Journal of Transport and Supply Chain Management
ISSN: (Online) 1995-5235, (Print) 2310-8789

Revolution of South African public procurement in the Industry 4.0 era

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Dates:
Received: 05 Aug. 2024
Accepted: 28 Oct. 2024
Published: 26 Nov. 2024

How to cite this article:
Mojaki, L.M., Tuyikeze, T. & Ndlovu, N.K., 2024, 'Revolution of South African public procurement in the Industry 4.0 era', *Journal of Transport and Supply Chain Management* 18(0), a1079. https://doi.org/10.4102/jtscm.v18i0.1079

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Background: Public procurement in South Africa is challenged by conventional methods that pave the way for human interference resulting in fraud and corruption, delays, unaccountability and poor performance of the value chain in the procurement process.

Objectives: This study aimed to investigate the Industry 4.0 capabilities for public procurement improvement. To address the challenges presented by the traditional manual procurement systems, the study embarked on a transformative journey by identifying the prospects and benefits of Industry 4.0 technologies in public procurement in South Africa, and the significance and application thereof.

Method: The study followed a six-step qualitative research methodology of content and thematic analysis which facilitated an understanding of the procurement process in South Africa and how it can be automated using Industry 4.0 technologies.

Results: The study revealed that Industry 4.0 technologies are crucial as they present digitalisation opportunities through platforms such as e-design, e-inform, e-sourcing, e-evaluation and e-contract. The platform will improve the process, encourage legislation compliance and achieve its goals as outlined in the constitution and *Public Finance Management Act* of 1996.

Conclusion: Implementing digital procurement will assist the government in achieving its policy requirements of value for money, open and effective competition, ethics and fair dealings, accountability and reporting, and equity. The technologies represent a strategic response to the challenges facing public procurement.

Contribution: The study contributed to the body of knowledge by presenting the prospects and benefits of Industry 4.0 technologies. In addition, it highlighted the significance and application to the South African public sector.

Keywords: digital procurement; public procurement; Industry 4.0; electronic procurement; supply chains; Fourth Industrial Revolution; public sector.

Introduction and background

The current corporate operations across the globe are characterised by a multifaceted and dynamic environment as well as highly congested markets. There is a digitalisation which is emerging in the background as a new phenomenon that revolutionises the majority of aspects of life and the corporate world (Ageron, Bentahar & Gunasekaran 2020:133). Fadhillah and Juwono (2021:124) state that in the current digital era, technology distribution is critical in every sector, including the procurement of products and services. In addition to its velocity, extent and impact, the Fourth Industrial Revolution (4IR) is notably distinct from its predecessors in that it advances exponential rate of change (The Small Business Institute [SBI] 2021:11). The dispensation of digital transformation has seen governments around the world increasingly recognising the need to embrace technology to enhance efficiency, transparency and accountability in their public procurement processes. The South African economy, which is not an exception, relies heavily on public procurement, which accounts for a large amount of governmental expenditure (Fourie & Malan 2020:1).

According to Akaba et al. (2020:3), public procurement is a fundamental government responsibility that involves the acquisition of commodities and services to meet the needs of residents. The effective management of procurement processes is crucial for ensuring that taxpayers' money is spent wisely and that goods and services are delivered efficiently to meet the needs of citizens (National Treasury 2017). Mpehle and Mudogwa (2020:2) emphasise that to foster the economic growth of a nation and advance the economic development of its citizens, a government must implement an effective and efficient procurement system that facilitates the acquisition of

products and services. Therefore, this study submits that the implementation of digital procurement by the South African government is crucial because of the accountability issues that afflict the outdated traditional system. According to Mathebula (2021:18199), this will bring a positive impact in terms of improved structures of governance, improved service delivery levels and a positive shift in policy paradigms.

The South African government faces many challenges in the process of providing basic services to its citizens. These are characterised by a lack of responsiveness that is brought about by a lack of digitalisation (Mathebula 2021:18203); the traditional paper-based procurement systems in use until now have been plagued by inefficiencies, delays and concerns about transparency. Furthermore, Mathiba (2020:642) highlights that one of the setbacks in procurement processes has been, over the years, compromising transparency and accountability in the quest for agility in the process. However, in terms of the legislative framework that governs public procurement in South Africa, the latter is as important as the former. Therefore, no principle should be upheld in negligence of the other. The setbacks associated with procurement in South Africa are very complex and require digital systems to navigate around. Digital procurement is anticipated to enhance transparency and expedite process completion, thereby improving overall accountability (Mpehle & Mudogwa 2020:5). In agreement, Fourie and Malan (2020:19) allude that over time, it will be imperative for the public procurement system in South Africa to evolve into a more resilient, streamlined and efficient provider of products and services, serving the collective welfare. South Africa, is a nation with a diverse and growing economy; therefore, digital transformation affects it equally as other developing nations. According to Sono and Malan (2021:937), there is a need for innovation in the public sector. This can address the complex challenges in development such as inclusive government and improved quality of service to previously marginalised groups (Plantinga & Adams 2021:315). To that effect, research is embarking on a transformative journey by uncovering the significance and benefits presented by Industry 4.0 technologies in South African public procurement.

Literature review

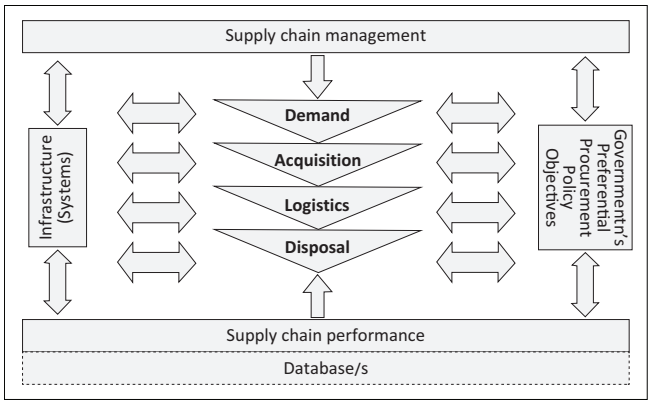
Procurement adoption in South Africa

The Supply Chain Management (SCM) Guide to Accounting Officers and Accounting Authorities developed by the National Treasury (2004) highlights several frameworks, one of which is the SCM framework to address issues related to public procurement in all spheres of government in South Africa. While there is no exclusive framework termed public procurement framework, the researcher is of the view that the existing SCM framework provides an overview of how the procurement is administered in South Africa. Figure 1 provides an overview of the procurement process in the South African public sector. The prescribed flow of government procurement currently in South Africa involves demand management, acquisition management, logistics management, disposal and supply chain performance management with the objective of providing high-quality services to the citizens (National Treasury 2017).

According to Manyathi, Burger and Moritmer (2021:4), procurement of goods and services is required to assist the government departments to achieve their constitutional mandates. In agreement, Mathiba (2020:648) highlights that procurement in public service is characterised by the entire process of buying goods and services to achieve government objectives. Fourie and Malan (2020:3) argue that the origins of public procurement in South Africa are linked to the responsibilities of the state's obligation to provide services to its people through all spheres of government. The current system of procurement in South Africa is a product of reformation in the public industry which was aimed at addressing socioeconomic imbalances that were created by the apartheid government (Thobakgale & Makgopo 2018:41).

The system was created with five key principles to address *namely* 'value for money, open and effective competition, ethics and fair dealings, accountability and reporting and equity' (National Treasury 2006). According to Mathiba (2020:649), these principles are mutually interdependent. Therefore, if one is broken, all are negatively affected. Notwithstanding its relevance at the time of creation, the researcher posits that the current fast-paced administration requires agility and the governments' ability to adapt to the transformation in the business world to enhance their processes and deliver services to their citizenry. Thus, digitalisation is critical for public procurement in the South African government.

In the South African context, demand management is a cross-functional part of the procurement process where the procurement planning is conducted (Mojaki & Chukwuere 2021:14). It is during this phase that buying entities determine the sourcing methods, analyse the market, budget for procurement and determine the buying approach (National Treasury 2017). Acquisition is the element in which the market is approached by the departments with a request for



Source: National Treasury, 2017, *National treasury*, viewed 30 March 2019, from http://www.redirect2.gpg.gov.za/e-tenders/Publications/Implementation%20Guide%20-%20Preferential%20Procurement%20Regulations%20March%202017.pdf

FIGURE 1: Supply chain management framework.

a bid or quotation (RFB/RFQ) depending on the budget threshold. Logistics in the public procurement context in South Africa refers to an element where purchase orders are generated and sent to the successful bidders. It further incorporates stores and inventory management. A growing number of governments across the globe have enthusiastically embraced digital procurement designs and invested financial resources in them (Bhagwan & Evans 2022:2). Therefore, South African government as a developing economy has to consider available technology capabilities to keep up with the rest of the world.

The revolution of Industry 4.0 and public procurement

According to Bhagwan and Evans (2022:2), the technological environment on a global scale is thriving, and Industry 4.0 is facilitating this transformation. For that reason, Mafungwa and Ngcobo (2019:10) advise that organisations and governmental bodies must contemplate how digital innovation will perturb not only the functioning of their respective businesses, but also the entirety of their procurement value proposition to service providers, consumers and internal stakeholders. Mabinane and Edoun (2022:1391) highlight that the disruption of technology on governments across the globe has forced them to introduce concepts such as Government-to-Government (G2G), Government-to-Business, Government-to-Citizens attempting to remain relevant and responsive to technological evolution. Thus, Industry 4.0 is a revolution that can be perceived as a solution to the service delivery challenges that are facing the South African government (Thani 2020:81).

Molepo and Jahed (2022:232) have conceded that there has not been much of a revolution regarding public procurement in South Africa owing to concerns around cyber security. However, Fourie and Malan (2020:4) posit that because of its nature, public procurement is likely to impact other industries. Therefore, transformation is needed in governance structures, policy paradigms and service delivery needs to conform to Industry 4.0 standards. To address the objective of this study, the following sections review literature on the application of Industry 4.0 technology on public procurement and their significance specifically to the South African context.

To keep up with a complex corporate environment, agility and resilience are needed to build risk mitigation capabilities and flexibility to respond rapidly to challenges (Ben-Daya, Hassini & Bahroun 2019:4719). According to Rodriguez et al. (2021:122), companies evaluated the prospects for development in Industry 4.0, particularly in terms of productivity, flexibility and efficiency, and concluded that Cyber-Physical Systems (CPS) technologies allow them to implement many creative applications in organisational business models. This has been happening in both the developed and developing economies in the Western world. For example, developing economies such as South Korea, Indonesia, the United Kingdom (UK), Japan, China, Germany, Malaysia and France to mention a few, have developed models on the application of technology to boost their resilience in business operations.

According to Yang, Kim and Yin (2021:2), the South Korean government developed a Flagship Project Support Program (FPSP) to assist its small and medium enterprises (SMEs) in technology fields. This model assisted South Korea in curbing barriers to entry to the markets. On the other hand, Rodrigues et al. (2021:131) reveal that the Malaysian government adopted Industry 4.0 initiatives thereby implementing automation in their processes and creating smart manufacturing for businesses. In Indonesia, the government adopted Industry 4.0 technologies and created a citizen-based intelligence model, which sought to promote sustainable development that will reduce poverty and lay the foundation for the coming generation (Anggusti & Siallagan 2018:3).

In South Africa, Mukwawaya, Emwamu and Mdakane (2018:1590) argue that the application of technology in public procurement will require a refocus from a traditional sense of Industry 3.0. Therefore, the government needs to plan and provide a suitable platform for the advancement of Industry 4.0 technologies in the procurement landscape. To emphasise more on the application of Industry 4.0 technologies on procurement, Jahani et al. (2021:2) argue that Industry 4.0 technologies facilitate the process of purchasing as a useful means. That is, it connects all the stakeholders in the value chain and allows a quick and robust collaboration and coordination beyond organisational limits. For the South African public sector, this implies that the collaboration will go as far as stakeholder engagement regarding required goods and services to the ultimate service delivery. SBI (2021:11) posits that the implementation of Industry 4.0 technologies may augment prospects for data collection and analysis, thereby facilitating the development of more precise and efficacious approaches to alleviating poverty.

Significance and application of Industry 4.0 technologies on public procurement in South Africa

In today's dynamic and competitive business climate, digitalisation through Industry 4.0 technologies has become a global phenomenon affecting several parts of life. These technologies have become significant for the public sector procurement on a global scale as well. South Africa as a developing economy is equally affected by the significance of Industry 4.0 technologies. Globally, Ageron et al. (2020:133) highlight that Industry 4.0 technologies have assisted companies that have adopted them to gain a competitive advantage over others. In agreement, Chamba, Chari and Zhou (2023:352) highlight that opportunities that result from the adoption and use of Industry 4.0 by numerous public and private organisations include leapfrogging efficiency through efficient communication, storage of large volumes of data, processing of big data and transmission of enormous volumes of data to multiple locations. These concepts are critical to the South African procurement process as efficient communication and data processing are significant to the planning phase (National Treasury 2017). The significance of Industry 4.0 technologies to South African Procurement processes, is informed by the need to respond rapidly to service delivery

needs. Industry 4.0 technologies such as the Internet of Things (IoT) and cloud computing offer ideal solutions to address the challenges that face the South African procurement landscape. According to Chamba et al. (2023:352), Industry 4.0 technologies have brought a significant change to businesses globally; for the South African government and its procurement process, the adoption of these technologies will lead to sustainable economic development which will come as a result of cost efficiency, improved service delivery, competitiveness among entrepreneurs and creation of innovative jobs in various sectors. Mukwawaya et al. (2018:1590) have suggested that in South Africa harnessing Industry 4.0 technologies will address the economic challenges that the country faces by creating competitiveness among companies which will lead improvement of efficiency.

Methodology

This study utilised the methods of thematic analysis as adapted by Kiger and Varpio (2020). These six-step methods have become a widely used approach in qualitative data analysis (Braun & Clarke 2006).

Ethical considerations

Ethical approval to conduct this study was obtained from the North-West University Senate Committee for Research Ethics (No. NWU-00656/24/A4).

Step 1: Familiarisation with data

According to Kiger and Varpio (2020:3–5), this step involves becoming familiar with the entire data set. This step is necessary for research to be able to identify suitable information that is relevant to the research objectives (Byrne 2022:1398). This study relied on secondary data extracted from journal articles between 2019 and 2024, and procurement legislation enacted by the South African government since the reformation of public procurement in 1996. The familiarisation was done on data collected from Scopus, Sabinet and Web of Science databases. On these databases, a literature search was carried out with the keywords 'Industry 4.0', 'Procurement', 'Public sector' and 'Fourth Industrial Revolution'. The search was limited to the period between 2019 and 2024 based on the researcher's view that Industry 4.0 is an evolving concept and literature should be within the last 5 years to reveal the most recent insights. The preliminary search conducted from the databases is presented in Table 1. This step was critical for this study to present a review of literature that is related and relevant to South African public sector procurement. The literature surveyed focussed on the procurement set-up in the public sector in South Africa, and thereafter the revolution of Industry 4.0 technologies with its prospects and benefits was taken into consideration.

The total number of papers retrieved was 121. After removing the duplicates, a total of 49 papers were used to address the research objectives of this study. Also, the study analysed SCM framework to provide context to the topic and bring alignment to the final report.

Step 2: Generate initial codes

This is an analytic step in the process that helps to shape data at a granular, explicit level (Kiger & Varpio 2020:5). In this step, the researchers begin to take notes on probable data items of significance, linking between data items and other preliminary intentions (Byrne 2022:1399). In other words, the idea of this step is to generate codes and not themes. This step systematically observed the description of the manifestation of Industry 4.0 and public procurement content. Coding was done manually, and to provide context, the research highlighted the keywords from which the codes were extracted (Table 2).

Step 3: Searching for themes

According to Braun and Clarke (2006), the third step encompasses scrutiny of the coded and collated data extracts to look for probable themes of broader significance. Kiger and Varpio (2020:6) highlight that themes are constructed by the researcher through analysing, combining, comparing and even graphically mapping how codes relate to one another. Table 3 depicts the construction of themes from the codes in relation to each other. This grouping considered the procurement set-up in South Africa's public sector context.

Step 4: Reviewing the themes

Braun and Clarke (2006) describe this step as a two-level systematic process. In the first level of analysis, the researcher looks at coded data placed within each theme to ensure proper fit. At this point, data extracts can be re-sorted and themes modified to better reflect and capture coded data (Kiger & Varpio 2020:6). For example, themes can be added, combined, divided or even discarded. During this step, the researchers reviewed the themes and e-Inform and e-Design were linked together as they addressed the same issues. The second level uses the same set of themes to determine if they fit meaningfully within the data set (Byrne 2022:1404). On this level, the researchers combined and created the linkage between the codes and themes as they fitted together meaningfully. Therefore, some of the codes and themes were grouped as they addressed the same functions as shown in Table 4.

TABLE 1: Literature search (N = 121).

Keywords	Scopus (n)		Web of science (n)		Sabinet (n)		Total (n)	
	Database search	Duplicates removed	Database search	Duplicates removed	Database search	Duplicates removed	Database search	Duplicates removed
'Industry 4.0' AND 'Procurement' AND 'Public Sector' AND 'Fourth Industrial Revolution'	63	24	40	16	18	32	121	72

n, the total number of articles returned.

TABLE 2: Code generation.

Codes	Source	Key Words
• e-Verification • e-Planning • e-Catalogue • e-Requisition • e-Inform • e-Design	• Addo (2019); • Sonavale and Londhe (2019); • Fadhlillah and Juwono (2021); • Madzimure et al. (2020); • Madzimure (2020); • Mafungwa and Ngcobo (2019); • McLennan and Prakash (2022); • Hudrasyah et al. (2019); • Mahat et al. (2022).	Procurement planning Information dissemination Demand forecasting Needs specification Efficiency promotion Data-driven decision making Government planning Service offering Service designing Product design Specification facilitation Draft contract Sourcing method Capacity planning Product/Service listing
• e-Tendering • e-Quoting • e-Reverse auction • e-Verification	• Fadhlillah and Juwono (2021); • Mpehle and Mudogwa (2020); • Boafo et al. (2020); • National Treasury (2017); • Addo (2019:54); • Sonavale and Londhe (2019); • De la Harpe (2012); • BHEL (2021); • Bajpai and Malviya (2023); • National Treasury (2017); • Madzimure (2020)	Supplier relations management Supplier selection Acquiring goods and services Closed bidding Reverse auction Seamless integration Progressively bid Open bid Multiple suppliers
• e-Verification • e-Award	• Ageron et al. (2020); • Lukhele et al. (2022); • Akaba et al. (2020:4)	Measures and metrics Determine productivity and efficiency Curb possible collusion Potential supplier Performance portfolio
• e-Monitoring • e-Reporting • e-Verification	• Babirye et al. (2022); • Mathiba (2020); • Molepo and Jahed (2022)	Contract compliance Non-compliance Procurement delays Late payments Monitoring and reporting Contract performance Spending is regular Value for money

Step 5: Defining and naming themes

According to Braun and Clarke (2006), once the thematic map has been refined, the researcher has to create a definition and narrative description. Further, there must be an explanation of why the themes are important to the broader study objective (Byrne 2020:1405). However, during this stage the researcher deemed it fit to provide clarity on the themes at the last step that deals with producing a report. This approach was deemed fit as it provides clarity on themes and addresses the intentions of the study more robustly.

Step 6: Producing a report

This final step involves writing up the final analysis and description of findings (Braun & Clarke 2006). Moreover, Peel (2020:8) describes this stage as a presentation of a detailed picture of the analysed data. It is for that reason that the researcher indicated at Step 5 that the description of themes will be done in this step. Therefore,

TABLE 3: Identification of themes.

Theme	Code
e-Sourcing	e-Tender
	e-Quote
	e-Reverse Auction
e-Evaluation	e-Verification
	e-Award
e-Contract	e-Monitoring
	e-Reporting
e-Invoicing	e-Verification
	e-Payment
e-Design	Blockchain
	e-Planning
	e-Verification
e-Inform	e-Verification
	e-Planning
	e-Catalogue
e-Requisition	e-Supplier selection
	e-Purchasing
	e-Submission

TABLE 4: Combination of themes.

Themes	Code
e-Design/e-Inform	e-Catalogue
	e-Planning
	e-Verification
e-Requisition/e-Sourcing	e-Tender/e-Reverse auction
	e-Quote/e-Submission
	e-Supplier selection

the final report moves beyond a mere description of codes and themes but also interlaces a narrative that provides a clear, concise and rational account of the interpretation of data.

The following sections provide a detailed description and analysis of the themes.

Application of Fourth Industry Technology on public procurement

To address the objectives of the study, the literature reviewed addressed the key features offered by Industry 4.0 technologies. In summary, Figure 1 presents the proposed application of digital public procurement in the government of South Africa extracted from different schools of thought presenting the six levelled methodology in the preceding Section 3. The researcher took into consideration the current procurement process and the digitalisation of the process based on the applications suggested by various scholars to enhance the system.

e-Design and e-Inform

To gain a deeper understanding of the elements of public procurement presented in Figure 2, the researchers aligned them to what the government intends to do in terms of its processes aligned to all legislative requirements. Furthermore, the researchers readjusted these elements to meet the objectives that the government hopes to achieve through the

SCM framework indicated in Figure 1. The procurement process starts with planning which in South African terms is referred to as demand management. Over the years, demand management has been neglected and reduced to compiling and submitting the procurement plan to the National Treasury and then reporting on its implementation quarterly. However, data-driven decision-making which will be made possible by e-inform will play a critical role in the process.

According to various scholars (Addo 2019; Fadhlillah & Juwono 2021; Sonavale & Londhe 2019), e-inform and e-design will not only address the planning phase but also disseminate information across every step in the entire value chain to assist the participants in making informed decisions. Thus, e-inform is not only critical for government planning, but it will also assist service providers in designing their e-catalogues for their products and service offerings. According to Madzimure, Mafini and Dhurup (2020:1), embracing technological initiatives in government procurement will allow small businesses to compete with larger enterprises for goods and services that are required by the government. The e-design allows both the supplier and the purchaser to design their product offering and requirements respectively on the digital platforms (Madzimure 2020:3). These elements, according to Addo (2019:54), will assist the government in facilitating specification drafting, determining the right sourcing method, drafting contractual agreements, and generation and authorisation of payment requisitions. In agreement, Mafungwa and Ngcobo (2019:11) propose a digital procurement enabler that will incorporate forecasting in demand, capacity planning, and collaborative optimisation in procurement. This can be achieved through e-inform suggested by Addo (2019:54), as it populates information that is crucial for procurement planning and service level agreement (SLA) drafting. It can be concluded that e-design and e-inform will gather crucial information at every stage of the process thereby creating seamless integration to design procurement plans and SLAs.

Furthermore, the suppliers can set up their products or list their services through e-catalogue (McLennan & Prakash 2022). While this might be the case, Hudrasyah et al. (2019:16) highlighted that an e-catalogue is ideal for direct purchasing in public procurement. Thus, in the South African context, it can be used for small amount purchases known as petty cash procurement. According to Mahat et al. (2022:347), these systems in government will not only allow contracting authorities to electronically purchase goods or services; they will further allow suppliers to display their products on the web.

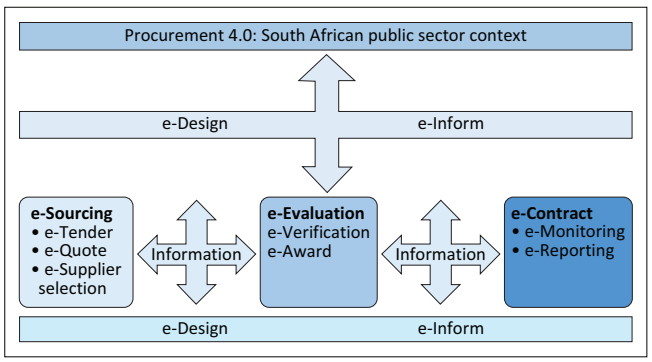


FIGURE 2: Application of Fourth Industrial Technology on public procurement in South Africa.

e-Sourcing

A study conducted by Fadhlillah and Juwono (2021:122) suggested two applications for digital procurement which are e-tendering and e-purchasing. Correspondingly, Mpehle and Mudogwa (2020:3) propose an e-catalogue to form part of the digital procurement systems. On the other hand, the study conducted by Addo (2019:54) suggests the key elements of digital procurement to include among others e-sourcing, e-tendering, e-reverse auction, e-ordering and web-based enterprise resource planning (ERP). Likewise, Sonavale and Londhe (2019:4) highlight that the seamless integration of e-reverse auction and e-tendering will yield positive results such as maintaining transparency, fairness and elimination of possible collusion between suppliers. Boafo Ahudey and Darteh (2020:242) also agree that e-tendering, e-supplier relations management, e-requisition, e-tender evaluation and e-supplier selection are significant to public procurement and should be applied.

It is suggested that e-reverse auction must be one of the key elements that Industry 4.0 must form as part of digital public procurement. According to De la Harpe (2012), an e-reverse auction is a topic that gained momentum in the mid-2000s and it became a trend in public procurement. Unlike a traditional auction that comprises one supplier and multiple purchasers, in an e-reverse auction, the process involves one purchaser and multiple suppliers (BHEL 2021). Bajpai and Malviya (2023:354) explain in a nutshell that a reverse auction is a type of auction in which the distinctive tasks of a purchaser and a supplier are exchanged. Thus, the purchaser specifies their needs, and suppliers progressively bid. The lowest bidder wins the right to supply. Therefore, such reverse auctions are often conducted electronically. However, in a reverse auction where the ultimate target is the lowest price, the researchers argue that the lowest price is not a balanced achievement as it does not align with the best quality of goods or services. Hence, the National Treasury (2017) emphasises competitive prices instead of low prices. To that effect, the research concurs with the notion of e-sourcing to determine the procurement approach. In the context of the South African government, the National Treasury (2017) divides this procedure into two categories (Request for Proposal [RFP] and Request for Quote [RFQ]). In line with the e-tendering and e-purchasing suggested, Sonavale and Londhe (2021:6) suggest that an e-reverse auction, e-sourcing in the context of this study, must address two categories namely, open bid and closed bid. This will align well with the intention of the National Treasury process as indicated. Lastly, setting up specifications will be made possible by e-design (Madzimure 2020:2).

e-Tendering

According to Sunmola and Shehu (2020:1586), e-tendering will allow service providers to submit their proposals digitally to the requesting entity. This will improve the current e-tender system which is all about publishing RFPs and does not have the function to allow bidders to submit using the same platform. In addition, Kazaz, Inusah and Ulubeyli (2022:67) posit that e-tendering will also bring stability to the entire value chain by reducing transaction costs. Therefore, it can be argued that e-tendering will become a platform business-to-business (B2B) process whereby a buying entity publishes its products and services specifications and bidder respond with proposals through the same platform. Sunmola and Shehu (2020:1587) conclude that e-tendering will improve the procurement system in many ways. These benefits are attributed to low costs of the procurement process, simplified tendering process, increased competitiveness among bidders, effective engagement, reduced collusion among bidders, consistent practice in the tendering process and fairness in the evaluation of tenders.

e-Quote

According to Fadhlillah and Juwono (2021:122), RFQ process in e-purchasing is often referred to as closed bidding. This approach will be made possible by the e-catalogue that is proposed in the study (Mpehle & Mudogwa 2020:3). Tran, Drew and Steward (2021:52) highlighted that connecting to digital platforms, small micro and medium enterprises (SMMEs) and government organisation will be able to sell and purchase products and services respectively. At this stage, the various procurement applications may be implemented and integrated. For example, the e-design, e-form and e-verification will always cut across all levels of the procurement system as they play a significant role in each element. Therefore, e-purchasing which is referred to as e-quote in this context will be made possible at this stage by these applications and it will support the entire procurement system as one element of e-sourcing. It can be concluded that e-quote will randomise the selection of supplier during the RFQ which will result in enhancement of fairness in the process.

e-Supplier selection

According to *National Treasury's Public Finance Management Act* ([PFMA] Republic of South Africa 1996) SCM instruction note 2 of 2021/22, there is a provision for closed quotation of up to a value of one million rand. Also, the National Treasury (2017) allows a selection of a few suppliers to provide quotations to address the organisation's needs at a particular point in time. Therefore, supplier selection will become mainly the function of e-quote whereby the system will generate a selection of a few suppliers to provide the quotations of a particular product or service. It can be concluded that the automated RFQ will send a notification to the service providers, selected by the system, who then will respond accordingly. This will also eliminate favouritism in the procurement process of closed bids.

e-Evaluation

The next element in the procurement process will be e-evaluation. According to Ageron et al. (2020:135), evaluation includes strategic, financial and non-financial measures and metrics to determine productivity and efficiency. The evaluation stage in public procurement is the most critical one, in that it is where most corruption occurs (Lukhele, Botha & Mbanga 2022:53). To counter that challenge, Mpehle and Mudogwa (2020:7) highlight that e-verification of supplier information will curb possible collusion among suppliers and promote a sound public procurement system that will force officials to be fair. Lukhele et al. (2022:64) suggested that officials award contracts to service providers who do not have the capacity to deliver. Therefore, to guard against this act, the verification will analyse the performance history of a service provider before the adjudication and award to assist decision makers with relevant information in awards.

e-Verification

Though the verification of information is critical at every stage in the procurement process, it is at the evaluation phase where it is most utilised. The e-verification in this context means that what has been done traditionally during the evaluation phase will now be automated. Lukhele et al. (2022:64) emphasise that e-verification at the evaluation stage will also assist the buying entity in determining the potential supplier's performance portfolio before awarding. Akaba et al. (2020:4) conclude that ultimately this phase will end with an e-award that is made possible by blockchain technology in Industry 4.0.

e-Award

According to Chan and Owusu (2022:12), the implementation of digital awards in many industries is yet to be exploited to a greater extent. The tendering process as a system has been implemented in the public sector to award contracts fairly (National Treasury 2017). Although the award activities may be performed digitally, they are particularly influenced by human choices and prejudice, as such, they repeatedly tend to eliminate the same intention of fairness the procurement process intends to achieve (Chan & Owusu 2022:12). Therefore, it can be argued that the e-award as solution provided by Industry 4.0 technologies will have to close all gaps both internal and external such as inconsistencies in monitoring and reviewing of procurement activities. In agreement, Kazaz et al. (2020:66–67) highlighted that streamlining and automation of legacy systems has improved procurement processes, especially in government whereby e-tendering is efficient from advert to award.

e-Contract

The contract management in the procurement process is one other critical aspect that has been overlooked. According to Babirye, Tait and Oosthuizen (2022:2), contract compliance is a significant role player in strategic management in that it addresses non-compliance, procurement delays and late

payments to suppliers. Further, Babirye et al. (2022:3) highlight that this compliance must be characterised by 'accountability, transparency, fairness, equity', and compliance with the legislation. These principles are consistent with the legislative provisions that govern South African public procurement (Mathiba 2020:649; Molepo & Jahed 2022:234). The introduction of technology in contract management will address challenges such as unethical and peddling in the contract phase of the procurement (Baghel, Dwivedi & Singh 2023:74). Also, the real-time monitoring offered by IoT assists in enhancing traceability allowing predictive maintenance and replenishment (Khan, et al. 2023:6). Thus, it will eliminate instances of defaulting on contracts by alerting both the buying entity and the service provider when there is a need for maintenance or replenishment of inventory items. Furthermore, Althabatah et al. (2023:27) highlight that smart contracts are considered to be enablers of transparency and secure transactions in the procurement process. According to a study conducted by Baghel, Dwivedi and Singh (2023:74) on leveraging IoT to detect fraud in credit card transactions, it was revealed that IoT can detect fraudulent activities by incorporating various components and processes. This can be used to detect fraudulent activities during contract implementation within public procurement.

e-Monitoring

The monitoring and reporting on contract performance on online platforms will ensure that the government achieves the value for money requirement and all spending is regular. The revolution of public procurement will not only benefit the government, the supplier will equally benefit from this change. According to Addo (2019:53), there is a need for the government to closely monitor the procurement process to determine the level of contract performance. To achieve this, Allioui and Mourdi (2023:6) confirm that Industry 4.0 platforms such as IoT offer devices that allow monitoring and optimising of the process.

e-Reporting

Reporting is a crucial activity in the procurement process; with data-driven decision-making that is provided by the e-inform, the buyer and sellers are privy to information regarding contract performance (Madzimure et al. 2020:3). In agreement, Sunmola and Shehu (2020:1566) posit that the tenderers will get a feedback that will assist them to assess their product offering and improve their proposal in the next offering. This means that the quality of the service that will be offered through the digital procurement process will improve over time leading to an effective and efficient procurement system.

Recommendations

The research recommends the concepts presented under the above-stated application of Industry 4.0 technologies in public procurement to be incorporated into public procurement in South Africa. The incorporation of these concepts will ensure that procurement in government is revolutionised for the betterment of government processes towards achieving its objectives. In so doing, the government firstly needs to consider re-designing the procurement process using the Industry 4.0 technologies. Secondly, the government should reduce legislative red tape that is hindering the adoption of technology in public procurement. South African public sector is characterised by challenges associated with manual systems as confirmed in literature by various scholars. These challenges impact negatively on service delivery to the ultimate suffering of ordinary citizens. To counter that, this study recommends the total implementation of Industry 4.0 capabilities to digitalise the process to make it easy for all stakeholders to collaborate and add value to the entire chain. This will ensure that planning is done properly, in time, for the right people and the correct cost.

Contribution

This study has contributed to the scientific body of knowledge by identifying the prospects and benefits of Industry 4.0 technologies in public procurement. Furthermore, the study has identified their significance and application to the South African processes. In terms of practical application, the study has contributed to the environmental impact of reducing paperwork and contributing to the green economy. On a larger scale, the study has contributed significantly to various Sustainable Development Goals (SDGs) – SDG 9 (industry, innovation and infrastructure), SDG 10 (reduce inequality), SDG 11 (sustainable development), and SDG 13 (limit and adapt to climate change).

Conclusion

This article aimed to identify the prospects and benefits of Industry 4.0 technologies in public procurement. The article further sought to uncover the significance and the application of these technologies in the South African public procurement context. The study highlighted the process of public procurement in South Africa. The discussion focussed on the revolution of Industry 4.0 to address the objective of this study. The study identified different benefits of Industry 4.0 technologies in public procurement and the elements of this process were built from the different applications presented by Industry 4.0 technologies. Lastly, the study presented the recommendations and highlighted the contribution towards SDGs.

Acknowledgements

The authors would like to thank Dr Tite Tuyikeze and Kaizer Ndlovu for their mentorship, supervision, support and guidance in writing this article. This article is based on the thesis for the degree Doctor of Philosophy in Economic and Management Sciences with Business Administration at the North West University.

Competing interests

The authors declare that they have no financial or personal relationship(s) that may have inappropriately influenced them in writing this article.

Authors' contributions

L.M.M. under the guidance of Northwest University supervisors, conceptualised and conducted the study towards his PhD research. The author was involved in writing of the article and handling all comments from the reviewers and the Editorial Board. T.T. and N.K.N. provided guidance and supervision to L.M.M., and reviewed and recommended improvement where necessary. T.T. and N.K.N. were also responsible for editing the final manuscript submitted to the journal.

Funding information

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Data availability

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

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