



Structuration theory perspective of Big Data in a typical South African municipality

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Background: Big Data, sourced from various digital sources, offers valuable insights for better decision-making, and organisations are implementing Big Data technologies to improve their services. This article is about how the City of Tshwane (CoT), a South African metropolitan municipality is using data collected from its various information and communication technology (ICT) projects to improve decision-making.

Objectives: The study aims to identify the type of Big Data generated by South African municipalities and to establish ways in which knowledge, expertise and suitable management techniques impact the efficient application of Big Data in these municipalities.

Method: A qualitative approach, a case study method and Semi-structured interviews were deemed fit to collect data while thematic analysis was employed to identify patterns and themes associated with participants' experiences. Structuration Theory was used to analyse existing social structures that govern how Big Data is used in the CoT.

Results: There is a lack of data integration and a Big Data management system in the CoT. However, the CoT is ready to embrace Big Data and it is currently establishing a unit to effectively analyse collected data.

Conclusion: Big Data's potential for developing effective data management systems has garnered significant attention in the public sector and the CoT is also ready to fully adopt and implement these technologies.

Contribution: South African municipalities can effectively utilise Big data by establishing skilled staff, good infrastructure and suitable policies for efficient data generation and interpretation.

Keywords: Big Data; South African municipalities; CoT municipality; structuration theory; Decision making.

Introduction

Big Data refers to enormous datasets with a complex structures that are challenging to manage (Yaseen & Obaid 2020), and the process of analysing these huge data sets is called Big Data Analytics (Hemlata & Gulia 2016). Global corporations and government agencies are currently enforcing and extending big facts technology because they realise the capacity benefits of adopting and using enormous amounts of data (Trom & Cronje 2019). Countries such as Singapore, Malaysia, France, Japan, Great Britain, Australia, China and South Korea are also utilising Big Data projects to provide the government with insights into citizens' needs and priorities (Anna & Nikolay 2015; Hajirahimova & Aliyeva 2017).

While most of these discussions are practice-driven, organisations are investigating how Big Data may be effectively used to create and extract value for individuals, businesses, communities and governments (Manyika et al. 2011). Big Data is becoming a tool that can forecast the chance of an event in addition to studying trends (Hassani & Silva 2015). Among the examples are web analytics and machine learning, which are used to predict disease outbreaks, individual behaviour, traffic patterns and customer preferences (Haas, Pentland & George 2014).

Although South African municipalities have adopted a number of approaches in order to achieve more efficient service delivery, the implementation of these policies has been hindered by political inertia, resistance from municipal organisations and insufficient collaboration within local government (Joseph & Williams 2022). The City of Tshwane (CoT) website (www.e-tshwane.gov.za) states that the municipality has made investments in initiatives related to smart cities. One of these initiatives is the usage of an Internet portal that enables citizens to contact city

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workers from any location. Additionally, residents can apply for water and energy connections, upload meter readings and pay for services using the platform. These initiatives vary across different regions and government departments and have the potential to produce mass volumes of data that can assist the city's decision-making process. Despite these smart city initiatives and projects, the city is yet to embrace the full opportunities created by modern technologies and data solutions to build a data-driven service delivery (Mail and Guardian, Ina Cilliers 2022).

Visser and Twinomurizi (2004) stated that the application of information and communication technology (ICT) in South Africa can improve municipal service delivery and strengthen governance. This exposes a major gap in addressing requisite knowledge, skills, attitude and appropriate management practices and enabling information technology (IT) architecture resources to access, interpret and use Big Data for decision-making for improved service delivery. However, despite the many advantages that other governments have gained from using Big Data, there is a lack of research on how South African municipalities use Big Data and how it affects their decision-making for improving community service delivery and therefore increasing citizen satisfaction and reducing service delivery protests.

This study focusses on examining the usage of Big Data derived from ICT projects within the CoT. The main aim is to investigate how data enhances decision-making processes within the municipal context. The primary research objectives are twofold: firstly, to identify the types of Big Data produced within the municipal framework, and secondly, to ascertain how the levels of knowledge, skills and appropriate management practices influence the effective utilisation of Big Data in the municipalities of South Africa.

Against the backdrop of rising protests for service delivery in South Africa, the study acknowledges the pressing need for municipalities to expedite and streamline service provision to citizens. The escalation of such protests underscores the urgency for municipalities to leverage available resources, particularly data from ICT projects, to optimise decision-making and service delivery. By delving into the specific case of CoT, the research aims to uncover insights that can potentially be generalised to inform strategies and best practices applicable to municipalities across South Africa.

The results of this study will contribute not only to the academic understanding of Big Data utilisation but also offer practical implications for policymakers and municipal administrators. Ultimately, the study aspires to offer insightful information that helps improve the productivity and effectiveness of decision-making processes in South African municipalities.

Improving governance means prioritising the needs of the people by showing impact, relevance, social significance and

innovation for improved services. It also goes beyond conventional frameworks or restrictions. Information and communication technology use in municipalities is alluded to improve governance through increased efficiency, accountability, transparency and reduced corruption. The CoT could tap into these ICTs such as readily available data generated with the assistance of their ICT projects that could assist in realising some of these mandates. This is imperative as data that are readily available could assist in alleviating some of their service delivery challenges.

Literature review

Big Data

Big Data is generated by technological devices such as laptops, mobile phones and personal sensors (Mnoney & Van Belle 2016). Furthermore, Big Data is being used widely in a range of disciplines, including engineering, operations management, finance, genomics, health care and the industrial Internet. To extract patterns and trends from these enormously large socioeconomic datasets, both within and between them, powerful computational tools are required (George et al. 2014). The basis is to extract insights from the existing data sets to make informed decisions.

The broad application of Big Data is facilitated by the industrial Internet, finance, operations management, engineering, genomics and health care. Robust computational instruments are required to identify patterns and trends within and across these enormously large socioeconomic datasets (Maciejewski 2017). Companies use advanced analytical techniques to process large and complex datasets to discern patterns, behaviour and trends. By employing these predictive algorithms, Big Data can anticipate user preferences based on historical data, interactions and contextual information (Dass & Prabhu 2022). One example from the private sector is Netflix, the most popular American entertainment corporation that specialises in providing its users with online on-demand streaming video. Netflix, an online streaming media platform used Big Data to enhance customer experience, with the aim of retaining viewers and encouraging them to continue to engage with its programming variety. The company constantly analyses viewer behaviour, identifying patterns and personal preferences, including content consumption. Through Big Data, Netflix has the ability to create and broadcast content tailored to demographic and consumer preferences, ensuring long-term viewer engagement (Shahid & Sheikh 2021). Netflix began to present itself as a content creator more recently, rather than merely a distribution channel (Mixon 2021).

Opportunities in the commercial and public sectors of administration are similar. Public authorities must acquire data science skills such as machine learning, programming, modelling, statistics, data management and natural language processing to fully harness Big Data's potential in the public sector (Maciejewski 2017). Additionally, the public sector

might need to adopt a distinct approach from that of the private sector, which would entail tailoring strategies to the goals, objectives and policies of the public sector.

Big Data in government

Governments are also trying to use Big Data in their operations like other business organisations to improve their efficiency and effectiveness (Khine & Shun 2017). It is therefore essential to increase understanding of Big Data and the role of Big Data and how governments might profit from massive datasets.

The United States of America is the nation that has adopted Big Data the fastest. The Big Data Research and Development Initiative was started by the Obama Administration (www.obamawhitehouse.archives.gov) in 2012 in order to create technologies, educate data scientists and support open data in order to guarantee that Big Data is utilised in ways that advance the administration's fundamental values, such as civil liberties and privacy. In order to capitalise on the advantages of Big Data sources, the administration consequently unveiled a strategic plan that describes new capabilities and guidelines (Marzullo 2016). Meanwhile, other nations have adopted Barack Obama's Big Data plan, including Australia, the UK and Italy (Veljković, Bogdanović-Dinić & Stoimenov 2014), advancing the idea of optimising the value of open data by recycling information from the public sector (Baek & Park 2015).

Countries such as Singapore, Malaysia, France, Britain, Japan, Australia, China and South Korea are also leveraging big data technology to gain insights into citizens' needs and preferences, improve governance, and drive socio-economic development (Anna & Nikolay 2015; Hajirahimova & Aliyeva 2017). Governments and other organisations are applying several ways such as advanced analytics to Big Data for anticipating critical cases, detecting and diagnosing infected patients, predicting outbreaks and providing decision support for determining which patients would benefit from a particular treatment, preventing the spread of the disease and organising future actions (Mehta & Shukla 2022). The use of Big Data has been extraordinarily beneficial in monitoring and predicting the transmission of ailments such as influenza, Ebola and the contemporary coronavirus disease 2019 (COVID-19) pandemic (Corsi et al. 2021). In China, the Big Data system is implemented in social credit systems and surveillance (Chen & Cheung 2017). Each person can be tracked, profiled and rated by the system based on standards set by the government, which may have negative social and legal repercussions. It is essentially a widespread, all-encompassing system of processing personal data, demonstrated by the extensive gathering and use of personal data with the express goal of the Chinese government to utilise Big Data technology to its fullest extent. In Singapore, the government uses Big Data for urban planning through its 'Smart Nation' initiative. It collects and analyses big data on traffic flow, public transportation and environmental

conditions to improve city living (Ang-Tan & Ang 2022). Also, the National Health Service (NHS) in the UK employs Big Data to manage patient records, optimise health care resources and improve patient outcomes (Lu & Keech 2015).

By harnessing the power of Big Data, other public sector organisations can also improve economic growth and enable better decision-making and opportunities. According to Kalema and Mokgadi (2017), an organisation's readiness to use Big Data is influenced by a number of factors, including scalability, ICT infrastructure, management support, organisational size, financial capabilities, culture and technological skills of consumers, vendors and staff. For example, the ability of the organisation's processes and systems including hardware, software and networking components to scale and handle the high volumes of data that come with Big Data initiatives may affect the adoption of Big Data (Baig, Shuib & Yadegaridehkordi 2019). Research has demonstrated the significance of top-level management backing in advancing the adoption of new technologies (Lutfi et al. 2020). Furthermore, the availability of financial resources to invest in the acquisition, deployment and maintenance of Big Data technologies, organisational culture, attitudes, values and openness to change, innovation and data-driven decision-making and the data-related skills among the workforce may delay the adoption of Big Data in organisations (Lunde, Sjusdal & Pappas 2019; Oesterreich et al. 2022).

However, according to Ganeshto (2023), South Africa is also leading with Big Data adoption in the year 2023. For instance, Gwebityala, Migwalla and Myburgh (2022) discussed projects enhancing government service delivery vehicle routes and leveraging Big Data tools to uncover R240 million in additional annual revenue for a mid-sized municipality.

Although Big Data provides organisations with more decision-making resources and insights, it also brings big challenges and in order to capitalise on vast amounts of incoming data, organisations will have to address these challenges. These challenges include those related to complexity, security, privacy, processing, storage and analysis as well as talent requirements and technical issues (Katal, Wazid & Goudar 2013; Kim, Trimi & Chung 2014; Löfgren & Webster 2020). Table 1 summarises the challenges, risks and ethical considerations associated with Big Data implementation, particularly in government settings.

There are still high expectations placed on the government in South Africa with regard to better service delivery and close citizen consultations. The government should recognise the potential of Big Data and e-services to enhance citizen service delivery in this area (Dlodlo, Olwal & Mvelase 2012).

South African municipalities

According to the South African government websites (www.gov.za; www.cogta.gov.za), municipalities are responsible for maintaining a safe and healthy environment, as well as for providing necessities such as water, trash collection and

TABLE 1: Big Data challenges.

Challenge	Description	Risk	Ethical considerations
Privacy	Securing sensitive information is a complex task because of the vast volume and variety of data it contains	Unauthorised access or breaches could lead to the exposure of personal citizens' information	It is important to balance between the advantages of data-driven governance and the protection of citizens' privacy
Security	The size of Big Data storage makes it vulnerable to cyber threats and attacks	Sensitive information can be exposed to attackers through data breaches, which involve unauthorised access or exposure of that information. This poses a major threat to national security. Furthermore, because private information is compromised, these breaches seriously jeopardise public safety	It is important for governments to allocate adequate resources and funds to establish and maintain robust cybersecurity infrastructure
Data access and sharing of information	It can be a challenge to balance open access with the need for controlled access to prevent abuse of Big Data	In the event of poorly implemented legal frameworks and policies, sensitive information has the potential for unintended and unauthorised spreading, raising the risk of inadvertent and potential disclosure of sensitive information.	It is important to have ethical data sharing that involves explicit communication about how data will be shared and for what purpose
Storage and processing issues	There is a need for scalable storage and processing solutions to handle the vast amounts of data that are generated. Many organisations may find themselves forced to consider outsourcing their data to the cloud because of the demanding nature of Big Data on networks, storage and servers	Inadequate storage solutions and mismanagement of data can lead to data loss or corruption, inefficiencies and delays	It is important to maintain the integrity of the data collected and ensure that it is accurate and consistent
Analytical challenges	Advanced analytical tools and techniques may be needed to analyse a variety of complex Big Data issues	Incorrect analytical algorithms can introduce biases, resulting in the misinterpretation of assessment results that can lead to incorrect decisions	It is important to have ethical practices that address bias in algorithms to ensure fair and unbiased results
Skill requirements and technical challenges	The insufficient skilled personnel to manage complex Big Data technologies and integrate new technologies into existing systems can pose significant challenges in Big Data implementation	Lack of skills can lead to ineffective or misuse of advanced technology	It is important to have ethical considerations that include investment in education and training programmes to address skills gaps

Source: Naeem, M., Jamal, T., Diaz-Martinez, J., Butt, S.A., Montesano, N., Tariq, M.I., et al., 2022, 'Trends and future perspective challenges in big data', in *Advances in Intelligent Data Analysis and Applications: Proceeding of the Sixth Euro-China Conference on Intelligent Data Analysis and Applications*, Springer Singapore, Arad, Romania, 15–18 October, 2019, pp. 309–325; Guo, J., Yu, H., Xing, S. & Huan, T., 2022, 'Addressing big data challenges in mass spectrometry-based metabolomics', *Chemical Communications* 58(72), 9979–9990.; Khan, N., Alsaqer, M., Shah, H., Badsha, G., Abbasi, A.A. & Salehian, S., 2018, 'The 10 Vs, issues and challenges of big data', in *Proceedings of the 2018 international conference on big data and education*, pp. 52–56; Martin, K.E., 2020, 'Ethical issues in the big data industry', in *Strategic Information Management*, pp. 450–471, Routledge, London

sanitation. Three categories of municipalities are established by the Constitution. South Africa has 278 municipalities total, made up of 226 local, 44 district and 8 metropolitan municipalities (*Local Government: Act 117 of 1998, the Municipal Structures Act*). Their priorities are service and infrastructure provision, as well as the expansion of local economies. These municipalities are categorised into the following:

1. Category A: Metropolitan municipalities

This municipality is the only one in its region with exclusive municipal executive and legislative authority. These metropolitan municipalities are broken into wards and their role is to coordinate the delivery of services in the area. The metropolitan municipalities are the CoT, Buffalo City, Ekurhuleni Metropolitan Municipality, Mangaung Municipality, City of Cape Town, Nelson Mandela Bay Metropolitan Municipality, City of eThekweni and the City of Johannesburg.

2. Category B: Local municipality

This municipality, which is part of a category C municipality, shares legislative and executive responsibility within its boundaries. All municipal duties not delegated to the district fall under the purview of the local governments, especially providing local services. Areas outside of one of the six metropolitan municipal areas are under the jurisdiction of local municipalities. There are 226 wards in total that make up these local municipalities. The responsibility of representing the residents of each ward falls on a ward councillor.

3. Category C: District municipality

This municipality oversees an area that is home to multiple municipalities and possesses both legislative and executive

branch authority. District municipalities are in charge of more general issues including public transportation, large-scale water and electricity supply, infrastructure development and integrated planning. District municipalities are made up of numerous local municipalities that are part of a single district. Four to six nearby municipalities often make up a district council. Even though metropolitan municipalities are fully liable for them, district and local municipalities jointly oversee the development and provision of all local services inside the metropolitan area. This is particularly true in extremely rural areas, where district municipalities will be in charge of development and providing services.

According to the South African Constitution, municipalities are accountable for ensuring that all residents have access to basic necessities such as clean water, sewage disposal, garbage collection, electricity and gas, municipal health services, municipal roads and stormwater drainage, street lighting, and municipal parks and recreation. The main services of the South African municipalities are (www.gov.za):

1. Providing local communities access to transparent and democratic governance.
2. Ensuring the long-term provision of services to communities.
3. Encouraging a healthy and secure environment.
4. Promoting the involvement of neighbourhood groups and communities in local government affairs.

The study aims to close the gap by urging the CoT to enhance the implementation of digital technologies to improve service provision in various urban communities under its jurisdiction. Many municipalities in South Africa lack the capacity to

bridge the digital divide. According to Maphangwa and van der Waldt (2023), smart cities are not particularly covered under the basic legal framework that governs ICT in South Africa. It is evident that there are rules and regulations that are needed to fill this and that there are currently discussions between partners regarding barriers to optimising data assets and the emergence of a solution.

City of Tshwane municipality

According to Statistics SA (2011), the largest municipality in South Africa in terms of land area is the CoT, a metropolitan municipality located in Pretoria. According to Gross Domestic Product (GDP), Tshwane is the second largest in Gauteng province and one of the six largest metropolitan municipalities in South Africa. Of Gauteng's 19 055 km², the Tshwane region occupies 6368 km² and is home to about 2.9 million people. Tshwane has 210 council members, 105 wards and is divided into seven regions. As part of its efforts to become a smart city, the CoT implemented several projects to better serve its citizens. The web portal e-Tshwane is one of the initiatives. Apart from making payments for services, electronically uploading meter readings, requesting clearance certificates, requesting a water or electricity connection and other tasks, it enables citizens to electronically be in contact with the city from anywhere. The e-Tshwane WhatsApp channel expands its services. This eliminates the need to download a new app and lets citizens communicate using one that most people already have. Wi-Fi scheme offering 1 GB of free data per person per day across 1100 hotspots throughout the city. This makes it possible for citizens to take advantage of possibilities that would normally cost money, including applying for a job or doing online education.

The CoT established projects such as the e-Tshwane Internet portal as part of its aspirations to become a smart city. By utilising cutting-edge technologies and data analytics, smart cities enhance the standard of living for their residents, increase the efficiency of services and infrastructure and promote long-term, sustainable economic growth (Gracias et al. 2023). It is also crucial to note that different government agencies and regions have different experiences with the implementation and success of these initiatives. Moreover, continuous efforts are made to develop and enhance these digital services, and these initiatives have the potential to generate large amounts of Big Data that can be utilised to enhance municipal decision-making (www.gov.za: Mandiwana 2022).

The CoT Metropolitan Municipality's Group Head for Shared Services, Musa Khumalo, presented the city's smart city initiatives in 2021. He also covered e-Tshwane statistics, future plans for e-Tshwane, how the city has outperformed many other municipalities and his vision for the city in 2040. He provided an illustration of how these initiatives have already benefited the city, showing how it has been able to collect R90 million in rates per month through its electronic platform, add 6000 new customer accounts on average each

month, process over 29 000 payments through the system each month, bringing in R80 million in revenue and process over 68 000 electronically uploaded meter readings per month (Khumalo 2021).

Underpinning theory

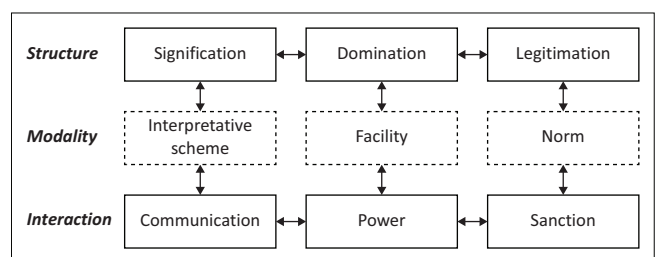
Information systems (IS) study how people, groups, organisations and society use and build information systems in actual social and organisational contexts. Sociology theories have widely been used to support various IS studies (Mkhomazi & Iyamu 2013). This research used Structuration Theory (ST), a theory that was developed by Anthony Giddens, a British sociologist who defines it as a social theory that focusses on the agents and structures that produce and reproduce actions (Giddens 1984). According to Giddens (1984), Structuration Theory provides a framework for understanding the connection between structure and agency in social systems. The basic principles of Structuration Theory are that social action cannot be fully explained by either agency theory or structure theory and that social systems are created and reproduced through social interaction. However, it acknowledges that social systems create the rules that actors have to adhere to and that these structures can only be strengthened by compliant behaviour.

Agency and structure

According to Giddens (1984), 'structure' refers to the enduring patterns of social relations, norms and rules that shape and constrain human behaviour within a social system, and 'agency' refers to the capacity of individuals to act, make choices and influence social outcomes within the framework of social structures. Giddens emphasises that structure is a central concept that encompasses both the organisational aspects of society and the regularities in social practices whereas that agency is not merely the result of individual intentions but is fully linked to the broader social context.

Duality of structure

The actions of the agent and structure are interdependent and produce and reproduce across time and this is a result of duality. The duality of structure in Structuration Theory implies that structures not only constrain human agency but are also continually reproduced and transformed through the actions of individuals. Signification, dominance and legitimation are the three aspects of duality of structure that



Source: Giddens, A., 1984, *The constitution of society: Outline of the theory of structuration*, Polity Press, Cambridge

FIGURE 1: The dimensions of the duality of structure.

are frequently used as interpretive frameworks to reflexively maintain communication within social systems. Modalities highlight ways in which the duality of structure works out in practice. For instance, institutions of domination mean that power resources are available as facilities to some agents (e.g. managers) and not others. Moreover, the ways that facilities are applied and maintained help reproduce domination in society and organisations (Giddens 1984). The modalities (interpretative schemes, facilities and norms) connect the process of interaction (communication, power and sanction) with the structural elements (signification, domination and legitimation) of social systems (Giddens 1984), as shown in Figure 1.

The concepts of the duality of structure can be described as follows:

- *Signification* – the process through which meaning is created and communicated in social interactions. Signification involves the use of symbols, signs and language to convey shared meanings within a society.
- *Domination* – refers to the unequal power relationships within a social structure. This means that certain individuals or groups have the ability to exercise influence and control over others.
- *Legitimation* – refers to the process by which social structures and practices gain legitimacy and acceptance in a society by maintaining the perceived appropriateness and validity of certain norms and rules.
- *Interpretative scheme* – refers to the set of shared understandings, meanings and interpretations that individuals use to make sense of their social world. This may include culturally and socially defined frameworks through which people interpret reality.
- *Facility* – refers to the physical or virtual tools, resources and infrastructure that enable individuals to carry out their activities within a society.
- *Norm* – refers to a shared expectation or standard of behaviour that guides individuals in their actions and interactions, prescribing what is considered acceptable or appropriate in a given context.
- *Communication* – refers to the process through which social actors convey meaning, coordinate activities and create shared understanding.
- *Power* – refers to a person's or a group's ability to influence and control social practices and structures.
- *Sanction* – refers to the consequences or penalties associated with adhering to or deviating from social

norms and rules. Sanctions can be in the form of rewards or punishment and play a role in maintaining social order.

Table 2 illustrates the relationships between the key components of Structuration Theory and how they apply to Big Data in South African municipalities. As indicated in the table, in order to make sense of encounters, human actors use *interpretative* systems when they *communicate*, and these interactions reproduce over time and influence the structure of *signification*. Similarly, the *facility* to distribute resources is enacted in the exercise of *power* and generates and reproduces social structures of *domination*. For example, efficient and effective communication may draw practical assumptions about the effectiveness of using Big Data and at the same time, this effective communication among humans may reproduce and modify these assumptions.

Structuration Theory aligns seamlessly with the research objectives of investigating the use of Big Data within the CoT municipality. This theoretical framework offers a complete lens through which to recognise the complicated dynamics between social structures and individual agencies. It also enables research objectives by providing a theoretical framework that captures the complex interactions between the various organisational aspects of Big Data usage and stakeholder agencies in the CoT. Furthermore, ST allows for an exploration of how Big Data, once fully implemented, may feedback into and modify the existing structures. Structuration Theory enriches the research objectives by offering a theoretical framework that captures the complex interplay between the institutionalised aspects of Big Data usage and the agency of those involved within the CoT municipality.

Research methodology

A qualitative research approach with open-ended semi-structured interviews was deemed appropriate in order to achieve the objectives of this study. Semi-structured open-ended interviews are a valuable research methodology that can provide deeper insights into the dynamics of Big Data use and provide windows into lived experiences, interpretations and processes of adaptation with individuals in the CoT Municipality revealing the complex interplay between social structures and agency in the Big Data sphere.

In order to determine how municipalities in South Africa are using Big Data collected from their various ICT projects to

TABLE 2: Dualism of Big Data implementation in South African municipality.

Structure	<i>Signification</i>	<i>Domination</i>	<i>Legitimation</i>
	The value of Big Data and relative advantage of using Big Data	How Big Data is used to improve decision making	Rules and regulations of Big Data in the municipality
Modality	<i>Interpretive scheme</i>	<i>Facility</i>	<i>Norm</i>
	Practical assumptions about the effectiveness of using Big Data. Underlying beliefs about the practice of using Big Data. Perceived role of technology in accomplishing the practice.	Tools and procedures for accomplishing Big Data tasks. Performance measurement system in the municipality. Communication and consultation.	Big Data public interest disclosure. Freedom of information. Public Big Data municipality documents and observations in a written format.
Interaction	<i>Communication</i>	<i>Power</i>	<i>Sanction</i>
	Communication between management and staff For efficient and effective operation	The role that management plays in promoting Big Data usage	Big Data tools availability

Source: Iyamu, T. & Nunu, K., 2021, 'Healthcare data management conceptual framework for service delivery', *Education and Information Technologies* 26(3), 3513–3527

tap into the readily available Big Data resources for better decision-making, the CoT municipality was selected for this study. The CoT has experienced service delivery protests. These protests and related crimes are mostly caused by poverty, unemployment, widespread public servant corruption, nepotism, a lack of governance and improper use of state funds. The key factors that drive service delivery protests and related crimes in the Tshwane area are, for example, poverty, unemployment, rampant corruption by public servants, nepotism, a lack of governance and mismanagement of state funds (Mokhomole, Khosa & Olutola 2022). Also, with the high number of technology initiatives to transform the city into a smart city, the CoT allows for an assessment of the existing technological infrastructure supporting Big Data initiatives.

A case of the CoT's Department of Economic Development and Spatial Planning was selected as the unit of analysis. This department is responsible for the processing of various land development and related applications as well as supporting client service in support thereof. It also ensures that the urban design accurately captures the idea of the capital city in order to guarantee seamless service delivery that is both approachable and sensitive to the demands of the locals. The department was selected as the primary unit of analysis because it has the authority to make decisions for the CoT based on accessible information.

The interviews included practitioners from three separate roles. The use of individuals from different positions ensures that interviews capture various aspects of Big Data integration, from operational challenges to strategy to the decision-making process. Two interviews were conducted in person at the CoT offices in Pretoria using the researcher's personal recording device, while two were recorded using Microsoft Teams. Despite the fact that in-person interviews made it possible to better interpret non-verbal clues like body language and facial emotions, organising in-person interviews may pose logistical challenges, especially if participants are located in different geographic locations. Other participants can opt to join virtual interviews from the comfort of their own environment which contributes to a more relaxed atmosphere and potentially enhancing their comfort level in sharing information. Virtual interviews are vulnerable to technical issues, such as connectivity problems, audio or video disruptions, or platform-related challenges. These issues can disrupt the flow of the interview and affect the quality of communication. To protect their anonymity, the participants were coded as Participant 1, Participant 2 and Participant 3. A pilot test was conducted with one interviewee to allow the researchers to enhance the reliability and validity of the interview protocol, leading to more effective data collection during the actual interviews.

To analyse the data collected, the study used thematic analysis, a widely used method of analysis in qualitative research. It is used commonly because of its flexibility in allowing for a rich, detailed and complex description of data. The data obtained from both in-person and virtual interviews was organised and themes were generated. The data were

analysed by means of identifying topics, ideas and patterns of meaning that come up repeatedly within data. This study does not have specific plans or the capability to use qualitative data analysis software.

The credibility of the data of this study will be examined through a thorough engagement with the participants and checking the findings with them. An enquiry audit will be done to establish dependability by reviewing and verifying that the data analysis and research methodology are sound and that there is no bias in the interpretation of the findings.

Results and findings

Thematic analysis, a popular approach of analysis in qualitative research, was utilised in the study to analyse the data collected. It is commonly utilised because it is sufficiently adaptable to allow for a rich and complex description of data and because it can be used for a wide range of research questions and themes (Braun & Clarke 2012). Themes, concepts and semantic patterns that appear repeatedly in the data were identified through analysis by looking for these patterns of meaning. Determining the usage of Big Data in the CoT was the goal of the interviews.

To protect their anonymity the instructors were coded as Participant 1, Participant 2 and Participant 3 as shown in Table 3.

Structure

Significance

All participants have confidence in the value the full implementation of Big Data frameworks can provide to the CoT. There is a common belief that as soon as the Big Data projects are implemented, the services that CoT is providing, internally to its own employees and externally to the public, will improve. This indicates that data holds a critical role that is not fully realised within the organisational structure:

'... [Y]ou only use it for one purpose, not knowing it can be integrated or it can be analyzed. It can be synthesized into something that is more meaningful to improve the policy strategy of the city and even budgeting.' (P2)

'The purpose of creating a data management and analytics environment is to make sure that decision made are accurate and there is up to date information at their disposal' (P3). The findings also highlight the significance of limited resources and capital as challenges that hinder innovation and creativity within the city. It emphasises the importance of financial support in fostering innovation and technological advancements and establishing structured mechanisms for guiding and regulating interactions related to data usage and decision-making.

TABLE 3: Participant profile.

Name	Job title	Gender	Age group
Participant 1	Director – Business Planning and Portfolio Assessment	Female	35–45
Participant 2	Director – Strategy and Research	Male	40–45
Participant 3	Director – Enterprise Information Management	Male	50–60

Domination

There is a lack of data integration in the CoT and data are not accurately being used to assist in identifying or solving some of the issues that the city is having:

'... You can utilize the data to make some decisions. That is fine. But I do not think it is done research. We also need to integrate data nationally. Like the SAS data, like your SAS data, police data to know where crime is happening in the city. What are the drivers of that?.' (P2)

The concerns expressed by participants regarding the current inaccessibility of data indicate a dominant situation where existing systems or barriers prevent smooth data access. This dominance might stem from established protocols or limitations in data accessibility within the organisation. However, Big Data's perceived benefit was seen to encourage creativity among participants:

'When you offer services. our political, principles can decide that as much as there are issues of Wi-Fi waste, if I can just even go straight to it and so forth, they can decide, okay, let us just focus on water.' (P1)

The dominance of limited resources suggests a prevailing situation where financial constraints dictate the extent of innovation and creativity within the city. This dominance might stem from budgetary restrictions or prioritisation of other municipal needs over technological advancements.

Legitimation

There are basic standards and processes through which employees should monitor and manage their daily operations when accessing and using data within the city. Among the participants, there is a general concern on how data are currently not accessible for decision makers to be given appropriate and accurate integrated information that will make them spend, invest or avoid spending unnecessarily:

'Like I said, there's some environmental regulations that we need to adhere to when it comes to data and information, we need to protect data that must be protected. We need to make accessible and available data that must be there. Secondly, we will have rationalized.' (P3)

Acknowledging compliance with environmental regulations and data protection standards legitimises the necessity for data safeguards. It reinforces the importance of adhering to legal and ethical guidelines in managing and accessing data. Furthermore, it is legitimate to acknowledge that Big Data technologies and techniques are still in their exploration phase, which encourages experimentation and learning. This acknowledgement confirms that the municipality's investigation of new technologies is a justifiable undertaking.

Modality

Interpretive scheme

Participants sharing a belief in the potential benefits of Big Data create an interpretive scheme within the CoT that values Big Data strategies for understanding basic requirements of

service delivery, fraud prevention and overall operational improvements:

'But the problem is they are not just capturing it in the right way, utilizing, analysing it and disposing and getting value out of it. This is what I think is the problem with this. Yes. And then in terms of service delivery because our research is mostly on service delivery. That is fine. Yeah. In terms of service delivery, how is this going to assist an ordinary person? That is ok. The Big Data analytics. That is ok. So, for us, we would know consumption patterns and in what areas are we, the services are being consumed more and are we doing it in an efficient way?.' (P2)

Facility

The study shows a need for increased facility or capability within the CoT to effectively address city issues, necessitating the implementation of advanced technological tools such as data integration platforms, analytics software and secure data-sharing mechanisms to facilitate seamless integration and analysis of these datasets.

Norm

The CoT is one of the biggest municipalities in South Africa and therefore has the potential to have even more data at its disposal. With the Big Data strategy that the city is working to have a single data hub, the right to access and publish that information will have to be effectively managed:

'... There is now, POPIA which then protects them. But you say, it is my data, it is the city. But they say, no, you cannot use it because we are the consumers. They are now exposing us. To some of the biggest users, probably, EXCO might want to come and then say, you are the big users, how then do you sort of plug it? So, There is a lot of things.' (P2)

The establishment of a dedicated unit reflects a norm within the CoT that prioritises the creation of structured mechanisms for data adoption and usage. It emphasises the importance of following specific procedures and systems for handling data.

Interaction

Communication

There is currently no effective communication both internally and externally regarding access and use of Big Data. Data are currently accessed individually by departments when necessary and there is a concern that these departments may perform better if data were integrated among all departments in the city:

'... [W]e do not necessarily correlate Big Data. We just collect data. So, the reason for establishing my unit was because there is no enterprise Big Data system or Big Data collection. Whatever data collection that is happening is happening in the various operational systems are operational solutions.' (P3)

However, the discussion of the benefits of data integration indicates ongoing communication within the CoT regarding the importance of combining different datasets for a more comprehensive understanding of the municipality's issues.

Power

The study revealed a power dynamic within the city administration that suggests potential barriers or obstacles in consolidating efforts to prioritise awareness and implementation. This power dynamic might involve decision-making challenges or power struggles hindering effective management coordination. However, the consistency in expressing confidence in Big Data suggests a power dynamic within the participant group that advocates for data-driven initiatives. This collective power could influence organisational decisions related to data adoption and utilisation:

‘Well, the city has got a long-term financial plan. It is a matter of getting the funding either from the national treasurer as a grant or to perhaps improve on the revenue streams that we have as a city. Like the payments, if you are going to bill people, are they going to pay? So, are you going to be able to recoup the money that you build for the services that we offer? Because that is the only way we can have revenue except from the division of revenue from the national treasurer.’ (P1)

Sanction

Sanctions involved in social interactions are enacted via the modality of norms. With the data that are largely unintegrated, the CoT has established a unit and has provided it with applications or tools to form systems and applications applicable to the adoption and use of Big Data to assist in making decisions... ‘So that is why when we establish this unit and provide it with its relevant applications or tools of trade in the form of systems or applications’ (P3). The acknowledgement of existing regulations such as POPIA and the need to balance data ownership sanctions a framework within the CoT that approves or authorises specific approaches to data management and privacy, emphasising compliance and ethical considerations.

Conclusion

Because of its potential to develop effective data management systems, the use of Big Data in the public sector has drawn a lot of attention. A systematic literature analysis was carried out in this study with the goal of gaining a thorough grasp of how Big Data is used in the municipalities in South Africa. The study has addressed the two fundamental research questions in the following manner:

The first question is ‘What type of Big Data is produced to be accessed and used by municipalities in South Africa to assist in decision-making?’. The CoT generates a massive amount of data through ICT activities such as eTshwane, aimed at facilitating municipal service delivery. These initiatives systematically store a variety of information such as customer names, addresses, payment history and preferences. As the use of these services expands, so does data collection, requiring the city to actively use these resources to improve the decision-making process.

The second question is ‘How does the requisite knowledge, skills, attitude and appropriate management practices

influence Big Data use in South African Municipalities for decision-making?’. The study found that there is a lack of data integration within various departments within the city. The city does not have a Big Data management system in place. Therefore, there is currently no evidence of how knowledge, skills and attitude influence Big Data in the CoT. The study did, however, demonstrate the city’s readiness to embrace Big Data technologies and a unit is currently being established to tackle the challenge of drawing conclusions based on the vast amount of data collected by the city through its various ICT initiatives. Presently, the Bureau of Marketing and Research (BMR) conducts data analysis. *This entity processes data from various city departments and delivers the final analysis to the city management responsible for decision-making.*

In order for the CoT municipality to successfully adopt and utilise Big Data, the city can consider establishing a governance framework to ensure that data that are generated within the city are available and ready to be used for decision-making. This includes making sure that there is necessary infrastructure to handle the increased amount of data that is generated daily, investing in advanced analytical tools and staff with the necessary skills to understand, analyse and interpret Big Data. By thoroughly addressing these considerations, the CoT municipality can lay the groundwork for the successful adoption and utilisation of Big Data.

The research findings have practical implications for municipal policymakers, highlighting the importance of integrating data sources, addressing data privacy concerns, enhancing data literacy among stakeholders and investing in robust data infrastructure for effective utilisation of Big Data in decision-making processes. The recommendations derived from this research hold promise, although the implementation may face challenges related to resource allocation, organisational structures and technology. In order to overcome these barriers, strategies that require careful consideration by municipal authorities must be considered.

The research study was limited to a single metropolitan municipality in South Africa and focussed on determining the current use of Big Data for decision-making. More research needs to be undertaken to test the relevance and value of ST to develop Big Data research frameworks in the public sector.

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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

M.P.K. conducted the research as part of a Master of Computing degree at the University of South Africa under the supervision of M.P.

Ethical considerations

This article followed all ethical standards for research without direct contact with human or animal subjects.

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Data availability

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

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