

Technology-Organisation-Environment Framework Theory for Adopting and Implementing Big Data Analytics: A Bibliometric Analysis Study

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Abstract

Small and Medium Enterprises play a crucial role in growing the economy of developing, emerging, and developed countries. With South Africa experiencing the highest unemployment rate, SMEs are known for eradicating that and bringing about innovation. Digitalisation has led enterprises and people to generate massive big data that can be used for gaining insights, making predictions, descriptions, and prescriptive. The use of big data can increase the revenue and productivity of the enterprise. Big enterprises often manage to adopt and implement big data as they have the resources to do so. Unfortunately, SMEs are reluctant to adopt and implement due to limited resources. For enterprises to embrace big data they should have a roadmap that they will follow. This study followed a bibliometric analysis where Scopus databases were used for analysis are 118. The purpose of the bibliometric analysis was to outline the research trends for the adoption of big data by SMEs following the TOE framework theory for the past 5 years dating from 2019. Network, overlay, and density visualisation are outlined in this study. Together with coauthorship. It was found that Malaysia, Saudi Arabia, and Australia are leading with the number of publications. South Africa is in the top 12 countries that have contributed more. It is recommended that there must be support for scholars in the discipline. Future studies should focus on action research where the TOE framework theory is tested for its effectiveness when adopted and implemented by SMEs implementing big data analytics.

Keywords

Big data, SMEs, TOE, Technology adoption, Innovation

1. Introduction

Small Medium Enterprises (SMEs) also known as Small, Micro, and Medium Enterprises play a very crucial role in growing the economy of any country, including developing emerging and developed (Chiromo, 2019). China, the United States of America, and Europe contribute a lot to exporting goods (Truong 2022). They contribute over 60% to the economy globally. As they are celebrated in different countries for their contribution to job creation, economic growth, and improving the standard of living of people, they also encounter a myriad of challenges where they operate.

In countries such as South Africa, where unemployment is skyrocketing, the hope is put on SMEs. There are several policies that are meant to support SMEs so that they may flourish and deal with the problem of business failure. It is purported that in South Africa, many SMEs fail in the first year of existence. The contributing factors to business failure in South Africa are attributed to issues such as crime; load shedding, marketing, finance, lack of appropriate technologies, and lack of skills. SMEs are also believed to be late adopters of technology, which makes them to be behind, and struggle to compete with bigger firms (Bilal & Mqbal, 2015). With that in mind, this study aims to understand the adoption of big data analytics using the Technology-Organisation-Environment (TOE) Framework Theory.

Big data (BD) is a crucial technology that is needed and should be used by organisations and governments to enable them to make decisions that are fact-based decisions that are influenced by gut feeling. This is very important in business, as organisations that have adopted the use of big data have increased their profitability and creativity (Mukherjee et al 2022). It is said that organisations can increase their profitability by up to 60%. Different academics have viewed big data as a crucial resource for business operations. It is said that big data is the new gold (The Economist, 2017), while (The PyCoach, 2022) likens it to oil. The author further argues that like oil, big data is useless when it is not refined and can make other commodities. In this case, refining data refers to the collection and cleaning of it. The data should then be used for data analytics. It is of no use to have data that is not organized and refined, as it cannot be used for decision-making. Truong (2022); Lutfi et al., (2022) posit that in 2020 the BD market was valued at an amount of 66.2 billion United States Dollars (USD) and is expected to reach 157.2 billion USD. This was asserted by the International Data Corporation.

Understanding all that, for big data to be adopted and implemented, there should be a framework theory that should be used for. This study identified the use of TOE, as it was the most proposed framework for the adoption of big data by SMEs. This study focused on the bibliometric analysis using Scopus databases to check this.

The study contributes by giving a bibliometric analysis of the adoption of big data by SMEs following the TOE framework theory. This is crucial for the industry and academics to see what has been done over the five years regarding this topic and can give a clear picture of where and who has written about this topic. Researchers will have a clear picture of where to start and find relevant data for studying the adoption and implementation of data by SMEs using the TOE framework theory. Studies prove that research aimed at the adoption and implementation of big data by SMEs is still very low (Lutfi et al 2022).

1.1 Objectives

The adoption of big data by SMEs is challenging. SMEs struggle to find the most accurate framework to base the adoption of the latest technology such as big data. Several publications have canvassed the adoption of the TOE framework theory as a roadmap. This study aims to outline researchers in this field and where the research was conducted. In understanding what has been happening in the research area for adoption of big data analytics for SMEs using the TOE theory framework. The study aims to outline the bibliometric analysis of the research trends of the study and display visualisations using overlay, network, and density for the past five years of published scientific research. Furthermore, this study will outline the leading authors and most cited in the discipline under study. This is very crucial for researchers to know who has published research using the TOE framework theory for the adoption of big data analytics for SMEs and understanding the trends over time.

2. Literature Review

This section reviews the literature related to SMEs, big data, and lastly the technology organisation environment framework theory. This study uses the traditional literature review.

SMEs

There is no universally approved acronym or definition for small medium-sized enterprises. They are generally known for contributing extensively to the economy (Lutfi et al 2022; Kamal et al 2023). Countries define small and medium-sized enterprises based on their economy. The definition of SMEs is determined by three factors the number of employees, income an SME receives, and the assets it has (Kamal et al 2023). For instance, in South Africa, it is called SMMEs, which stands for Small Micro and Medium Enterprises. In India and Malaysia, it is called Micro, Small and Medium Enterprises (MSME). In the United States of America (USA), China, and many other countries they use SMEs. However, the acronym is defined based on the country's economy and how strong it is. The number of

employees and the turnover is used. For instance, in South Africa, SMEs are defined as businesses that have 0 to 200 employees. In the USA the number of employees is up to 500, Japan is 500, Belgium is 200 and Switzerland is 100 (Mohamed 2013) while China's definition has about 2,000 employees (Xiangfeng 2008).

The Adoption and Implementation of Big Data

Truong (2022) argues that the adoption and implementation of big data is a crucial resource as it increases the chances of making informed decision-making speedily and increasing revenue in the enterprise. Furthermore, it helps the SMEs to understand the real needs of the customers, and the trends that SMEs can take leverage on, and most importantly, it has increased the operational efficiency of the enterprise. Several authors (Awa and Ojiabo 2016; Maroufkhani et al 2020; Tien et al 2020; Maroufkhani et al 2022; Lutfi et al 2022; Wessels and Jokonya 2022) recommend that SMEs use the TOE framework theory for the adoption and implementation of big data. Additionally, BD assists with giving SMEs predictions, and prescriptive and descriptive outcomes when used well. The business insights can lead to innovation and productivity. However, big enterprises employ and enjoy the adoption of BD, while SMEs struggle to adopt and implement BD. For the successful adoption and implementation of BD, enterprises should have a roadmap that should be followed (Jang et al 2018). Unfortunately, several enterprises especially SMEs do not adopt it due to the high costs associated with the adoption and implementation of BD and the difficulty it presents (Mukherjee, et al., 2022). In organisations that have adopted and implemented, BD has reported positive success. Sadly, it is very difficult for SMEs to enjoy the benefits that are presented by BD since they struggle to implement due to limited resources and inability to understand the technology. This makes it harder for them to compete with big enterprises (Lutfi et al 2022).

Technology Organisation Environment Framework Theory

Fleischer (1990) proposed a framework theory for the adoption of technology and innovation that entrepreneurs and engineers can follow. The TOE is an acronym for Technology Organisation and Environment. These are factors that make up the framework theory that needs to be present and observed when new technology and innovation are adopted and implemented by engineers and or entrepreneurs (Ansong & Boateng, 2017). The first factor is the Technology context, which includes the availability of technology and the characteristics of such technology. The availability refers to the technology that is currently in use in the SMEs and whether it is compatible with the technology that will be used by SMEs. SMEs should examine where they are ready to adopt and implement technology, which refers to big data technology. Furthermore, the adopters and implementers of such technology look at the benefits they will get from implementing it in their enterprise. In the context of big data, SMEs will focus on business efficiency, improved timely business decision-making, timesaving, reduced costs, and gaining business insights, which will translate as saving money, and making data-driven business decisions. On the other hand, the organisation context refers to all the things that happen within the organisation such as support from management, a commitment by the SMEs, investment into the resources required, and removing all the obstacles that SMEs may foresee as hindrances. The last one is the environment, which refers to the regulations about the proposed new technology that needs to be adopted. In the case of this study, this will be the privacy act, data act, and competitors. The enterprise focuses on complying with the regulations for the new technologies so that they are not on the wrong side of the law (Truong, 2022).

3. Methods

This study used a bibliometric analysis of the Technology-Organisational-Environment theory framework adopted by SMEs when adopting big data. Publications that were sourced from Scopus databases were 118. Scopus was used due to it being the largest scientific database that is credible.

The keywords that were analysed were 807. The keywords had to occur a minimum of five (5) times for it to be included in the analysis. Only 34 keywords met the threshold set by the researchers. The data period was 6 years. It started from 2019 to 2024.

Below is a table of the top 20 keywords with the highest link strength. The Table 1 is in the order of the highest link strength and then the total occurrences.

Table 1: Keywords

Keyword	Occurrences	Total Strength
SMEs	36	78
Technology adoption	14	59
Small and medium-sized enterprise	16	53
Competition	11	38
Developing countries	8	37
Sustainable development	9	32
TOE	11	30
Information and communication technologies	6	29
Digital transformation	8	28
Small and medium enterprise	5	27
TOE framework	12	27
Environmental technology	6	25
Technological innovation	7	25
Technology	9	24
Top management support	6	23
Competitive advantage	5	22
Surveys	5	22
Cloud computing	7	21
SME	7	21
Structural equation modeling	5	21

“SMEs” had the highest total link strength of 78 with occurrences of 36. This is followed by “technology adoption” with a total link of 59 and occurrences of 14. The third highest is “small and medium-sized enterprise” with a total link strength of 53 and occurrences of 16. Similar keywords are merged due to having the same meaning and mostly used interchangeably. In the top 20 keywords, the following words were merged and presented in a table form below.

Table 2: Merged keywords

Similar keywords	Original occurrences	Merged occurrences
SMEs		
SMEs	36	64
Small and medium-sized enterprise	16	
SME	7	
Small and medium enterprise	5	
TOE		
TOE	11	23
TOE framework	12	
Technology Adoption		
Technology adoption	14	57
Technology	9	
Digital transformation	8	
Technological innovation	7	
Cloud computing	7	
Environmental technology	6	
Information and communication technologies	6	
Competition		
Competition	11	16
Competitive advantage	5	

Table 2 highlights keywords that are merged due to them being similar. Four categories were created using the most used keywords or well-known ones. The categories are SMEs, TOE, technology adoption, and competition. SMEs include SMEs which occurred 36 times, followed by Small and medium-sized enterprise which occurred 16 times, SME 7 times and Small and medium enterprise occurred 5 times. The first category accounts for 64 occurrences. The second category is TOE which merged two keywords. The two keywords in the category are TOE which occurred 11 times and TOE framework which occurred 12 times. The total merged categories and their occurrences are 23. The third category is technology adoption which has seven keywords. Included keywords are technology adoption occurred 14 times, followed by technology which occurred 9 times, digital transformation occurred 8 times, technology innovation occurred 7 times, cloud computing occurred 7 times, environmental technology occurred 6 times and lastly, information and communication technologies occurred 6 times. The total number of occurrences of the third category (technology adoption) is 57 times. The fourth and last category is competition which has two keywords. The first keyword is competition which occurred 11 times followed by competitive advantage which occurred 5 times. The total occurrences for category four is 16 times.

4. Data Collection

The researchers sourced data articles from the Scopus database which is said to be the largest peer-reviewed scientific publication. The authors searched on the following themes, "Big Data" AND "TOE" AND "SMEs". 118 articles were found, selected, and downloaded using a comma-separated values file (CSV). The file was then uploaded on VOSviewer for analysis.

5. Results and Discussion

This section outlines and discusses the results as analysed using VOSviewer software. About 118 publications were used for analysis. The discussion includes network visualisation, overlay visualisation, and density visualization (Figure 1). The type of analysis chosen is co-authorship and the unit of analysis chosen is countries. The maximum number of countries per document is 25. When choosing thresholds are minimum number of documents of a country is 5, minimum number of citations of a country is 0. Of the 58 countries that appeared, 12 met the threshold.

5.1 Numerical and Graphical Results

SMEs in Figure 2 occurred 36 times, and it is cluster 2 with 28 links (innovation, electronic commerce, technology, adoption, TOE framework, cloud computing, TOE, competitive advantage, top management, developing countries, competition, small-and-medium enterprise, sustainable development, structural equation modeling, firm performance, COVID-19, Blockchain, technological innovation, industry 4.0, technology adoption, small and medium-sized enterprise, digital transformation, SME, environmental factor, commerce, and surveys) and 78 total link strength. Technology adoption occurred 14 times. It is cluster 4 with 29 links (innovation, electronic commerce, small and medium-sized enterprise, technology, SMEs, adoption, TOE framework, TOE, small and medium enterprises, developing countries, competitive advantage, competition, top management support, small-and-medium enterprise, firm performance, sustainable development, environmental technology, commerce, COVID-19, Blockchain, industry 4.0, SME, digital transformation and environmental factor) total link strength of 59. TOE occurred 11 times and it is cluster 2 with 17 links (technology, adoption, cloud computing, competitive advantage, developing countries, top management support, competition, information and communication, COVID-19, technology adoption, SME, digital transformation, and environmental factor) and total link strength of 30. TOE framework occurred 12 and is cluster 2. It has 16 links (electronic commerce, adoption, cloud computing, competitive advantage, top management support, developing countries, technology-organisation-environment, small-and-medium enterprise, SMEs, technology adoption, industry 4.0, small and medium-sized enterprise and digital transformation) and total link strength of 27.



Figure 1: Density Visualisation

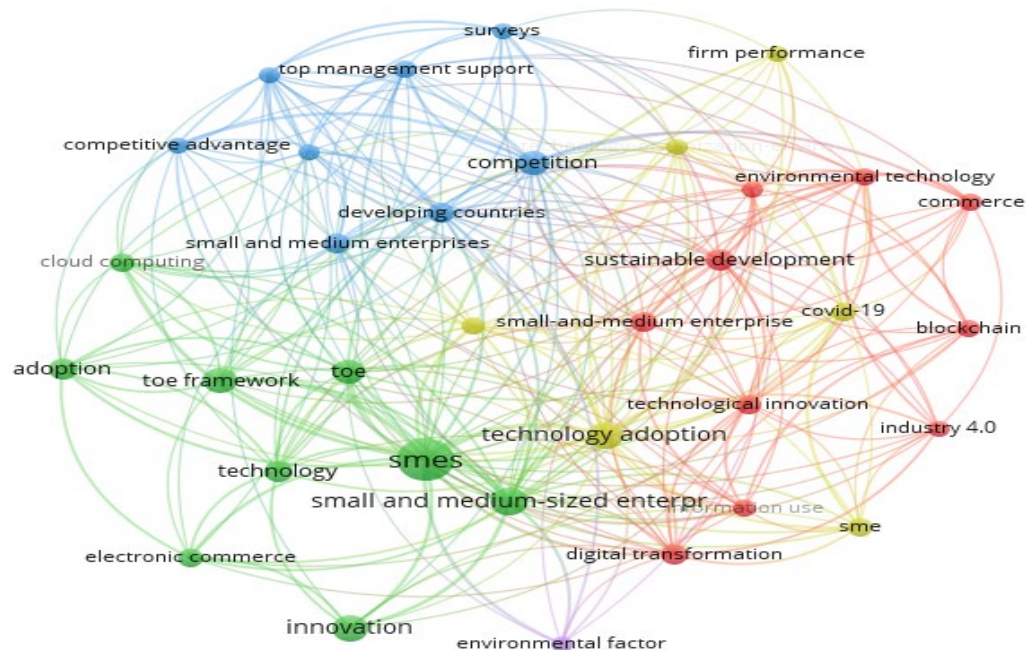


Figure 2: Network Visualisation

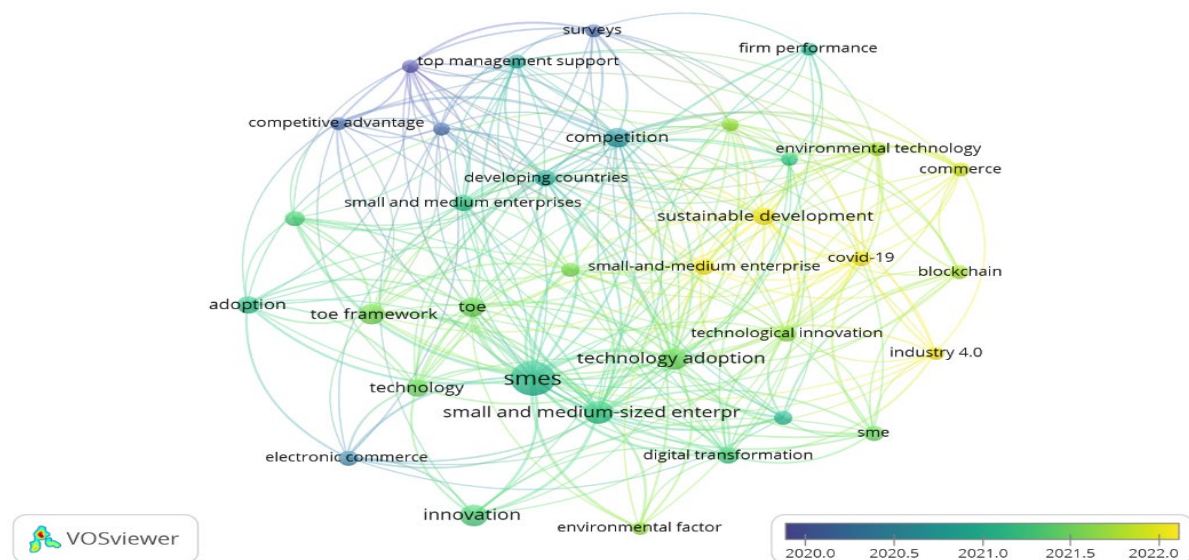


Figure 3: Overlay Visualisation

The overlay visualisation in Figure 3, starts from 2020 with a purple colour. Which colour surveys, top management support, competitive advantage, and electronic commerce. In 2021, the trends were SMEs, small and medium-sized enterprise, competition, adoption, digital transformation, developing countries, and firm performance. In the second half of 2021, the trends were SME, TOE, TOE framework, blockchain, technology, technological innovation, and technology adoption. In 2022, the trends were sustainable development, commerce, industry 4.0, COVID-19, and medium enterprise.

Table 3 below outlines co-authorship per country, documents, citations, and total link strength. 12 countries have met the set minimum threshold as alluded to in the first section of the discussion.

Table 3: Co-Authorship and Citation

Country	Documents	Citations	Total link strength
Malaysia	21	619	9
Saudi Arabia	6	457	5
Australia	6	91	4
United Kingdom	7	318	4
France	7	73	3
China	11	585	2
Italy	9	378	2
India	7	90	1
Jordan	5	133	1
United States	6	29	1
Indonesia	7	135	0
South Africa	8	9	0

As outlined in Table 3 above, Malaysia contributed the highest published research that was cited the most. The total number of published documents is 21, the total citation for 5 years is 619 and the total link strength for the co-authorship is 9. The second-highest published documents are from China with 11 documents and a citation of 585. The total link strength for co-authorship is 2. Italy is the third country with the highest number of publications which is 9. However, the citation is the fourth highest following Saudi Arabia with 457 citations, while the total number of published scientific documents is 6. Italy has a citation score of 378. South Africa has the least citation which is 9, with 8 published documents. South Africa has no link strength in its co-authorship with other countries. Indonesia has no link strength too however, the citation score is 135, and has only published 7 documents.

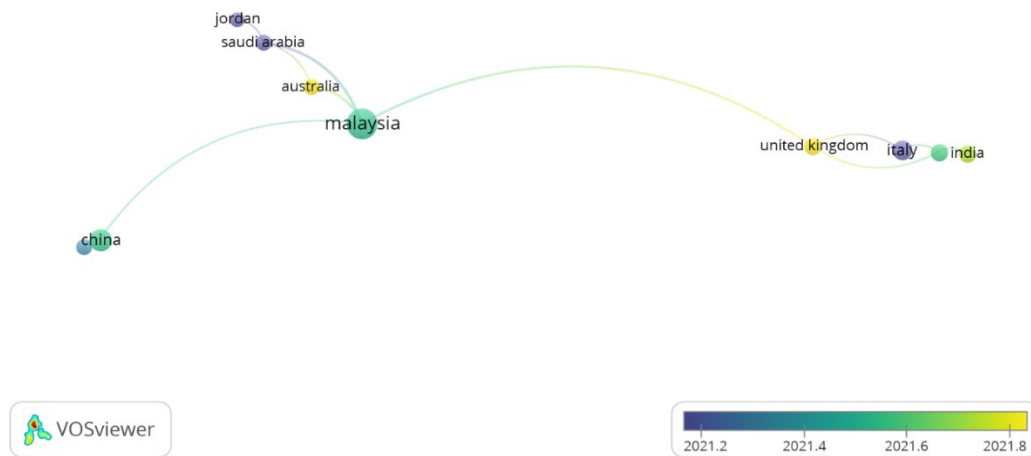


Figure 4: Co-authorship

Figure 4 depicts the countries and their link strength. The first is Jordan in 2021.2 in Cluster: 3, the link is 1 and is with Saudi Arabia. The documents are 5. The total link strength is 1. While Saudi Arabia is cluster 3, has 3 links (Jordan, Australia, and Malaysia). The total link strength is 5 and the average publication per year in 2020.33. Malaysia is cluster 4, and its links are (China, Australia, Saudi Arabia, and the United Kingdom). The total link strength is 9, the documents are 21, and the average number of publications per year is 2021.52. The United Kingdom is cluster 1,

with links of 3 (Malaysia, Italy, and France), and total link strength is 4, documents 7, and an average publication per year is 2021.86.

5.2 Proposed Improvements

Countries such as South Africa are contributing to the body of knowledge through research. It is in the top 12 globally, however, a lot still needs to be done to increase the research contribution. There is a call for impactful research that will be cited by many people. What will lead to this collaboration with leading authors from other countries? The must be incentives for scholars who co-author with international leading scholars. They must be awarded for top cited in the topic understudy. This will encourage academics to write impactful research and to collaborate with the right scholars. The National Research Foundation (NRF) which is a national foundation should facilitate the awards, and administration related to NRF.

6. Conclusion

The research in the adoption of big data analytics by SMEs using the TOE framework has gained momentum. Recommendations have been made that SMEs should adopt TOE as a framework theory for basing the adoption of big data analytics. It is worth noting that the TOE framework theory is used when engineers and entrepreneurs want to adopt the implement big data analytics. The growth in the publications in the Scopus databases shows that researchers are writing about this topic. During COVID-19 times the has been a sharp growth of the research in this discipline. This is a result of lockdowns and the number of data created during that time as many people did most of the things on the internet. The country under study, South Africa is in the top 12 countries that have contributed significantly to this country. However, it remains the lowest contributor on the top 12 list. The country can do more in terms of increasing publication because it has a high number of SMEs and this presents an opportunity for more research. Furthermore, South Africa has a presidential task team on the Fourth Industrial Revolution. It is worth noting that the Fourth Industrial Revolution includes big data. They should be invested energy in the adoption of big data by SMEs and research should be done on this topic. Future studies should focus on action research where the TOE framework theory is tested for its effectiveness when adopted and implemented by SMEs implementing big data analytics.

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Biographies

Lawrance Seseni is an Entrepreneurship Lecturer who teaches undergraduates and supervises honours and master's students at the University of Johannesburg. As part of his work in disadvantaged communities, he has initiated several developmental projects, such as conducting career exhibitions in those communities. He currently serves as the Primary Faculty Advisor of the Enactus University of Johannesburg, an international student organisation dedicated to solving societal problems through social entrepreneurship. In addition, he launched the Business Clinic at the University, as he believes that teaching students to take part in community service projects will create citizens of value. This initiative aims to help struggling SMEs in and around Johannesburg. Furthermore, he is the editor of the department's newsletter and a houseparent in a mixed residence on campus. Among his commitments, he is the lab manager for the European Union's and Erasmus+'s Common Good First Digital Storytelling project. Participants in the Digital Storytelling Project are universities from Iceland, Norway, Denmark, Scotland, Spain, and South Africa. A major goal of this project is to showcase community-generated innovative content. As a researcher, he has had a number of his articles published in international conferences that are indexed by Scopus. His recent experience includes serving as a Session Chair at international conferences, reviewing conference papers, and serving as a Track Chair as well as presenting as a distinguished speaker at conferences. A Golden Key member, Lawrance Seseni is in the process of achieving his Ph.D. in Operations Management.

Professor Charles Mbohwa is the former Pro-Vice-Chancellor of the University of Zimbabwe. As an established researcher and professor in the field of sustainability engineering and energy, his specializations include sustainable engineering, energy systems, life cycle assessment, and bioenergy/fuel feasibility and sustainability, with general research interests in renewable energies and sustainability issues. Professor Mbohwa has presented at numerous conferences and published more than 150 papers in peer-reviewed journals and conferences, six book chapters, and one book. Upon graduating with his B.Sc. Honors in Mechanical Engineering from the University of Zimbabwe in 1986, he was employed as a mechanical engineer by the National Railways of Zimbabwe. He holds a Master's degree in Operations Management and Manufacturing Systems from the University of Nottingham and completed his doctoral studies at the Tokyo Metropolitan Institute of Technology in Japan. Prof. Mbohwa was a Fulbright Scholar visiting the Supply Chain and Logistics Institute at the School of Industrial and Systems Engineering, Georgia Institute of Technology; is a fellow of the Zimbabwean Institution of Engineers; and is a registered mechanical engineer with the Engineering Council of Zimbabwe. He has been a contributor to the United Nations Environment Programme and a Visiting Exchange Professor at Universidade Tecnológica Federal do Paraná. He has also visited many countries on research and training engagements, including the United Kingdom, Japan, Germany, France, the USA, Brazil, Sweden, Ghana, Nigeria, Kenya, Tanzania, Malawi, Mauritius, Austria, the Netherlands, Uganda, Namibia, and Australia.

Dr Nelson Sizwe Madonsela (ND: IT, BTech, MTech, Ph.D). Business Intelligence Analyst, Senior Lecturer, and Acting Head: Department of Quality and Operations Management, University of Johannesburg (UJ). He holds a doctoral degree (Ph.D. in Engineering Management) from UJ and obtained his Master of Technology degree in Operations Management from UJ. He received a Bachelor of Technology degree in Quality from the University of South Africa (UNISA) and a National Diploma in Information Technology (Software Development) from Tshwane University of Technology (TUT). His research focuses on Business Artificial Intelligence and operation management, focusing on operational excellence. He also focuses on areas such as quality management systems, digital

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