another one would use wind and another one would use solar.' (Participant 6, Solution Architect, Consulting industry)

According to the findings from the qualitative data, South Africa's energy crisis has led organisations to consider the cloud. Cloud computing providers by design promise almost zero downtime, particularly if there are multiple availability zones (AZ) within a region that do not rely on a single power source. This ensures that services remain available even during power outages. Therefore, knowing that data centres, whether private or public, will be online during power outages appears to be a compelling reason for organisations to embrace the cloud.

In phase 2, the quantitative results corroborate the significance of various hybrid cloud drivers. Security stands out as the most impactful driver on the quality of HDP information, system and service. Power supply (electricity) is considered the least impactful driver. The reliability of these identified drivers is confirmed through Cronbach's alpha reliability testing, with an alpha value exceeding 0.80 across information, system and service quality assessments.

Exploratory factor analysis was employed to assess the commonality of factors, except for organisational drivers. Exploratory factor analysis revealed that technological and environmental drivers contributed to the variance in data platform information, system and service quality, signifying the reliability and interrelatedness of these factors. The results of the regression analysis for hypotheses 1–9 indicate that all alternative hypotheses were accepted except for hypothesis 5. These findings provide strong support for the impact of hybrid cloud drivers on HDP quality.

Data challenges and the practices of data platforms in a hybrid cloud environment

Qualitative data in phase 1 reveal eight specific impacts of hybrid cloud drivers on data platforms. These impacts encompass quicker data access, increased flexibility, improved compliance capabilities, centralised data platform access, enhanced security, cost-effectiveness, increased complexity, and a need for cloud and hybrid approach strategies. Each impact is closely associated with specific data challenges and practical implications.

For example, the impact of 'increased complexity' results from the management of additional resources, necessitating a robust data integration layer. Following is what one participant said:

> 'I think it's going to be a challenge that what you end up doing is do some analytics on the cloud, get a subset of the results, and then match that data with what you got hosted on-prem and the other way around.' (Participant 3, Development Manager, Insurance sector)

The quantitative analysis in phase 2 supports the significance of various impacts on hybrid cloud DW platforms. Participants rated 'Quicker Access to Data' and 'Security' as extremely important, followed closely by 'Flexibility'. All the impacts were considered important for determining the success of hybrid cloud data platforms. 'Added Complexities' was rated as the least important impact. Correlation, Bartlett's test of sphericity and Kaiser–Meyer–Olkin (KMO) (measure of sample adequacy) indicated that these impacts were intercorrelated and valid for factor analysis.

Through EFA, a two-factor solution emerged, explaining 60.1% of the variance in the data. These factors were named 'Immediate Impacts' and 'Long-Term Impacts'. 'Quicker Access to Data', 'Flexibility', 'Assisting with Compliance', 'Access to Centralized Data Platform' and 'Security' were associated with 'Immediate Impacts', explaining 45% of the variance. 'Appropriate Cost Level', 'Added Complexities' and 'A Need for Cloud and Hybrid Approach Strategy' were linked to 'Long-Term Impacts', explaining 15% of the variance.

Techniques, tools and technologies required for the success of hybrid data platforms

To answer this research objective, only data from phase 1 of the study were collected and used. The findings of phase 1 of the study identified seven techniques to be used in HDPs. These techniques are applying data governance, applying security and privacy mechanisms, adopting data virtualisation, improving user experience, defining data strategies, embracing modern data architectures and using the right tools for the right workload.

This is what one participant observed about a need for data virtualisation platform:

> 'Abstraction must be part of it, always. You need to abstract people away from your technology. Now that's easier said than done. Something like the Denodo plays great. You saw how we've done the Denodo for warehouse migration, but I think it's oversold. But abstraction needs to be understood. It's not like there won't be any changes. There will be impact, but will minimize the change.' (Participant 5, Architect and Data Platforms Manager, Banking industry)

As per the extract, this study also observed that participants focused more on techniques rather than specific tools. Tools are just enablers of these techniques, and any capable tool can be utilised. To maintain and implement a successful HDP, the results show improving user experience, applying data governance, and applying security and privacy mechanisms as the top three techniques used in HDPs.

Measures of success for a hybrid data platform

To understand the success measures of data platforms, the study investigated various constructs as depicted in the study's framework including hybrid cloud technological, organisational and environmental drivers, HDP information quality, system quality, service quality, user experience and net benefits. For example, the data in phase 1 of the study show that the user experience indicators, including the ability to meet and support business needs, quicker access to data, increased data security, flexibility for scaling and enabling the cloud journey, were identified from the qualitative data as measures to contribute to a positive user experience of HDPs. This is what one participant had to say regarding quicker access to data as a measure for user experience:

> 'So we will be successful when we can say that teams and business analysts and scientists can proliferate data quicker and get access to data and bootstrap solutions without waiting months to get your data right. So I think that would be a critical part for us for success.' (Participant 2, BI Architect and Administrator, Banking industry)

The qualitative analysis also identified various benefits of HDPs, such as enabling the journey to the cloud, offering control over data, flexibility, rebuilding opportunities, increased data availability and reduced operational costs. Participants recognised hybrid architecture as a parallel hybrid that enables a gradual transition to the cloud.

The results of the quantitative data in phase 2 demonstrate that participants consider 'Meeting and Supporting Business Needs' as the most crucial indicator of a positive HDP user experience, while 'Enabler for the Cloud Journey' is viewed as the least important. The HDP user experience construct and its individual items went through the EFA and the results show that one factor (latent construct) was extracted and named HDW User Experience and it explained 67.633% of the variance.

Phase 2 also explored the impact of data platform quality factors on user experience. The results show that participants strongly agreed that 'Access to Data as and When Needed' and 'Access Audibility' from the Information Quality perspective had a significant impact. Similarly, 'Performant System' and 'Must-Have Seamless Integration' from the system quality perspective were highly ranked. From the service quality perspective, 'Quicker Turnaround Time' was deemed the most important indicator of a positive user experience.

For the regression analysis procedure to test hypotheses 10, 11 and 12, latent constructs of HDP information, system and service quality obtained and validated through EFA were used as independent variables, and the HDP user experience obtained and validated through EFA was used as dependent variables.

Discussion and recommendations

While phase 1 indicated that cloud computing was in its early stages, phase 2 quantitative findings showed a growing interest in cloud computing among participants. This finding aligns with past articles (Gillwald et al. 2013; Muriithi & Kotzé 2013), suggesting that, in 2023, there is increasing interest, but the growth rate remains slow. Participants favour the hybrid approach because of ongoing learning in cloud technologies and dependence on legacy systems that cannot be easily migrated. Less than 25% of data platforms are running in the cloud, indicating that a hybrid approach will persist. Literature (Muriithi & Kotzé 2013) supports these findings, highlighting concerns in the financial sector about security and reliance on legacy systems hindering innovation. For instance, a study by Gillwald et al. (2013) identified security as one of the challenges of cloud computing. This study found critical factors influencing the implementation of a hybrid cloud and security is still considered an important factor. Given that security still poses a threat to cloud computing adoption, this demonstrates the importance of ensuring security measures in the cloud are in place to ensure effective and secure hybrid cloud deployments. As a result, this research underscores a burgeoning interest in cloud computing, amid persistent challenges posed by legacy systems and security concerns within the financial sector, suggesting a cautious yet evolving landscape in cloud adoption and innovation.

The qualitative phase of the study identified nine hybrid cloud drivers categorised into technology (three drivers), organisation (two drivers) and environment (four drivers). Skill availability emerged as the most supported technological driver among interview participants, while security was the least supported. However, quantitative results in phase 2 highlighted security as the top technology driver, potentially impacting information, system and service quality of HDPs positively. Comparing these findings with existing literature, security concerns in hybrid cloud, including security controls, data protection, identity and access management, were acknowledged (Raza, Imtiaz & Shoaib 2019). The study contributes to a deeper understanding of the dynamics shaping hybrid cloud deployments, highlighting the necessity for comprehensive security strategies to ensure the success and resilience of such initiatives.

Though phase 2 of the study identified power supply (electricity) as the least impactful driver for hybrid cloud deployment, power outages in South Africa have become a daily challenge for every industry, including cloud computing. According to ITWeb, Randall Thyssen, a senior Sage Consultant at integrated ICT solutions provider, is also of the view that power outages put business continuity and data quality at risk for those companies reliant on the cloud. Different studies which assessed the impact of load shedding in South Africa found that it affects production and operations of machines, information flow, use of technologies and economy (Erero 2023; Mabunda, Mukonza & Mudzanani 2023). Therefore, this underscores the critical need for further research to explore the intricate relationship between power supply reliability and the effectiveness of hybrid cloud solutions in mitigating operational disruptions and ensuring data integrity within the South African context.

In response to the main research question, the study concludes that the contextual nuances of hybrid cloud architecture significantly influence organisations in the FSS to implement HDPs. These nuances encompass various factors, including cloud maturity, availability of resources, comprehensive cloud strategies, security concerns, understanding impacts on data platforms and the selection of the right tools. The study demonstrated how these contextual nuances, if understood and implemented correctly, can enhance the success of modern data platforms, particularly HDPs. As such, to conclude this research, the study recommends the following five strategies for implementing successful HDP:

- **Enhance cloud computing skills:** Organisations should prioritise the development of cloud computing skills among their data professionals. This investment in skill development is essential for the effective execution of cloud adoption strategies and for mitigating security and regulatory compliance risks.
- **Conduct workload assessment:** Before embarking on cloud adoption or the integration of cloud-based services, organisations should conduct a thorough workload assessment. This preliminary assessment is a critical prerequisite for a successful cloud adoption strategy and will ensure seamless integration into the organisation's existing ecosystem.
- **Align data platform cloud strategy with organisational cloud strategy:** Organisations should align their data platform cloud strategy with the broader organisational cloud strategy. By doing so, data platform teams can proactively identify potential cloud and hybrid cloud drivers that are likely to impact data platforms.
- **Identify required data platform capabilities before technology acquisition:** Data platform teams should proactively identify the capabilities necessary to meet their data management objectives. There is no one-size-fits-all solution, so organisations must identify their specific needs and select the appropriate technology accordingly.
- **Measure HDP success:** Success in the realm of HDPs can vary significantly from one organisation to another. Hence, organisations should engage in activities that enhance positive data platform user experiences.

Conclusion

The study concludes that the contextual nuances of hybrid cloud architecture significantly influence organisations in the FSS to implement HDPs. These nuances encompass various

factors, including cloud maturity, availability of resources, comprehensive cloud strategies, security concerns, understanding impacts on data platforms and the selection of the right tools. The study recommends adopting the identified drivers for hybrid cloud deployment, with a focus on security and skill availability. Organisations are encouraged to assess the impacts and challenges of modern data platforms in a hybrid cloud environment, prioritising them based on business requirements and security implications. Techniques such as applying data governance, security mechanisms and adopting data virtualisation are essential, with data virtualisation strongly recommended as a top feature.

This research also contributes to Sustainable Development Goals (SDGs) 4 and 9. SDG 4 seeks to ensure quality education and lifelong learning opportunities for all, promoting inclusive and equitable education. SDG 9 focuses on building resilient infrastructure, fostering innovation and supporting sustainable industrialisation. Cloud computing relies heavily on a reliable Internet infrastructure, and the study's technological drivers contribute to sustainable cloud computing infrastructure, supporting reliable and secure Internet access. The research findings also have the potential to bolster education in the domains of cloud computing and data platforms, thus aligning with SDG 4's objective.

Future research

The study recommends that the research framework employed in this study be validated using different datasets from various fields to assess its generalisability. Additionally, exploring the evolving landscape of cloud and hybrid cloud developments in developing countries like South Africa should be a focal point for future studies. Given the immaturity of cloud technologies, substantial unknowns remain to be explored. Investigations into the economic and practical aspects of implementing HDPs need to be extended. The study also recommends that future research delves into the implications of modern data platforms on existing data management processes, procedures and data governance.

To strengthen the qualitative phase of future studies employing the exploratory sequential mixed methods approach under similar circumstances, it is advisable to consider increasing the number of participants. A larger participant pool can offer a broader range of perspectives and insights, leading to a more comprehensive understanding of the data management in HDPs. Additionally, diversifying the participant demographic can enrich the qualitative data, providing valuable context and depth to the findings. By incorporating a greater number of participants, future research endeavours can strive for increased validity, reliability and generalisability of the qualitative results, thereby contributing to a more robust and nuanced exploration of the research subject.

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The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

S.V.G. conceptualised and designed the research. S.V.G. also collected and analysed the data and discussed the results. K.J.B. guided the study as a supervisor. All authors have read and agreed to the published version of the manuscript.

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Data availability

All data collected and analysed during this study can be obtained from the corresponding author, S.V.G., upon request.

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