AOSIS

Data driven human resource management in the Fourth Industrial Revolution (4IR)

CrossMark
click for updates

Authors:
Tasneem Majam[1]
Dawchund B. Jarbandhan[1]

Affiliations:
[1]School of Public Management, Governance and Public Policy (SPMGPP), College of Business and Economics, University of Johannesburg, Johannesburg, South Africa

Corresponding author:
Tasneem Majam,
tmajam@uj.ac.za

Background: The Fourth Industrial Revolution (4IR) has brought with it opportunities to improve government services. Amongst the services that have benefited from the 4IR is policy-making and organisational design. However, recent studies have indicated that the 4IR and big data can improve public resources, especially human resources (HR) for instance in managing employee performance, promotions, retention and talent management by using data analytical tools to improve service delivery.

Aim: To analyse how big data can be used to optimise public service human resource management (HRM).

Setting: The South African Public Service.

Methods: This study is based on a theoretical and conceptual analysis in order to explore the complex nature of HR data analytics for the South Africa Public Service. This will be supported through a literature review in order to draw rich information to support the underlining assumptions and implications of the concepts under this study.

Results: The literature indicates that big data usage within the South African Public Service is limited. Moreover, this article found that it is important for HR specialists to use forecasting and data applications to anticipate where the supply and demand for skills would be needed in order to capacitate and improve service delivery.

Conclusion: It was concluded that big data is primarily used in the private sector with the public sector latching onto its utility in countries such as Australia, New Zealand and South Korea. The opportunity is ripe for the South African Public Service to investigate the use of big data to improve public services.

Keywords: big data; Fourth Industrial Revolution (4IR); public service; developmental state; human resource management.

Introduction

The last three decades have seen a major growth in data generated through the onset of new technologies, including the Fourth Industrial Revolution (4IR). It has been observed that the human–computer interaction has grown tremendously, and every element of the society has been impacted on by the proliferation of data. It has come to the fore that if data are managed well, governments will be able to use data to enhance good governance and improve the society. Service delivery, policy-making and organisational management can benefit from the use of data to improve governmental outcomes.

The human resource management (HRM) process within the government will also be a beneficiary of big data, where, for example, recruitment and selection, performance management and talent acquisition can benefit from analysing big data. It is imperative that government's HRM component plan to effectively use data to improve performance outcomes and promote a public service that could ultimately promote the vision of a 'better life for all'. However, this can be realised only if skilled individuals are attracted and retained in the public service so they could interpret and use data to manage the public service human resource (HR) component. This study aims to analyse how data analytics and big data can be used to optimise public service HRM. Public service priorities can only be realised when HR systems are aligned to the state's overarching objectives.

Problem statement

Given an analysis of the wide literature reviewed, it is evident that the public sector is not effectively prepared to manage data-driven HRM. Moreover, given the importance of the growing

need for data to enhance government policy-making processes and performance, a capable HRM component is a key strategic requisite (see, for example, Ubaldi, Van Ooijen & Welby 2019). While the private sector makes greater use of performance metrics using data science, the public sector lags behind. This creates a cause of concern given that the public sector is relied on to set the policy agenda for all stakeholders. Given this background, the problem statement that this article wishes to analyse is how data analytics, and big data can be used to optimise public service HRM in the South African public sector.

Conceptual clarification

The following sections provide a conceptual clarification of the concepts that underpin this article.

Fourth Industrial Revolution

In 2016, during the World Economic Forum (WEF) discussions in Davos, Switzerland, Klaus Schwab, the Chairman of the WEF articulated that the 4IR is a 'technological revolution that will fundamentally alter the way we live, work and relate to one another' (Jarbandhan 2017:65). This holds true, as it is evident that the 4IR has fundamentally changed the way we view technology. For example, driverless cars, smart robotic technology, three-dimensional (3D) printing and biotechnological advances will have a tremendous impact on communities (Van der Westhuizen 2021:83). Although the challenges of 4IR seem overwhelming, the opportunities for harnessing the power of 4IR-created technology can be used to improve the fate of humankind (Jarbandhan 2017:66).

Sihlongonyane et al. (2020:7) agree, adding that the 4IR builds on specifically the digital revolution, which incorporates the physical, digital and biological dimensions rooted in communities. It does so:

> [E]xponentially which intensifies its impact thus causing a need for the transformation of systems of governance, management and production and is marked by emerging technology breakthroughs in a number of fields, including robotics, artificial intelligence (AI), nanotechnology, quantum computing, biotechnology, the Internet of Things (IoT), 3D printing and autonomous vehicles. (Sihlongonyane et al. 2020:8)

The 4IR could be seen as having unlimited opportunities from an HRM standpoint (PriceWaterhouseCoopers [PWC] 2018:3). The 4IR presents the 'opportunity to "reinvent" HRM'. This relates to aligning to the rapid pace of change within the working environment and understanding and uniting machines, employees and systems. Furthermore, it relates to employees being flexible within the working environment, adapting to change and being incentive driven (PWC 2018:33).

Big data

Corea (2019:2) is of the opinion that data are quickly becoming 'a new form of capital, a different coin, and an innovative source of value'. It is imperative to channel the power of the big data into an efficient strategy to manage and grow the organisation to achieve success. Ozdemir and Hekim (2018:2) add that regarding the strategy, big data is related to the five 'Big Vs': volume, velocity, variety, veracity and valorisation. The five Big Vs 'demand innovation and cannot be matched by the limited scale, speed, or geographical diversity of traditional implementation science practices' (Ozdemir & Hekim 2018:2). Hence, Ozdemir and Hekim (2018:2) are of the opinion that the old ways of doing things are arguably dead, and that big data and innovation are the key. This includes, firstly, data that need to be continuously accumulated from different information sources and combined with other systems and platforms. Secondly, common reporting standards must be generated and any information that needs to be validated to assess accuracy and completeness. Finally, there is a need to assess the skills and profiles, as well as to design efficient data value chains and set the right processes required to extract value from data (Corea 2019:7).

According to the World Bank Group (2017: Internet Source), governments must strengthen technical and legal frameworks to access and use big data responsibly and need to develop combined competencies to put big data insights into action and to be responsive to citizen feedback on services and policies. Big data innovation is a 'rich process of learning that will require perseverance as solutions are tested, adapted and mainstreamed' (World Bank Group 2017: Internet Source) to ensure its success within the government organisation.

Curry (in eds. Cavanillas, Curry & Walster 2016) outlines the varied definitions of the term 'big data', as reflected in Table 1.

Big data analytics

'Big data analytics' is defined as the 'methods that are used to study and process high volume and varied types of datasets'

TABLE 1: Definitions of big data.

Big data definition	Source
'Big data is high-volume, high-velocity, and/or high-variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimisation'	Laney (2001); Manyika et al. (2011)
'When the size of the data itself becomes part of the problem and traditional techniques for working with data run out of steam'	Loukides (2010)
Big data is 'data whose size forces us to look beyond the tried-and-true methods that are prevalent at that time'	Jacobs (2009)
'Big data technologies (are) a new generation of technologies and architectures designed to extract value economically from very large volumes of a wide variety of data by enabling high-velocity capture, discovery, and/or analysis'	Industrial Development Corporation (IDC) (2011)
'The term for a collection of datasets so large and complex that it becomes difficult to process using on-hand database management tools or traditional data processing applications'	Wikipedia (2014)
'A collection of large and complex data sets which can be processed only with difficulty by using on-hand database management tools'	Mike 2.0 (2014)
'Big data is a term encompassing the use of techniques to capture, process, analyse and visualise potentially large datasets in a reasonable timeframe not accessible to standard information technology (IT)'. By extension, the platform, tools and software used for this purpose are collectively called 'big data technologies'.	NESSI (2012)
'Big data can mean big volume, big velocity, or big variety'	Stonebraker (2012)

Source: Cavanillas, J., Curry, E. & Wahlster, W. (eds.), 2016, *New horizons for a data-driven economy. A roadmap for the usage and exploitation of Big Data in Europe*, Springer, Geneva

(Gandomi & Haider 2015:138). The methods of data analytics, as identified by Acharjya and Ahmed (2016:514), include data mining and statistical analysis. According to Iqbal et al. (2017:8), big data analytics can uncover hidden patterns and identify relationships within big data using specific techniques, such as descriptive, predictive and prescriptive analytics, for analysing large volume and a variety of datasets, which are both structured and unstructured (Sun, Sun & Strang 2018:164).

Human resource management

Human resource management is defined as a 'strategic and coherent approach to the management of an organisation's most valued assets – the people working there who individually and collectively contribute to the achievement of its objectives' (Armstrong 2006:3). Human resource management can be seen as the practice, theory or field of study that is concerned with managing the factors, decisions, principles, strategies, operations, practices, functions, activities, methods, processes and procedures related to employees in public institutions, and to the elements related to employment relationships and the dynamics that flow from them (Van der Westhuizen 2021:4), keeping in mind the constantly changing technological environment. Importantly, employees must be viewed as the assets of the public institution. As such, they should be empowered through career development, personal growth and job security. Storey (1987) agrees adding that HRM involves 'treating employees as valued assets, a source of competitive advantage through their commitment, adaptability and high quality'. Hence, the idea is that employees are viewed as a means rather than objects.

Armstrong (2006:9) and Legge (1987) are of the opinion that HRM can be two-pronged, namely a hard version and a soft version of HRM. Both the authors clearly differentiate between the two-pronged approach. They explain that the 'hard' version of HRM is viewed as a process that emphasises 'the close integration of HR policies and technological advancements with business strategy which regards employees as a resource to be managed'. In contrast, the 'soft' version of HRM views employees as 'valued assets and as a source of competitive advantage through their commitment, adaptability and high level of skills and performance' (Armstrong 2006:9; Legge 1987).

Developmental state

Leftwich (2011:395) explains that a developmental state focuses on socio-economic development performance. Within this context, the institutional structures and institutions' political objectives focus specifically on development and are development-driven. Trubek (2009:31), on the other hand, adds that a developmental state's political economy recognises that the private sector may not have the capacity for effective entrepreneurial orientation, technological development, or risk-taking tendencies necessary to manipulate new opportunities and maintain competitiveness in an open-world economy. As a result, state intervention may be needed to empower the private sector by stimulating entrepreneurship,

subsidising knowledge creation, developing technologies and reducing risk (Trubek 2009:31).

In ensuring the success of developmental states, Haggard (2018:2) and Takagi, Kanchoochat and Sonobe (eds. 2019:1) agree that a mutually beneficial relationship is required between the state, the private sector, labour organisations and communities which will enhance the political and institutional foundations for long-term economic development. This requires that leaders and policy-makers have a shared commitment regarding the primary purpose of economic activity and the central goals of the developmental state. Moreover, there should be an emphasis on a set of institutional arrangements, policy expressions as well as technological advancements (eds. Takagi et al. 2019:7–8)

Research methodology

This study is based on a theoretical and conceptual analysis in order to explore the complex nature of HR data and data analytics in its utility for a developing country, that is, South Africa. A conceptual analysis includes the variables one intends to measure and the relationships one seeks to understand. In this case, the variables that the researchers seek to explore include HR data management and data analytics. Put succinctly, Bless, Higson-Smith and Sithole (2020:80) indicate that concepts (and by association the analysis thereof) serves three functions, namely:

- To facilitate communication among human beings.
- They aid in the classification of the elements of reality and their generalisations.
- From a research perspective, concepts are the building blocks of theory.

Although the intention of this study is not to build theory, its intention is to explore the relationship between the aforementioned concepts and their linkage to HRM. Moreover, a conceptual analysis involves assessing concepts, terms, variables, constructs, definitions, assertions, hypotheses, and theories for clarity and coherence in order to understand complex constructs. This will be supported through a literature review in order to draw rich information pertaining to reasonable interactions, and recognising assumptions and implications of the concepts under this study.

Legislative, statutory and policy framework supporting the Fourth Industrial Revolution in South Africa

It is important to understand the legislative, statutory and policy framework that supports the 4IR in South Africa.

National Development Plan vision: 2030

One of the aims of the National development plan (NDP 2012:190) is to promote and enhance the flow of communication and information and to ensure technological developments through Information and Communications Technology (ICT). By the year 2030, government wants to

ensure universally available and accessible ICT infrastructure that will connect the public administration and communities, promote economic development and growth, strengthen social cohesion, take advantage of the technological developments that are continuously transforming and promote innovation. Furthermore, the NDP 2030 states that the continued advancement of technological innovations plays a critical role in the growth and development of ICT (NDP 2012:326).

The National e-Strategy, as discussed in the NDP 2030, focuses on 'the transformative power of the digital technologies in many industries and sectors of the economy and hence these e-strategies lay a strong foundation for a programme in the 4IR' (4IR Presidential Commission 2018:11):

> The NDP should therefore be seen as the basis or foundation of South Africa's approach to the 4IR – meaning that our policies, strategies and plans should seek to advance the goals of an inclusive and shared growth. (4IR Presidential Commission 2018:10)

Electronic Communications and Transactions Act, Act No. 25 of 2002

The purpose of the *Electronic Communications and Transactions Act, Act No. 25 of 2002* (Republic of South Africa 2002) is to provide for the facilitation and regulation of electronic communications and transactions, provide for the development of a national e-strategy for the Republic, promote universal access to electronic communications and transactions and the use of electronic transactions by SMMEs, provide for human resource development (HRD) in electronic transactions, prevent abuse of information systems, encourage the use of e-government services, and provide for matters connected therewith.

Furthermore, Section 2(1) of the *Electronic Communications and Transactions* Act, Act No. 25 of 2002 (Republic of South Africa 2002) states that the objectives of the Act include the following:

- Promote e-government services and electronic communication and transactions with public and private bodies, institutions and citizens.
- Encourage investment and innovation regarding electronic transactions in the Republic.
- Develop a safe, secure and effective environment for the consumer, business and the government to conduct and use electronic transactions.
- Promote the development of HRs in the electronic transactions environment.

Human resource development strategy for South Africa 2010–2030

Human resource development is crucial to South Africa's development agenda, and the HRD strategy represents a critical intervention for promoting the country's development agenda. The HRD-SA (Department of Labour 2009:22) states that the need to develop and implement a robust HRD strategy has steadily grown in importance.

Accordingly, one of the strategic priorities is to improve the credibility, validity, utility and integrity of the various data and management information systems that play a vital role in the successful planning and implementation of the HRD strategy. To this end, the HRD-SA (Department of Labour 2009:45) outlines the strategic objectives regarding data and management information systems, which include to ensure that an explicit design and policy framework is established for data and management information systems, and to ensure that the above data and management information systems are integrated successfully. This requires the smooth integration of data fields across all datasets.

The Fourth Industrial Revolution

According to Kayembe and Nel (2019:80), the term 'Industrial Revolution' can be seen as a development, change, or transformation that has taken place in the past. Notably, the process includes the use of machines, telecommunications, electricity, as well as new developments in the form of technology advancements. Okoye, Ogbu and Ome (2020:67) agree, adding that 'the Industrial Revolution has spanned over three centuries with an impact that continues to shape human existence in contemporary times'.

The world has experienced four such industrial revolutions. The National Planning Commission of South Africa (NPC) (2020:48), Caetano and Charamba (2017:26), Kayembe and Nel (2019:80) and Okoye et al. (2020:68) characterise the various industrial revolutions as follows. Firstly, the First Industrial Revolution (1IR) was based in Britain and was described in terms of mechanisation, water, steam power and railways in the late-18th and early-19th centuries (Kayembe & Nel 2019:80; NPC 2020:48). Secondly, the Second Industrial Revolution (2IR) focussed on electricity-enabled mass production and assembly lines in the late-19th and early-20th centuries. It also saw the major technological developments in steel, chemicals, electricity and in various other fields (Caetano & Charamba 2017:26; NPC 2020:48). Thirdly, the Third Industrial Revolution (3IR) began in the mid-1900s and was characterised by the development of nuclear power, as well as the wide use of electronics (Kayembe & Nel 2019:80; NPC 2020:48). In addition, from the 1960s, 3IR was also characterised by information processing with the advent of computers and automation. By the 1980s, the expansion of Internet access and the liberalisation of markets took place. Finally, from the beginning of the 21st century, the current 4IR is associated with cyber-physical systems and is based on the interconnectivity between physical, biological and digital spheres (NPC 2020:48; Okoye et al. 2020:68).

The 4IR has changed the world as we know it. It has changed the way we communicate, live and work. It has changed the relationship between the government, the private sector, labour organisations and communities, and has forced us to adapt to the changing technological environment. Undeniably, strengthening the relationships

between the above stakeholders depends on the positive and proactive management of the changing technological environment. Nalubega and Uwizeyimana (2019:1) agree, adding that the innovations and technological advancements of the 4IR are uprooting and changing how societies do business, carry out their daily work and interact with other stakeholders.

According to Satyam and Keleher (2018), Sihlongonyane et al. (2020:8) and Markowitz (2019:5), 4IR is characterised by the following:

- Big data (large amounts of data can be stored, processed and distributed instantly)
- The rise of autonomous machines and robotics (physical, digital and biological world)
- AI (software algorithms that can complete processes traditionally completed by humans)
- Nanotechnology, quantum computing and biotechnology
- IoT (sensors that connect everyday products to the Internet)
- 3D printing (computational design is used to complete processes of manufacturing, materials engineering and synthetic biology by 'printing' parts) and autonomous vehicles.

The 4IR is viewed as 'the major driver of growth and transformation, with the potential to influence the social, political, economic and service environment' (Xing, Marwala & Marwala 2018:173). The use of big data to make decisions requires data analytics to obtain understanding, inferences and predictions from the data (Nalubega & Uwizeyimana 2019:8). With the technologies adopted in most services, data can be harvested to improve the health, HR, agricultural and education sectors, to mention a few (Nalubega & Uwizeyimana 2019:8). Furthermore, as the 4IR is driven by digital data, it is imperative that for any data analysis to be conducted on disruptive technologies, there must be a focus on advancing HR-related information technology (IT) skills (Nalubega & Uwizeyimana 2019:8). Human resource management is critical in this regard. Within this context, Opaneye (2020:26) argues that HRs will create new roles and responsibilities to manage the integration and new culture emerging as a result of this technological advancement and improvement of IT skills. Thus, the workplace will become 'more complex as people work in a highly diverse structure of different nationalities and combinations of human-robotics systems' (Opaneye 2020:27).

The NPC (2020:66) is of the opinion that in the public sector, there is minimal sharing of data among the three spheres. To solve this problem, government needs to adopt a business approach and implement 4IR projects that are dictated by a business model. Hence, one of the requirements is HRs with a strong skills base. Jarbandhan (in Van der Westhuizen 2021:93) adds that '[h]uman resource specialists need to deploy the right skills at the right time at the right place with minimal wastage of financial resources'. In this regard, the government must ensure that a new and effective data management system as well as data-driven tools are implemented for effective decision making to ultimately acquire diverse digitally skilled HRs (NPC 2020:82).

Using big data to optimise human resource management: An international perspective

Public sector organisations have been the custodians of large volumes of data because of their nature, scope and mandate. However, it is difficult to judge whether large volumes of data support societal improvement, despite the many studies that have been undertaken on the topic, for example, by Garcia-Arroyo and Osca (2019:2–3) and Barnes (2014). With the onset and popularisation of the 4IR, the focus has now shifted to the use of big data to solve complex societal issues. Public HRM can also benefit from the use of big data. For instance, using data-driven decision-making and analytic metrics for managing turnover rates, human capital risks, training efficiencies, and talent and recruitment can help determine whether a person has the right competencies and qualifications for a specific job. However, organisational readiness regarding the use of big data, artificial intelligence (AI) and machine learning to optimise organisational effectiveness are still in its infancy. According to (Capelli, Tambe & Yakubovich (2020:1) argues that:

> Companies are still struggling to make progress building data analytics capabilities: 41 percent of chief executive officers (CEOs) report that they are not at all prepared to make use of new data analytic tools, and only 4 percent say that they are to a large extent prepared. (p. 1)

Figure 1 outlines the journey from traditional HRM to data-driven HRM.

The below section outlines the international perspective of using big data in government, especially to fulfil the HR mandate.

Australia and New Zealand

Several Australian state and government agencies use big data to improve transparency and communication by making their data available to all stakeholders. The availability of data helps to eliminate tedious paperwork and frees up time for more pressing projects. Notably, data and data analytics can help bolster internal efficiency by reducing routine administrative tasks. Moreover, data management and analytical tools can be used for the custodianship of environmental resources, for example, the delivery of sustainable water resources. This

HR DECISIONS ARE NO LONGER BASED ON GUT FEELING

Operational HR 1900s → Strategic HR 2000s → Data-driven HR now

Source: Rangaiah, M., 2020, *What is HR analytics? Role, challenges and applications*, viewed 12 May 2021, from https://www.analyticssteps.com/blogs/what-hr-analytics-role-challenges-and-applications

HR, human resource.

FIGURE 1: The journey of data-driven human resource management.

could result in better government policies (University of New South Wales in the Organisation for Economic Co-operation and Development [OECD] 2019:Online source). If Australia wishes to develop its smart city projects, trained public servants will be a future requirement. Open data to assist smart cities with managing waste disposal, parking and energy usage was piloted in Victoria, where it was found that the use of data sets could be used effectively to manage smart cities (Watson & Ryan 2020:672).

In New Zealand, studies undertaken by Du Plessis and De Wet Fourie (2015:4) indicated that HR practitioners in this country should be aware of the benefits of big data to ensure the future sustainability of their organisations. Du Plessis and De Wet Fourie (2015:2) point out that, 'HR practitioners in New Zealand have been exposed to big data and the use thereof through their HRISs [*human resource information systems*] in adding value in organisations to be successful'. The authors further highlight that big data could support the development of succession planning for managers, employee training and development, workforce productivity and output and managing labour costs, among others. The use of big data to manage HRs effectively has gained traction over the last 10 years.

Mexico

Mexico has used big data to support workforce planning. Notably, workforce planning is essential for the success of any organisation, be it public or private. The changing working landscape (especially remote working), the advent of technology and the shift to a fit-for-purpose workforce have made workforce planning an essential element of the HR function. Big data supports, predicts and measures the outcomes of certain planning actions, such as assessing the supply and demand of staff. For example, in Mexico, the Ministry of Energy uses workforce planning to identify:

> [*C*]urrent and future skills gaps in oil and gas occupations over a ten-year period. The gaps are modelled on macro-economic variables of supply and demand and the skills demands are tempered with acquiring labour accordingly. (Deloitte 2016 in OECD 2017:Online source)

Korea

The OECD report (2019) provides an example of how Korea uses data-driven HRM for monitoring and evaluation (M&E) purposes. As Korea places a high premium on an ethical public service and transparent government, the country set up the Ministry of Personnel Management in 2014. The Ministry focuses on an innovative and a responsive public service. According to the Korean Ministry of Personnel Management (in the OECD Report 2019), HR Innovation Diagnosis Indicators were developed to carry out objective assessments of each of the government departments' innovation capabilities. The indicators consisted of five fields, namely:

- Innovation and excellence in HR plans.
- Open and diverse recruitment.
- Awareness among staff of the HR training interventions to support development.

- Professional standards to support performance management.
- A flexible working environment and non-discriminatory practices (Korean Ministry of Personnel Management in the OECD Report 2019).

To measure these indicators, the Ministry used both quantitative (e.g. employment rates) and qualitative methods (e.g. appropriate educational qualification). The Ministry also sets innovation criteria (Korean Ministry of Personnel Management in the OECD Report 2019).

The Ministry provides feedback and offers an incentive scheme for staff who excel. Incentives include overseas training. Departments that fail to perform according to expected guidelines are offered further training through, for example, workshops (Korean Ministry of Personnel Management in the OECD Report 2019).

A synopsis of the literature relating to African countries using big data to manage their affairs, including HRs, indicates that not much research has been done on the management of this type of data on the continent. In a similar vein, South Africa has undertaken and published limited research on the use of big data in government. A research article published by the African Organisation of English-speaking Supreme Audit Institutions (AFROSAI-E 2020:1), entitled 'Integrating Big data in Public Service Audit' points out that Africa is lagging behind 'with regard to data and digitalisation'. The report further indicates that, in many African countries:

- Key processes and reporting in the public sector are not yet fully digitalised.
- Government data is not readily available both within government and to the public.
- The data is not available in machine-readable format and is not reusable, not free of charge and not updated regularly.
- Data is not used actively in decision-making and for service delivery.
- The public sector is not governing, managing and valuing data in the same way as the other assets that are relevant for their success (AFROSAI-E 2020:3).

Using data to optimise human resource management: A South African perspective

Because of the rapid development of the Internet, the South African government has attempted to manage human resources electronically (e-HRM). This has resulted in large data sets being created. However, the management of the data has not resulted in organisational efficiency. The below sections focus on how data could be used to optimise forecasting, strategic workforce planning, talent retention, leadership predictability, M&E and learning from HR policy.

Forecasting

The current challenge within the South African Public Service is that while personnel budgets are spent, vacancies still remain. To add to the complexity of the situation, 'good supply

and demand forecasting' systems are unavailable. Furthermore, poor planning and forecasting, due to uncertainty regarding the number of vacancies within the sector, remains a challenge (Department of Public Service and Administration [DPSA] 2015:24).

By analysing short-term data, senior line managers and HR specialists will be able to forecast supply and demand in strategic demand-driven areas within the public sector. Any shortfall in skill requirements can be planned for with accurate and up-to-date data sets.

Based on past and present data from various sources, predictive analytics involves the development of statistical models and forecasts to help identify future workforce and talent pool trends. Anticipating such trends gives managers and organisations a critical head-start in preventing, mitigating or encouraging developments. This approach helps to cut costs and improve performance.

The possibilities for predictive HR analytics are still being explored. However, a few common applications have thus far included strategic workforce planning, improving diversity and inclusion, and retaining top talent (OECD 2019). Predictive analytics utilise a variety of statistical, modelling, data mining, and machine learning techniques to study recent and historical data to make predictions about the future (Becker, Curry, Jentzsch & Palmetshofer 2016:266).

Strategic workforce planning

Strategic workforce planning for HRM in the public sector plays a crucial role in predicting workforce change, for example, demographic, technological and economic situations, and to prepare to recruit for these situations (OECD 2019). According to the United States General Accounting Office (in HRP Strategic Framework 2015:9–10), strategic workforce planning addresses two critical aspects:

- Aligning an organisation's human capital programme with its current and emerging mission and programmatic goals.
- Developing long-term strategies for acquiring, developing and retaining staff to achieve programmatic goals.

Strategic workforce planning is a core HRM process that helps to identify, develop and sustain the necessary workforce skills. In doing so, it also contributes to employees' career and lifestyle goals and ensures the continued effective organisational performance. Workforce planning is a dynamic process, which ensures that the organisation has the right number of people, with the right skills in the right place at the right time to deliver short and long-term organisational objectives. Workforce planning aims to optimally combine available personnel budget and appropriate number of HRs endowed with the required skills to bring about organisational objectives. Workforce planning not only identifies mission-critical occupations and the essential competencies to meet organisational goals but also detects competency gaps (Huerta Melchor in OECD 2019).

According to Dynamic Consulting (2020:Online source), strategic workforce planning can benefit from big data. It is anticipated that big data can sort candidates by their specific skill sets and work experience. This can help both the private and public sectors to tap into talent pools and exclude candidates who fail to meet the minimum requirements for advertised posts. Ultimately, this helps to save costs and time.

Talent retention

Managing and retaining talent is core to the success of the public service. In line with this, Kock and Burke (2017) state that:

> The South Africa's Public Service is not exempt from the raging war for talent, which is a global phenomenon. Much of the talent within the public service is either unidentified or simply leave the public service in search of greener pastures within the private sector. (p. 5)

Frye et al. (in OECD 2019) argue that database analysis and analytical tools, such as logistic regressions, help to identify why employees may either remain in or want to leave their jobs. Their studies revealed that resignations spike around 6.25 years of service, regardless of age (Frye et al. in OECD 2019).

By effectively applying models to predict talent management, employers can adjust workplace conditions such as remote work and flexible working hours.

Leadership predictability

According to the HRP strategic framework (2015), there are:

> [A] number of challenges that impacts on a department's endeavours to conduct HR planning. These stem from, among others, departmental capacity, organisational structures, restructuring, leadership and accountability, role definition of the human resource function, process and design of the HR Plan, information management and training and development. (pp. 22–23)

Constant changes in both political and administrative leadership are persistent challenges for the public service.

Diversity within the South African Public Service is a constant bone of contention. Undeniably, data can help to address this issue. The New South Wales Public Service Commission in Australia adopted a data-driven approach to designing and monitoring progress on diversity and inclusion policies (OECD 2019). Data predictability models were used to identify the proportion of men to women in leadership positions in senior positions. The South African Public Service could use similar data predictability tools to foster gender-based equity with the public service. Data-driven scenario planning could also help to promote a diverse workforce.

Monitoring and evaluation and learning from human resource policy

A common challenge within the South African Public Service is the lack of M&E practices. According to the HRP strategic framework (2015), there is an:

[U]navailability of the M&E framework and lack of ownership of the HR Plans. HR Planning is seen more as compliance burden then a strategic process and is allocated to the HR unit for development. (p. 28)

For any government-wide HR M&E framework to be successful, the analysis of data sets is crucial. The OECD (2019) indicates that HR data collected through M&E can be used to spark innovation in the design and delivery of people management policies and processes. An example of this is the United States (US) HRStat Programme, which 'creates empirical evidence to inform HR decision making and provide agencies with a continuous means of learning and gaining insights for improving HR processes' (US Office of Personnel Management in OECD 2019).

By analysing data on implemented HR policies, HR planners and strategists can predict trends and outcomes to facilitate organisational efficiency and effectiveness.

Challenges to managing data in the public service

The HRP strategic framework (2015:23) identifies various challenges within the South African Public Service relating to HRM planning. These challenges stem from departmental capacity, organisational structures and poor information management. The HRP strategic framework (2015) indicates that:

[D]ata verification by departments has been cited as one of the challenges which stem from multiple departmental system[s], i.e., PERSAL, BAS and VULINDLELA. Departmental access to VULINDLELA and PERSAL systems does not provide adequate HR Planning data and information and cannot be relied upon as being valid. This has an impact on the authenticity of the HR Planning information sourced from these systems. (p. 27)

This issue is further exacerbated by information and data not being shared across departments.

Human resource departments and data scientists also face the challenge of not sharing common job profiles within the public service to make the relevant analyses to source candidates (OECD 2019). The OECD (2019) further highlights the following challenges in implementing data-driven HRM in the public service:

- Technical barriers to roll out data-driven HRM due to poor infrastructure. Some domains may have developed their IT infrastructure in a more advanced setting compared with others.
- Legal barriers, such as privacy concerns.
- Human resource barriers, such as a lack of skills and knowledge among HRM professionals and senior managers on the utility of big data to manage their domains.

Additionally, Wyatt (2018:Online source) lists the following challenges to data management within the South African context. Some of these challenges correlate with the OECD (2019) challenges listed above:

- Ethical challenges are not fully understood, especially in developing countries where the legal rights and responsibilities of data usage are limited.
- It is essential to have a fully developed data infrastructure to harness the benefits of big data.
- South Africa currently has limited skills sets to manage big data leverage.
- Systems and process for big data management are not aligned between the private and public sector. For example, the Department of Transport could benefit from the data that reside within private vehicle-tracking companies to monitor road usage, trends and so on.

The private sector has made advances in the use and management of big data to improve operations. However, the public service must invest in skills and data infrastructure to harness the full benefit of big data to increase the efficiency within the service.

Advantages of big data in human resource management

The following section outlines the advantages of using big data in HRM.

Selection and recruitment

Big data ensures that the right staff is recruited. It can be used to reduce the number of days between advertising and filling a post. Big data calculation tools could streamline the process (Rangaiah 2021:Online source). Moreover, big data is being optimised to help select the correct candidate. According to the OECD (2019), '[a] bad hire is too costly a mistake for companies to make. That is why they use big data to reduce the possibility of that mistake'.

Rangaiah (2021:Online source) states that AI can be used to get rid of gender bias in the selection process and to select the best possible candidate for the job based on competencies. According to Feldman (in Guiles 2020):

By mining employee data and identifying patterns related to skills, performance ratings, tenure, education, past roles, etc., companies can reduce their time-to-fill, improve employee engagement and productivity and minimise turnover. (Online source)

Improving retention

Staff turnover can have costly consequences. Therefore, organisations value staff retention. In this regard, big data can help 'to spot employees who are likely to walk out on the company by going through their job performances, employment history, payroll data, profile updates, and other online activities' (Guiles 2020:Online source; OECD 2019). In addition, algorithms can be designed and used to spot and retain talented employees.

Managing and predicting performance

Big data can help to predict the performance of individuals before hiring them. Moreover, HR departments can build data sets of high-performing employees to outline talent pools.

Improving benefit packages

Big data could be used to track, for example, the health and wellness of employees. This type of data could be used to create better healthcare packages for employees (Foster 2021:Online source; OECD 2019). However, this should be performed with due ethical consideration.

Dealing with legal and ethical issues

With big data comes the privacy concerns. However, big data can be used by the 'HR department [as] a technique for risk management' (Foster 2021:Online source; OECD 2019). Over the recent past, there has been a wider call for governments to use information more transparently. Given that governments find themselves operating within a digital space, there is a need for information to be used transparently and responsibly. Data are seen as being instrumental in dealing with challenging policy issues and consequently need to be used strategically to promote the needs of the citizenry (Ubaldi et al. 2019). However, when it comes to managing the legal and ethical implications of HRM data management, prudence must be exercised in ensuring that human rights of employees as enshrined in the Constitution is not compromised. Moreover, the *Protection of Personal Information Act* (POPI Act) makes provision for employee data to be responsibly managed, with honest intentions from all parties as is prescribed in the relevant legislation – after all employee data are personal. The POPI Act also makes provision for employers to store data in accordance with the prescription of the Act (POPI Act, Act 4 of [Republic of South Africa] 2013).

Because of the COVID-19 pandemic, many employees were forced to work remotely. Remote working, although cost-effective and advantageous from a health perspective, has led to 'monitoring/surveillance [*that*] also extends across employment grades and pay levels' and has led to companies using more physically invasive methods of surveillance, such as microchip implants that connect employees to the company network (Astor 2017 in Ebert, Wildhaber & Adams-Prassl 2021:1). This study found that the legal and ethical issues to manage employee surveillance using data analytics have to be managed within a legal framework, and the reasons for such data management need to be discussed with employees and employee representatives (such as trade unions). The responsibility of the employer and employee need not be breached in managing the HRM process by data analysis. It must be mentioned that the literature in terms of studies undertaken with the public sector is currently underrepresented and further studies need to be undertaken to explore the legal and ethical challenges in data management. A properly developed HRM data-management system could be developed in order to ensure productivity and the management of risk within the public sector. Figure 2 shows the advantages of big data in HRM.

Embracing big data in human resource management

With the generation of large volumes of data within the HR public service domain, it becomes imperative to manage and use the data to improve efficiency within the sector. As alluded to earlier in this article, evidence indicates that HR offices across the globe are striving to embrace big data in the management of its human capital. The benefits of big data include strategising around the workforce, managing talent, improving decision-making around HR and retaining competent staff, as outlined in Figure 3.
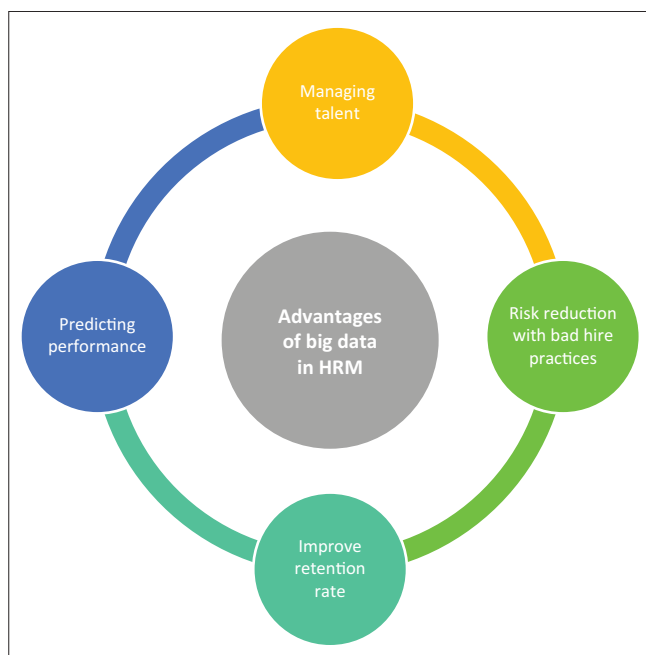
Source: Foster, T., 2021, *The role of data in human resource management*, viewed 11 April 2021, from https://www.datasciencecentral.com/profiles/blogs/the-role-of-big-data-in-human-resource-management
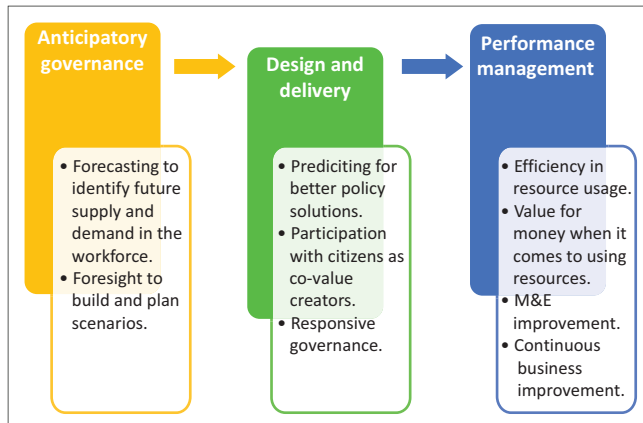
HRM, human resource management.

FIGURE 2: Advantages of big data in human resource management.

Source: Dynamic Business Outsourcing Solutions, 2020, *8 benefits of embracing big data in HR*, viewed 13 April 2021, from www.dbos.com.au

HR, human resource; HRM, human resource management.

FIGURE 3: Embracing big data.

Source: Ubaldi, B., Van Oojien, C. & Welby, B., 2019, *A data driven public sector. Enabling the strategic use of data for productive, inclusive and trustworthy governance*, OECD Working Paper on Public Governance No. 33, OECD, Paris
M&E, monitoring and evaluation.

FIGURE 4: Opportunities for big data usage in the South African human resource management.

A model opportunities for big data in the South African Public Service

Given that the literature on big data usage within the South African Public Service is limited, the following model could be applied to enhance the use of data to improve HRM. It is important for HR planners and specialists to use forecasting and data application to anticipate where the supply and demand for skills would be needed. Policies must be designed to fill the identified gaps, and, finally, performance must be managed by using tools for continuous improvement within the public sector. Data could be derived from various sources, including (Figure 4):

> [G]overnment organisations, citizens, businesses, researchers and other societal stakeholders. All, knowingly and unknowingly, contribute to the generation of data, in open and closed formats, in big and small quantities, with and without structure, and of personal and non-personal nature. (Ubaldi et al. 2019:3)

Recommendations

The following recommendations are made:

1. Need for a detailed systematic literature review as there are gaps in the literature relating to the public sector.
2. Undertake an empirical study to ascertain the preparedness of the South African public sector for managing data in relation to HRM.

Conclusion

It can be concluded that the private sector uses big data to improve customer relations and protect the bottom line. However, this is not the case within the South African Public Service, especially from an HR perspective. Internationally, the literature on big data usage within the public service is scant. Moreover, while countries such as Australia, New Zealand and Korea use big data, the application is in its infancy. The South African Public Service has the opportunity to invest in big data to identify skills shortages, to improve retention rates and to manage talent. The political will and the advantages presented by using big data in an ethical fashion are overwhelming. The opportunity is ripe for the South African Public Service to investigate the use of big data in order to improve organisational efficiency and the lives of all South Africans.

Finally, the COVID-19 pandemic has changed the face of employment. Many private companies and non-essential public service staff have been asked to work remotely. Remote working has created many challenges for HR practitioners. This includes monitoring of staff, assimilating meeting hours, the availability of data to log onto networks, data security, managing staff performance while they work remotely, integrating new workers remotely into the workforce through on-boarding, managing talent, determining staff wellness and the like. The future of HRM will benefit from examining how to bridge the gap between big data and HRM during the post-COVID-19 recovery period. In line with this, future research in HRM must address remote working and how working remotely can benefit from big data.

Acknowledgements

References

Acharjya, D.P. & Ahmed, K., 2016, 'A survey on big data analytics: Challenges, open research issues and tools', *International Journal Advanced Computer Science and Applications* 7(2), 511–518. https://doi.org/10.14569/IJACSA.2016.070267

African Association of Supreme Audit Associations (AFROSAI-E), 2020, *Integrating big data in public service audit*, pp. 1–44, Research article.

Armstrong, M., 2006, *Strategic human resource management: A guide to action*, 3rd edn., Kogan Page, London.

Astor, M., 2017, 'Microchip implants for employees? One company says yes, The New York Times, 25 July', in I. Ebert, I. Wildhaber & J. Adams-Prassl (eds.), *Big data in the workplace: Privacy due diligence as a human rights-based approach to employee privacy protection*, Sage. https://doi.org/10.1177%2F20539517211013051

Barnes, N.D., 2014, 'Analyse this: The big demand for big data professionals', *Information Management* 48(1), 34–37.

Becker, T., Curry, E., Jentzsch, A. & Palmetshofer, W., 2016, *New horizons for a data-driven economy: Roadmaps and action plans for technology, businesses, policy, and society*, Springer, Berlin.

Bless, C., Higson-Smith, C. & Sithole, S.L., 2020, *Fundamentals of social research methods. An African perspective,* 5th edn., Juta & Co., Claremont, CA.

Caetano, L. & Charamba, A., 2017, 'Implications of the fourth industrial revolution', *HR Future.net* 2(1), 26–28.

Capelli, P., Tambe, P. & Yakubovich, V., 2020, 'Can data science change human resources?', in *The future of management in an AI world,* Palgrave Macmillan, London.

Cavanillas, J., Curry, E. & Wahlster, W. (eds.), 2016, *New horizons for a data-driven economy. A roadmap for the usage and exploitation of big data in Europe,* Springer, Geneva.

Corea, F., 2019, *An introduction to data everything you need to know about AI, big data and data science*, Springer, Geneva.

Department of Labour, 2009, *Human resource development strategy for South Africa (HRD-SA), 2009, 2010–2030*, Department of Education and Labour: Republic of South Africa, Pretoria.

Department of Public Service and Administration (DPSA), 2015, *Human resource planning for the public service: Strategic framework 2015*, Government Printers, Pretoria, viewed 14 July 2020, Available from: https://www.gov.za/sites/default/files/gcis_document/201409/hr-planning-str-framework.pdf

Du Plessis, A.J. & De Wet Fourie, L., 2015, 'The use of big data and HRIS by HR practitioners in New Zealand. Empirical evidence from a longitudinal study', in N.J. Delener, F.V. Fuxman & S. Rodrigues (eds.), *Proceedings of the Global Business and Technology Association, 17th Annual International Conference,* July, pp. 1–11, Research Bank, viewed 14 July 2020, from https://researchbank.ac.nz/handle/10652/3341.

Dynamic Business Outsourcing Solutions, 2020, *8 Benefits of embracing big data in HR*, viewed 13 April 2021, from http://www.dbos.com.au/.

Dynamic Workforce Consulting, 2020, *Dynamic workforce planning and resource strategy – Be ready to grow again*, viewed 14 July 2020, from https://www.linkedin.com/pulse/dynamic-workforce-planning-resource-strategy-ready-grow-hepworth.

Ebert, I., Wildhaber, I. & Adams-Prassl, J., 2021, *Big data in the workplace: Privacy due diligence as a human rights-based approach to employee privacy protection*, Sage, New York. https://doi.org/10.1177/20539517211013051

Foster, T., 2021, *The role of data in human resource management*, viewed 11 April 2021, from https://www.datasciencecentral.com/profiles/blogs/the-role-of-big-data-in-human-resource-management.

Gandomi, A. & Haider, M., 2015, 'Beyond the hype: Big data concepts, methods, and analytics', *International Journal of Information Management* 35(2), 137–144. https://doi.org/10.1016/j.ijinfomgt.2014.10.007

Garcia-Arroyo, J. & Osca, A., 2019, 'Big data contributions to human resource management: A systematic review', *The International Journal of Human Resource Management* 32(20), 4337–4362. https://doi.org/10.1080/09585192.2019.1674357

Guiles, C., 2020, *The many roles of big data in HR*, viewed 12 May 2021, from https://www.smartbrief.com/original/2020/09/many-roles-big-data-hr.

Haggard, S., 2018, *Developmental states: Elements in the politics of development*, Cambridge University Press, Cambridge.

Human resource planning (HRP) strategic framework, 2015, *Department of Public Service and Administration*, viewed 14 July 2020, from https://www.gov.za/sites/default/files/gcis_document/201409/hr-planning-str-framework.pdf.

Industrial Development Corporation (IDC), 2011, *IDC's worldwide big data taxonomy*.

Iqbal, R., Doctor, F., More, B., Mahmud, S. & Yousuf, U., 2017, 'Big data analytics and computational intelligence for cyber-physical systems: Recent trends and state of the art applications', *Future Generation Computer Systems* 105, 766–778. https://doi.org/10.1016/j.future.2017.10.021

Jacobs, A., 2009, 'The pathologies of big data', *Communications of the ACM* 52(8), 36–44. https://doi.org/10.1145/1536616.1536632

Jarbandhan, D.B., 2017, 'Principles of public sector leadership in the fourth industrial revolution: Critical considerations', *Administratio Publica* 25(4), 60–77.

Kayembe, C. & Nel, D., 2019, 'Challenges and opportunities for education in the fourth industrial revolution', *African Journal of Public Affairs* 11(3), 79–94.

Kock, R. & Burke, M., 2017, 'Managing talent in the South African public service', *Public Personnel Management* 37(3), 457–470. https://doi.org/10.1177/009102600803700406

Laney, D., 2001, *3D data management: Controlling data volume, velocity, and variety*, Technical report, META Group, California.

Leftwich, A., 2011, 'Developmental states, effective states, and poverty reduction: The primacy of politics', *Indian Journal of Human Development* 5(2), 387–411. https://doi.org/10.1177/0973703020110205

Legge, K., 1987, 'Women in personnel management: Uphill climb or downhill slide?', in A. Spencer & D. Podmore (eds.), *In a man's world: Essays on women in male-dominated professions,* pp. 33–60, Tavistock Publications, London.

Loukides, M., 2010, *What is data science? O'Reily Radar*, viewed 14 July 2020, from https://www.oreilly.com/radar/what-is-data-science/.

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C. et al., 2011, *Big data: The next frontier for innovation, competition, and productivity*, p. 156, McKinsey Global Institute, Chicago.

Markowitz, C., 2019, *Harnessing the 4IR in SADC: Roles for policymakers,* Occasional Article 303, South African Institute of International Affairs, Johannesburg.

Mike 2.0, 2014, *Big data definition – Mike 2.0*, viewed 14 July 2020, from http://mike2.openmethodology.org/wiki/Big_Data_Definition.

Nalubega, T. & Uwizeyimana, D.E., 2019, 'Public sector monitoring and evaluation in the fourth industrial revolution: Implications for Africa', *Africa's Public Service Delivery and Performance Review* 7(1), 1–12. https://doi.org/10.4102/apsdpr.v7i1.318

National Planning Commission (NPC), 2012, *Our future – Make it work:* National Development Plan (NDP) 2030, National Planning Commission: Department of the Presidency Republic of South Africa, Cape Town.

National Planning Commission (NPC), 2020, *Digital futures: South Africa's digital readiness for the fourth industrial revolution*, Department of the Presidency Republic of South Africa, Cape Town.

NESSI, 2012, *Big data: A new world of opportunities*, NESSI White Paper, Operational Database Management Systems (ODBMS), viewed 14 July 2020, from http://www.odbms.org/2014/04/big-data-world-opportunities/.

Okoye, U.M., Ogbu, E.O. & Ome, G.E., 2020, 'The place of Africa in the fourth industrial revolution', *Journal of African Philosophy, Culture and Religions* 9(3), 65–84. https://doi.org/10.4314/ft.v9i3.5

Opaneye, Y., 2020, 'HR must prepare for the fourth industrial revolution', *HR Future* 1(1), 26–27.

Organisation for Economic Cooperation and Development (OECD), 2017, *Government at a glance 2017,* viewed 03 March 2021, from https://doi.org/10.1787/gov_glance-2017-en.

Organisation for Economic Cooperation and Development (OECD), 2019, *Data-driven human resource management. Enabling the strategic use of human resources data for a high-performing civil service*, OECD Library, viewed 03 March 2021, from https://www.oecd-ilibrary.org/sites/6669e814-en/index.html?itemId=/content/component/6669e814-en.

Ozdemir, V. & Hekim, N., 2018, 'Birth of industry 5.0: Making sense of big data with artificial intelligence, "the internet of things" and next-generation technology policy', *Journal of Integrative Biology* 22(1), 1–12. https://doi.org/10.1089/omi.2017.0194

Presidential Commission on the Fourth Industrial Revolution, 2018, *Establishment of the presidential commission on the fourth industrial revolution*, Department of Telecommunications and Postal Services Republic of South Africa, Pretoria.

PriceWaterhouseCoopers (PWC), 2018, *Workforce of the future. The competing forces shaping 2030*, viewed 03 July 2021, from https://www.pwc.com/gx/en/services/people-organisation/publications/workforce-of-the-future.html.

Rangaiah, M., 2020, *What is HR analytics? Role, challenges and applications*, viewed 12 May 2021, from https://www.analyticssteps.com/blogs/what-hr-analytics-role-challenges-and-applications.

Republic of South Africa, 2002, *Electronic Communications and Transactions Act, Act No. 25 of 2002*, Government Printer, Pretoria.

Republic of South Africa, 2013, *The Protection of Personal Information Act (POPI Act)*, Government Printers, Pretoria.

Satyam, A. & Keleher, H., 2018, *How will the fourth industrial revolution transform how we govern?*, viewed 28 June 2021, from https://blogs.cisco.com/government/how-will-the-fourth-industrial-revolution-transform-how-we-govern.

Sihlongonyane, F.M., Ndabeni, M., Ndabeni, L.L. & Ntuli, B., 2020, *The fourth industrial revolution: Synopses and implications for STI policy development,* Department of Science and Innovation Republic of South Africa, Pretoria.

Stonebraker, M., 2012, 'What does "big data" mean', Communications of the ACM, BLOG@ ACM, viewed 14 July 2020, from https://cacm.acm.org/blogs/blog-cacm/155468-what-does-big-data-mean/fulltext.

Storey, J., 1987, *Developments in the management of human resources: An interim report,* Warwick Articles on Industrial Relations, No. 17, University of Warwick, Coventry.

Sun, Z., Sun, L. & Strang, K., 2018, 'Big data analytics services for enhancing business intelligence', *Journal of Computer Information Systems* 58(2), 162–169. https://doi.org/10.1080/08874417.2016.1220239

Takagi, Y., Kanchoochat, V. & Sonobe, T. (eds.), 2019, *Developmental state building: The politics of emerging economies*, Springer, Cham.

Trubek, D.M., 2009, 'The political economy of the rule of law: The challenge of the new developmental state', *Hague Journal on the Rule of Law* 1(1), 28–32. https://doi.org/10.1017/S1876404509000281

Ubaldi, B., Van Oojien, C. & Welby, B., 2019, *A data driven public sector. Enabling the strategic use of data for productive, inclusive and trustworthy governance,* OECD Working Paper on Public Governance No. 33, OECD, Paris.

Van der Westhuizen, E., 2021, *Human resource management in government: A South African perspective on theories, politics and processes,* Juta and Company, Cape Town.

Watson, R.B. & Ryan, P.J., 2020, 'Big data analytics in Australian local government', *MDPI Open Access, SmartCities* 3(3), 657–675. https://doi.org/10.3390/smartcities3030034

Wikipedia, 2014, *Big data*, Wikipedia article, viewed 14 July 2020, from http://en.wikipedia.org/wiki/Big_data.

World Bank Group, 2017, *Big data in action for government. Data innovation in public services, policy and engagement*, viewed 24 June 2021, from http://documents.worldbank.org/curated/en.

Wyatt, A., 2018, *How big data can solve South Africa's biggest challenges*, viewed 22 June 2021, from https://technologysalon.org/big-data-solve-south-africa-biggest-challenges/.

Xing, B., Marwala, L. & Marwala, T., 2018, 'Adopt fast, adapt quick: Adaptive approaches in the South African context', in N.W. Gleason (ed.), *Higher education in the era of the fourth industrial revolution*, pp. 171–206, Macmillan, Singapore.