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Factors influencing Big Data governance in enhanced service delivery in South African public sector

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Background: Public sectors generate large data volumes, necessitating improved data management and governance. Economic, political, and technological challenges hinder data management, leading to inefficiencies in service delivery. In South Africa, service delivery problems are exacerbated by a lack of accountability, weak leadership, poor procurement practices, and ineffective human resource management. Despite investments in information communication technology (ICT), data management challenges persist, especially with the rise of semi-structured and unstructured data. Public sectors must treat data as a strategic asset for governance, ensuring timely, reliable, and organised data to meet citizens' needs.

Objectives: This study aimed to identify factors influencing Big Data governance to enhance service delivery in the Limpopo Vhembe municipality, South Africa.

Method: A mixed-method approach was used, including a closed-ended questionnaire and qualitative validation. Simple random sampling targeted information technology (IT) professionals and data-related personnel. Descriptive statistics analysed respondent demographics and situational variables.

Results: Data quality management, such as data quality principles, analysis, planning, quality assurance, and control, were found to be critical for effective Big Data governance. These elements help increase trust in data, improve productivity, reduce costs, ensure compliance, and enhance decision-making and innovation, ultimately enabling citizen-centric services.

Conclusion: This study reaffirmed the potential of enhancing decision-making in Big Data governance by uncovering additional insights and implementing proactive strategies to address present and near-future opportunities and challenges.

Contribution: The study contributes to the field by addressing the gap in existing Big Data governance environment within the public sector.

Keywords: Big Data; Big Data governance; public sector; factors; enhancing; decision-making; technology.

Introduction

The world has evolved into a society that is heavily reliant on information and data. The increased usage of information technology (IT) has thus led to enormous growth of data within organisations. Additionally, it is projected that there will be between 20 trillion and 100 trillion different connected devices by the year 2030, which will lead to a significant increase in data collection (Favaretto et al. 2020). These generated data can be categorised into three, namely structured, semi-structured and unstructured data (Bimonte et al. 2022). This phenomenon is known as Big Data.

Big Data is characterised by its five Vs: velocity, volume, variety, veracity and value. Organisations are relying on data to make decisions and produce actionable insights; therefore, these large volumes of data drive them to invest in new data management tools for analysing voluminous data to enhance decision-making as well as better data management (Hosen et al. 2024).

Although data have become a central focus for organisations and academics, they are often seen as a potential source of business value, whereby organisations have not effectively

harnessed Big Data because of challenges such as lack of expertise, inadequate IT infrastructure, data security concerns and the complexity of processing large datasets (Sumbal et al. 2019). Thus, organisations must invest significant effort in enhancing data governance, quality and integrity within the realm of Big Data to stay competitive. This commitment to improving data integrity and ensuring quality and value is referred to as data governance (Gandomi & Haider 2015; Janssen et al. 2020).

Big Data can benefit organisations in various ways such as uncovering the causes of declining revenue for a particular product or analysing human resources (HR) data to understand employee performance trends (Salih, Ismail & Hamed 2018). However, poor data quality can also lead to reduced efficiency and even significant errors in decision-making. Therefore, Big Data raises concerns about ensuring its inherent quality, conducting effective analysis, and leveraging information and expertise properly (Yang et al. 2019). Although there have been considerable Information Communication Technnology (ICT) investments to increase efficiency and improve service delivery, the main challenges in the South African public sector are primarily because of lack of accountability, defective HR practices, inadequate procurement practices and absence of leadership (Reddy 2016). Additionally, some challenges in data management are linked to the recent emergence of semi-structured and unstructured data, which adds complexity because of the growing volume and diversity, thereby increasing the veracity of the data produced (Jim & Chang 2018).

The advent of the Internet of Things, cloud computing and social networks in the 21st century has revolutionised the IT landscape, ushering in the era of Big Data characterised by voluminous datasets (Perera et al. 2015; Ullah et al. 2020). Organisations now face large inflows of diverse and uncertain data, which, when processed in real time, poses significant governance challenges, including data integrity, quality, security and management (Al-Badi, Tarhini & Khan 2018; Eugster 2021).

The growth of data in science dashboards and the enhancement of applications through artificial intelligence introduce further threats to data governance, necessitating effective, scalable and adaptive strategies to meet evolving data privacy regulations (Eugster 2021; Sumbal et al. 2019). To remain competitive, organisations must improve their analytics, management and governance capabilities to address the diverse nature of structured, semi-structured and unstructured data (Da Bormida 2022).

Despite some studies developing models for Big Data governance in the public sector, most existing research is limited to white papers and lacks empirical evidence, highlighting a gap in comprehensive models for effective Big Data governance (Abraham, Schneider & Vom Brocke 2019; Dash et al. 2019; Sivarajah et al. 2017). To address this gap, this study developed a conceptual framework to inform Big Data governance to enhance service delivery in public sector.

Problem statement

The rise of technologies like Internet of Things, cloud computing and social networks has driven the expansion of Big Data, creating challenges for organisations in processing diverse data formats while maintaining data quality, integrity and compliance. The public sector heavily relies on data for service delivery but lacks robust models to address the governance of structured, semi-structured and unstructured data. Despite existing research, most studies lack empirical evidence, highlighting the need for modernised Big Data governance models, leveraging technologies such as automation to enhance scalability, security and decision-making.

Literature review

Big Data governance

Big Data governance is part of a broader knowledge governance programme handling data optimisation, privacy, and monetisation policies, dictating data storage, handling, timing and quality (Samoilenko & Shilina 2017). Organisations need strategies to prevent Big Data misuse and manage reputational and legal risks (Al-Badi et al. 2018; Chamberlain 2013). Key strategies include:

- Data principles: Establish standards, guidelines and policies that align with Big Data objectives and regulatory compliance (Andreotta, Kirkham & Rizzi 2022).
- Data quality strategy: Set standards to ensure data are current, complete and reliable, and clearly define data quality goals and evaluation processes.
- Data management strategy: Classify and categorise data to ensure effective and efficient data management aligned with organisational objectives (Shamim et al. 2018).
- Data access: Implement strong information security to protect data, ensure compliance with privacy and legal standards, and build customer trust (Al-Ruithe, Benkhelifa & Hameed 2019).

Factors influencing Big Data governance

Big Data governance is crucial for guiding how organisations manage and use data to create value, mitigate risks and drive innovation. It involves addressing challenges like data privacy, quality, security and organisational culture. While data privacy safeguards sensitive information, it struggles with the scale and speed of Big Data. Similarly, data quality ensures reliability but faces issues with integration and timeliness (Kalema & Busobozi, 2020). Organisational culture, management support, skills and collaboration significantly impact governance success. External factors such as public trust, perception and legacy systems also play a role. This study emphasises the importance of strategic frameworks to enhance governance in the public sector by leveraging innovation, collaboration and relational governance.

Related work

Big Data is becoming an important technological phenomenon, prompting academics, researchers and practitioners to consider ways to incorporate these advancements into their competitive strategies (Mikalef, Pappas & Krogstie 2018). Several studies, such as those by Sekli and De La Vega (2021) and Bruintjies and Njenga (2024), have focused on Big Data adoption and analytics within government sectors; however, there has been little attention given to the Big Data governance area (Janssen et al. 2020).

The study reviewed related work in the field of Big Data governance to highlight existing gaps. For instance, Asquer (2013) found that Big Data is transforming the public sector by introducing innovative methods for managing unstructured and semi-structured data, while emphasising the need for updated regulations. The study also uncovered differing perspectives among public sector stakeholders and identified challenges such as the need for new policies, regulations and skilled personnel. However, it was limited to a small European community and recommended further research to improve governance practices, particularly in developing countries.

Another study by Yang et al. (2019) introduced a Big Data governance framework to help organisations manage structured and unstructured data, aiming to maximise value, promote best practices and ensure good data management. The framework's implementation, illustrated through a network security case study, highlights a research gap for a more general Big Data governance model. Maniam and Singh (2020) focused on Big Data governance, emphasising security and privacy. They noted that methods and policies for ensuring these aspects remain unclear. Their proposed governance model, aimed at balancing data privacy and security to enhance system efficiency and usability, is based on five pillars: quality and consistency, standards and policies, privacy and security, regulation and compliance, and retention and archiving.

Conceptual framework

The study's conceptual model for Big Data governance, as shown in Figure 1, was developed based on identified factors. These factors were drawn from the Diffusion of Innovation (DOI) theory, developed by Rogers (2003), and the Technology–Organisation–Environment (TOE) framework, developed by Tornatzky and Fleischer (1990). In the DOI theory, Big Data governance is supported by how organisations implement governance practices, technologies and frameworks. The TOE framework stands out with regards to the support of Big Data governance by addressing three key dimensions: technology context, which emphasises the role of scalable tools, real-time processing, and secure systems in managing structured, semi-structured and unstructured data effectively; organisation context, which addresses internal factors, such as leadership support, skilled personnel, organisational culture and resource availability, which are critical for successful implementation; and lastly, environmental context, which refers to the external influences, including regulatory compliance, industry standards, competitive pressures and partnerships, which drive the adoption of robust governance practices. These factors provide a clear and effective way to set up Big Data governance.

A conceptual model comprising seven hypotheses was formulated based on the factors identified in the underlying theories. The study proposed the hypotheses to examine the relationship between factors and Big Data governance. By using the TOE framework, the research investigates how these factors influence Big Data governance to improve service delivery.

The study examines how various factors influence Big Data governance to enhance service delivery, using the TOE framework's dimensions.

Technological factors:

H1a: Technology characteristics (scalability, flexibility, complexity and efficiency) influence Big Data adoption.

H1b: People's perceptions (security, trust, efficiency, complexity, and privacy) play a crucial role in adoption.

Organisational factors:

H2a: Management support (training, executive involvement, IT budgets, and communication).

H2b: Organisational size (structure, culture and regulations) either promotes or hinders Big Data implementation.

Environmental factors:

H3: External factors (regulations, resource availability, competition and technological obsolescence) shape decision-making and adoption processes.

Individual factors:

H4: Individual beliefs, preferences, skills and experience significantly influence Big Data adoption.

Big Data characteristics:

H5: The five Vs (velocity, volume, veracity, variety and value) drive organisations towards new processes and structures.

Data quality management:

H6: Relevance, accuracy and safeguards ensure better data usage.

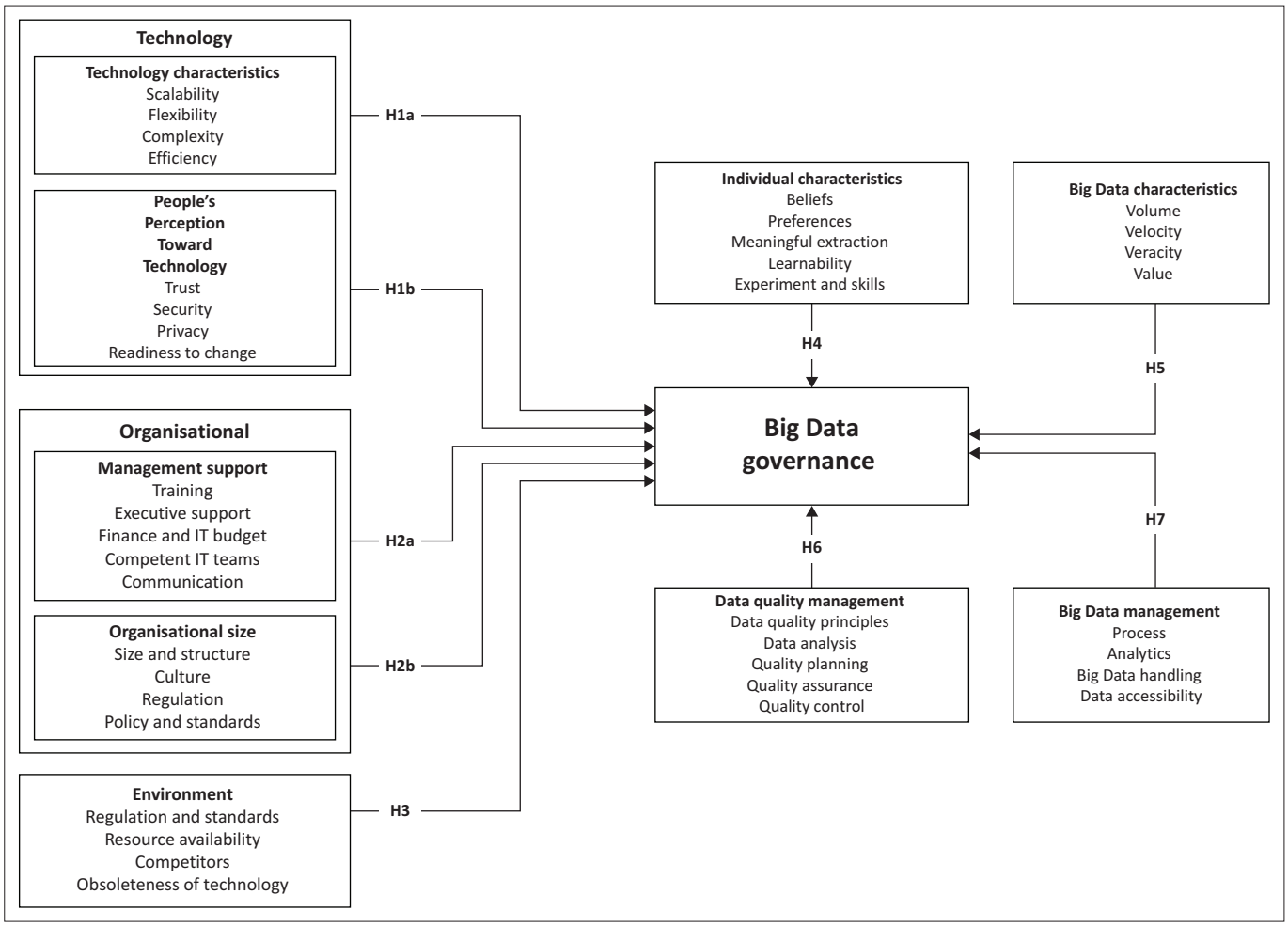
Big Data management:

H7: Processes, analytics, storage and accessibility support governance and service delivery improvements.

These constructs collectively form hypotheses (H1–H7) to understand their role in enhancing Big Data governance.

Operationalisation of hypotheses

Table 1 illustrates the derived hypotheses from the study based on the factors of the conceptual model.



Source: Adopted from Tornatzky, L.G. & Fleischer, M., 1990, *The processes of technological innovation*, Lexington Books, Lexington, MA
IT, information technology.

FIGURE 1: Big Data governance conceptual model.

Methodology

This study adopted a pragmatic paradigm that provided a deeper understanding of the research questions and findings, allowing for a balanced assessment of the opportunities and challenges related to the study problem (Windmill 2021). The research was conducted in two phases. Initially, a quantitative approach was used to identify the factors governing Big Data for improving service delivery in the South African public sector, based on existing literature. These factors served as the foundation for developing a Big Data governance model, leading to the formulation of hypotheses. The quantitative approach was employed to assess and quantify the relationships between independent and dependent variables, with statistical methods used to test the hypotheses.

A survey research strategy was chosen, and data were collected through a close-ended questionnaire. The study targeted employees in the public sector who work with large volumes of data within the Limpopo district municipality. The participants were selected using simple random sampling based on accessibility, approachability and the presence of an IT directorate with enough employees for the quantitative study. A survey link was sent to 210 respondents who met the inclusion criteria, yielding 165 completed responses, resulting in a response rate of 78%. Of these, 143 datasets were usable. A designated contact person was identified at the data collection sites to assist with distributing the survey link. The second phase involved a qualitative approach, where users of Big Data in government sectors were randomly selected to validate the model.

Ethical considerations

An application for full ethical approval was made to the Faculty of Information and Communication Technology, Faculty Committee of Research Ethics, Tshwane University of Technology, and ethics consent was received on 11 November 2021. The ethics approval number is FCRE/ICT/2021/09/004(1).

Discussion and results

Descriptive analysis was employed to examine the demographics and situation variables of the respondents; thereafter, correlation analysis was used to assess the relationships between factors, while regression analysis was utilised to evaluate the model's predictive capability and the

TABLE 1: Operationalisation of hypotheses.

Hypotheses	Measuring items
H1a:	Technology factors because of technology characteristics influence Big Data governance to enhance service delivery.
H1b:	Technology factors because of peoples' perceptions influence Big Data governance to enhance service delivery.
H2a:	Organisational factors because of management support influence Big Data governance to enhance service delivery.
H2b:	Organisational factors because of organisation size enhance Big Data governance to enhance service delivery.
H3:	Environmental factors influence Big Data governance to enhance service delivery.
H4:	Individual factors influence Big Data governance to enhance service delivery.
H5:	Big Data characteristics influence Big Data governance to enhance service delivery.
H6:	Data quality management factors influence Big Data governance to enhance service delivery.
H7:	Big Data management factors (processes, analytics, storage and accessibility) influence Big Data governance to enhance service delivery.

individual contributions of each construct to the overall model. The overall reliability result of the questionnaire was 0.939 on 42 items, which is above the acceptable criteria of 0.7. The model overall prediction for Big Data governance to improve service delivery was R^2 = 0.709. To achieve the study's objective, the respondents were asked about their own views about Big Data governance in enhancing service delivery in the South African public sector.

This study involved a sample population of 201 participants. The sample method by Krejcie and Morgan (1970) was used. The participants were public sector employees working in IT or data consumers. Simple random sampling was used for the study.

Correlation analysis of factors

Table 2 represents the finding of the contribution of the independent variables towards overall prediction of the model. The correlation results indicated that there is high correlation between factors that might suggest multicollinearity. Therefore, regression analysis included the measure of the variance inflation factor (VIF) to check for collinearity (Cohen et al. 2018). The rule of thumb states that for collinearity to exist, the VIF > 10.

Interpretation of correlation results

The findings displayed in Table 2 reveal that most factors significantly contribute to the model's overall prediction, except for individual characteristics. Among these factors, technological characteristics (TechChar) had the highest contribution at 47.8% (Beta = 0.478), with t = 3.718 and p = 0.000. Following closely, environmental factors (Envt) contributed 44.5% (Beta = 0.445), with t = 3.521 and p = 0.001. Conversely, organisational characteristics exhibited the least significant contribution at 10.1% (Beta = 0.101), with t = 1.993 and p = 0.045. Additionally, individual characteristics (IndCh) were found to have an insignificant contribution, with Beta = 0.074 and p = 0.586.

Hypotheses testing

The hypotheses were tested based on regression and correlational analyses, with the results displayed in Table 3.

TABLE 2: Factors coefficients.†

Model	Constructs	Unstandardised coefficients		Standardised coefficients	*t*-value	Sig.	Collinearity statistics	
		B	SE	Beta			Tolerance	VIF
1	(Constant)	4.546	0.966	-	4.707	0.000	-	-
	TechChar	0.405	0.109	0.478	3.718	0.000	0.558	1.793
	PPer	0.270	0.132	0.106	2.049	0.021	0.395	2.533
	MgtSup	0.304	0.095	0.156	3.206	0.003	0.389	2.568
	Org	0.239	0.120	0.101	1.993	0.045	0.412	2.426
	Envt	0.522	0.148	0.445	3.521	0.001	0.408	2.449
	IndCh	-0.073	0.133	-0.074	-0.546	0.586	0.350	2.856
	BDC	0.237	0.104	0.182	2.278	0.024	0.320	3.120
	DQMgt	0.217	0.109	0.144	1.994	0.036	0.261	3.826
	BDMgt	0.275	0.125	0.173	2.199	0.031	0.291	3.440

VIF, variance inflation factor; Sig., significance; SE, standard error; TechChar, technological characteristics; PPer, people's perception of technology; MgtSup, management support; Org, organisational; Envt, environmental factors; IndCh, individual characteristics; DQMgt, data quality management; BDC, Big Data characteristics; BDMgt, Big Data management.

†, big data governance to enhance service delivery (dependent variable).

TABLE 3: Hypotheses testing summary.

Hypothesis	*t*-value	Results	Action
H1a: Technology factors because of technology characteristics influence Big Data governance to enhance service delivery.	3.718	p = 0.000 < 0.05	Accepted
H1b: Technology factors because of peoples' perceptions influence Big Data governance to enhance service delivery.	2.048	p = 0.021 < 0.05	Accepted
H2a: Organisational factors because of management support influence Big Data governance to enhance service delivery.	3.206	p = 0.003 < 0.05	Accepted
H2b: Organisational factors because of organisation size enhance Big Data governance to enhance service delivery.	1.993	p = 0.045 < 0.05	Accepted
H3: Environmental factors influence Big Data governance to enhance service delivery.	3.521	p = 0.001 < 0.05	Accepted
H4: Individual factors influence Big Data governance to enhance service delivery.	-0.546	p = 0.586 > 0.05	Rejected
H5: Big Data characteristics influence Big Data governance to enhance service delivery.	2.278	p = 0.024 < 0.05	Accepted
H6: Data quality management factors influence Big Data governance to enhance service delivery.	1.994	p = 0.036 < 0.05	Accepted
H7: Big Data Management factors influence Big Data governance to enhance service delivery.	2.199	p = 0.031 < 0.05	Accepted

The study's hypotheses encompass various factors influencing Big Data governance and its impact on service delivery. It investigated the multifaceted influences on Big Data governance aiming to improve service delivery, revealing several key findings. In this study, factors with significant t-values and p-values below 0.05 were supported, because in hypothesis testing, a p-value below 0.05 indicates that the results are statistically significant. This is indicated in Table 3. The hypotheses testing highlights the critical factors influencing Big Data governance. Technology factors (H1b, H1b), including robust system capabilities and user perceptions, play a significant role in effective governance. Organisational factors (H2), including management support and organisational size, also have a notable impact, demonstrating the importance of leadership and resource capacity. Environmental factors, such as regulatory requirements

and market dynamics, significantly shape governance practices, while Big Data characteristics (volume, velocity and variety) underscore the need for tailored governance frameworks. Although individual factors were not found to be significant, data quality management emerged as a crucial element, emphasising the importance of accurate and reliable data for effective decision-making and enhanced service delivery.

Conclusion

Public sector worldwide increasingly recognises Big Data as an asset. However, the lack of evidence indicating that insufficient attention to Big Data governance poses a significant challenge, especially in the public sector, is concerning. This is particularly true in the absence of proper governance models for Big Data initiatives. This study reaffirmed the importance of enhancing decision-making in Big Data governance by uncovering new insights and suggesting proactive strategies to address both present and future opportunities and challenges. Moreover, the research identified a gap in the literature related to business issues surrounding Big Data challenges, especially in areas such as data modernisation and democratisation, where governance could play a crucial role.

The study aimed to identify the factors influencing Big Data governance in South Africa's public sector. The most significant factor identified was data quality management. Key elements of data quality management, such as data quality principles, analysis, planning, quality assurance and control, were found to be critical for effective Big Data governance. These elements help increase trust in data, improve productivity, reduce costs, ensure compliance and enhance decision-making and innovation, ultimately enabling new, citizen-centric services.

In conclusion, the study provides valuable insights into the factors essential for effective Big Data governance, emphasising the importance of data quality management. Future research should replicate this study in other contexts to strengthen the identified factors and further validate the findings. Additionally, collaboration with academics in developing countries could broaden the understanding of Big Data governance. As knowledge in this field grows, it will be crucial to balance the potential of Big Data with the need for stronger governance to protect both organisations and individuals whose data are being managed.

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Competing interests

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

Authors' contributions

P.P.M. was a primary investigator and a main author as a doctoral student. T.S.A. and B.M.K. contributed to the conceptualising, reviewing, and editing of this journal article as supervisors.

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Data availability

The data that support the findings of this study are available from the corresponding author, P.P.M. upon reasonable request.

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