



Research Article

© 2021 Waliu M. Adegbite and Cookie M. Govender.
This is an open access article licensed under the Creative Commons
Attribution-NonCommercial 4.0 International License
(<https://creativecommons.org/licenses/by-nc/4.0/>)

Received: 27 June 2021 / Accepted: 26 September 2021 / Published: 5 November 2021

Emerging Roles of Small and Medium Enterprises in the Fourth Industrial Revolution in Africa

Waliu M. Adegbite

Department of Industrial Psychology and People Management,
College of Business & Economics,
University of Johannesburg, South Africa:
Corresponding Author

Cookie M. Govender

Department of Industrial Psychology and People Management,
College of Business & Economics,
University of Johannesburg, South Africa

DOI: <https://doi.org/10.36941/mjss-2021-0065>

Abstract

The Fourth Industrial Revolution (4IR) is more than just technology-driven change, disruptive innovation impacts core industries, including the informal sector. Expectedly, the revolution will raise the level of innovation and creativity of the manufacturing SMEs through the Industrial Internet of Things (IIoT). Unfortunately, fewer studies attempted to examine the knowledge level of SME's adoption of 4IR technologies, and their benefits to the sector in low-income countries, especially in Africa. This research paper takes a closer look at the expected roles of SMEs. It examines the emerging roles of SMEs in the 4IR towards sectoral growth and intending transformation of the informal sector in Africa. Twenty-nine studies dealing with this range of topics are examined in the framework of a systematic review. Although the reviews showed that the level of awareness on the benefits of adopting 4IR technologies in manufacturing SMEs is increasing, research has not highlighted the specific roles expected of SMEs in the digital revolution, especially in low-income countries like Africa. The study identified from the literature that if SMEs are fully transited into industry 4.0, small businesses in Africa will mobilise future jobs, create a new business model, and promote the internationalization of SME products, among others. The study proposed a framework to facilitate the role of SMEs in the 4IR. A unique regional approach towards governance and cooperation focusing on 4IR to grow the activities of the SMEs for regional development may be necessary for Africa.

Keywords: SME 4.0, Fourth Industrial Revolution, SME Hub, SME 4.0 Partnership, Africa

1. Introduction

Marked by the technological progress of the third industrial revolution (1970-2011), the Fourth Industrial Revolution (4IR) presents a unique opportunity to emerging and developing countries for potential growth to attain a higher level of prosperity (Alqam & Saqib, 2020; WEF, 2020; Stentoft et al., 2019; Vrchota et al., 2019). Accordingly, the 4IR, which builds on the third industrial revolution, is

characterized by the fusion of technologies that blur the lines between the physical, digital, and biological domains (Xu et al., 2018). It is a convergence of various technologies and integration of many disciplines, including mechanical and electrical engineering, computer science (Peters, 2017), and lately, encompasses fields in behavioural science (Naudé, 2017). The fourth industrial revolution (4IR), also known as Industry 4.0 (I40), basically is about new business and production model; merging the physical-digital component; new organizational structure; and new ways of collaboration even within the same organization (Alqam & Saqib, 2020; Kamaruzaman et al., 2019). Compared with previous revolutions, the 4IR is expected to transform industrial production, society, and the economy towards maximizing sustainable social benefits (Müller & Voigt, 2018). It is with essential attributes of sophisticated technologies that require highly skilled manpower due to the interconnectivity and autonomous nature of the central machine (cyber-physical system) that will oversee the entire production line (Kamaruzaman et al., 2019; Liao et al., 2018; Morrar et al., 2017).

The fourth industrial revolution is more than just technology-driven change (Xu et al., 2018); it powered disruptive innovation, impacting core industries, including the informal and education sector. For example, the model of learning in the first revolution was the standard mode of learning, standardized testing in the second industrial revolution, and the customer learning model form of education characterized the third industrial revolution (Peters, 2017). In the 4IR, the mode and content of learning have been redefined with specific demand towards digitalization. Across the stages of civilization and revolutions, knowledge is the most dominant. Noticeably, knowledge is an important part of the revolution; the main asset and primary driver of the industrial ages are machines and capital – people were necessary but replaceable (Xu et al., 2018). In the previous revolutions, employees were motivated to perform physical labour; however, the challenge in the current era is how employees can be motivated to use their knowledge to release their human potential (Trento et al., 2018). Within the manufacturing value chain, regions and countries of the world are working out the most appropriate fit-to-situation acronyms for the fourth industrial revolution; for the Germans, it is industry 4.0, the European Union preferred the factory of the future; the South Koreans considers it as manufacturing innovation 3.0; while the Chinese tagged it as Internet Plus within the program called made in China 2025 (Müller & Voigt, 2018).

It is difficult to ignore Africa in discussions around the fourth industrial revolution. The region has the highest youngest working-age population in the world (International Labour Organization, 2018). For a sustainable economy, especially in the period of 4IR, the region desires a strong and globally competitive manufacturing sector. More than before, the projection that Africa's economy is on a sustainable path has been truncated by the devastating impact of the Covid-19 pandemic. The World Economic Forum (WEF) emphasised that the region's working poverty, which was projected to have declined by 31% in 2018, may have suffered in the face of the pandemic (WEF, 2020). The absence and non-adoption of digital technologies in emerging and developing countries explains the reasons business activities continuously shutting-down during the community lockdown to contain the COVID-19 pandemic (Akpan et al., 2020). Undoubtedly, the strategies to survive by SMEs in the new normal and beyond in the face of fierce global competition imposed by the 4IR include a successful adoption of advanced technologies. While the majority of white-collar jobs have been automated due to the technologies of 4IR and Covid-19 measures, creating a double-disruption scenario in the labour market (WEF, 2020); the exact impact of 4IR paradigm on jobs cannot be predicted at the moment. However, studies have suggested that workers in some countries are more defenseless than others. According to Segal (2018), more than 25 percent of jobs are at high risk due to automation in some regions. It would be too risky for Africa to focus on the large formal organizations at the expense of the informal sector including the small businesses in the face of 4IR. After all, the fourth industrial revolution is to enhance technological innovation and serve as a catalyst to manufacturing intelligence (Morrar et al., 2017; Wu et al., 2019).

For economies that are doing well in job creation, poverty reduction, and social integration, small and medium enterprises (SMEs) are the focal point in shaping enterprise policy. On this premise, the regional body like the European Union (EU) considers SMEs as key to promoting

economic growth, innovation, job creation, and inclusivity (Eurostat, 2018). According to Menon and Fink (2019), the fourth industrial revolution, if properly managed, will empower the SME sectors and create the opportunity to leap-frog the traditional pathways of development. The foregoing is peculiar to Africa's scenario in which the region is still catching up with previous revolutions and globalization. The integration of information and communication technology such as the technology of 4IR into the production process will help the SMEs activate their potentials towards competitiveness. Menon and Fink (2019) stated that the 4IR is to unleash a world of micro-transaction in which blockchain technology is expected to turn around the payment and logistics of SMEs through trusted interaction with suppliers even beyond local customers and markets. For a positive contribution to national and regional economic growth, the SME sector must innovate through technology. Already, research from Germany, the acclaimed origin of 4IR, suggested that industry 4.0 might be designed in favour of the requirements of large enterprises with less applicability to SMEs (Müller & Voigt, 2018). This portends a great mismatch for the world economy, especially when established that global inclusive economic growth depends on the informal sector (i.e. SMEs) (Matt & Rauch, 2013; Seseni et al., 2019). There may be a need to pay attention to the above proposition to avert what is similar to the aftermath of the 2008 recession in the informal sector. After the global financial crisis, the large corporations drove the global GDP growth as workers' productivity in large organizations outpaced that of the SMEs because of the inability of the SMEs sector to take the risk and invest in technology (WEF, 2020).

At the inception, there are opinions that the fourth industrial revolution (industry 4.0) as it were is incompatible with SMEs characteristics due to lack of expertise and the complexity involved in the 4IR technologies (Gumbi, & Twinomurinzi, 2020; Seseni et al., 2019; Sommer, 2015). Small and medium enterprises are the main driver of most economies, including developing countries (Alqam & Saqib, 2020; Seseni et al., 2019; Müller & Voigt, 2018; Ganzarain & Errasti, 2016). SMEs, the highest employer of labour, contribute between 50 – 60 percent to the global GDP; the sector's contribution to household income and innovation is imminent (WEF, 2020). The sector also provides social mobility, creates about 95 percent of new jobs in developing and emerging economies to reduce poverty and inequality (Kamaruzaman et al., 2019; International Labour Organisation, 2018; Wu et al., 2019). Across the various sectors in the economy, including the manufacturing and agricultural value chain, SMEs serve as critical suppliers, partners, and customers in all industries. As much as the adoption and diffusion of technology of 4IR is poised to impact all businesses positively, including SMEs, the relative advantage, the complexity of technology, and compatibility of smart manufacturing to SMEs has not been properly researched (Alqam & Saqib, 2020; Seseni et al., 2019). A study by Mitt et al (2018a) indicates that scholars in behavioural science, especially in the field related to organizational behaviour and development, are not paying attention to topics related to 4IR (industry 4.0), particularly small businesses.

Within Africa, most studies are not showing effort in investigating the knowledge level of SMEs' adoption of 4IR technologies and its benefits to the sector. Gumbi and Twinomurinzi (2020) observed that there are gaps in studies relating to 4IR/smart manufacturing in low-income countries, especially in Africa, as most studies on the subject emanated from high-income countries, notably from Europe. Because of the heterogeneous nature of SMEs, which by estimates constituted more than 80 percent of businesses in the African economy in various sectors across manufacturing activities, there is a need to focus on research exploring the future of SMEs concerning the 4IR. Also, many studies have attempted reviews to underscore the contextual perspectives and dimensions of factors inhibiting SMEs' adoption of the 4IR technology. For instance, Ganzarain & Errasti (2016) examined how maturity models can be adopted in the transition phase of SMEs-4IR adoption.

Further, from 2017 till date, only scholars in engineering and production research are leading discussion in this area. The key question is not whether SMEs should introduce industry 4.0 or not; rather, the contention is how SMEs can harness the potential of industry 4.0 to create more jobs and growth in the region. According to leading experts in the area of SMEs, despite the contributions of small businesses to industrial development and the national economy, research exploring SMEs and

4IR as the new paradigm in manufacturing activity remains rare, especially on the specific roles expected of SMEs in the fourth industrial revolution era (Ganzarain & Errasti, 2016; Seseni et al., 2019; Stentoft et al., 2019; Vrchoťa et al., 2019).

Generally, Africa lacks specialists in fields typically associated with the fourth industrial revolution (WEF, 2020). Experts in machine learning and data scientists who can build systems and interact with the technology of the 4IR are in low availability in the region (Asghar et al., 2020; AfDB et al., 2018). Because the manpower requirement in the new revolution is substantially different from that of the previous ones, the required human resources with appropriate skill sets that can drive the 4IR transition in Africa is a challenge. As noted by Asghar et al. (2020), developing countries lack technical manpower that can drive the 4IR; therefore, in responding to the 4IR, Africa needs an adequate supply of knowledgeable scientific, technical, and decision manpower in industry 4.0 technologies. Although, countries like South Africa, Mauritius, Botswana, and a few others have relatively high numbers of skilled workers compared with the majority of countries in the region (Mabotja, 2018). However, these few countries cannot successfully implement the 4IR in Africa; hence establishing a regional strategy may be necessary.

Despite the significant contributions of SMEs to the Africa economy, there is uncertainty on the part of small business owners and government on specific roles SMEs can play in the era of the fourth industrial revolution. Generally, from the extant literature, empirical research on the adoption, application, implementation, and emerging roles of SMEs in the 4IR are scarce (Stentoft et al., 2019). Part of the challenges of not having in the literature a clear role of SMEs sector in the 4IR, especially in Africa, is because SMEs are present in all sectors, and in various firm sizes, technology level, and at various stages of formalization. In this paper, the objective is to examine the emerging roles of SMEs in the 4IR towards sectoral growth and intending transformation of the informal sector in Africa. Therefore, this paper sought to provide answers to the question: i) What are the roles of SMEs in 4IR? ii) Propose a framework depicting the expected role of SMEs in 4IR. Our effort follows from the suggestion of Matt et al. (2016) that special research and investigation is required for the implementation of SMEs in line with the concept of 4IR; particular research should be directed towards the roles that the technologies of the fourth industrial revolution is expected to play in promoting the activities of SMEs towards job creation, value addition, competitiveness, and economic growth. According to the above-identified gap, this paper considers the roles of the SMEs sector in the fourth industrial revolution in Africa. This paper seeks to fill part of this gap by identifying the emerging roles of SMEs in the era of 4IR.

2. Literature Review

Most small businesses tend to operate in the informal sector with limited funding and human and social capital (Ogunsade & Obembe 2016). In some cases, the small and medium scale businesses in these countries are either unaware or lack the technical capabilities to implement the available technologies (Amiri & Woodside 2017). However, SMEs in these economies are gradually adopting the Internet and Web-related technologies to create social businesses and develop new business models (Amiri & Woodside 2017; Omotosho 2020). The revolution in Internet technologies and telecommunications provides new and affordable ways for SMEs in these economies to market products and promote brands (Omotosho 2020). In the field of the 4IR (Industry 4.0), for SMEs, the scientific literature with the keywords "fourth industrial revolution" as well as "Industry 4.0" in the title, abstract, and keywords is linked with the occurrence of the keywords "SME Roles" and "small and medium scale enterprises roles" in the title of the papers for our search. The database Scopus is used due to its high quality and inclusivity. The results of the search are a list of 29 papers, out of which 13 are conference contributions, 11 journal articles, two book chapters, and three reviews. The search results show an important increase in scientific papers starting from 2017.

Table 1: Search Result in SCOPUS

Year	Papers
2020*	4
2019	10
2018	7
2017	4
2016	2
2012	1
2010	1
Sum	29

*15 December 2020

Further search points to the hypothesis that the topic 4IR in SMEs is increasingly important for scholars in engineering and production research. Our search reveals that the contribution of scholars from Africa is generally very low; perhaps, while we summarize the findings from the region, the general perspectives from the identified papers concerning the role of SMEs in 4IR will also be documented. Fourth industrial revolution: Kademteme and Twinomurinzi (2019) examine the ineffectiveness of technology adoption models in the 4IR era using the SMEs in South Africa as a case study. Until this moment, there were no known technology adoption models for small-sized enterprises in the 4IR in Africa. Also, Gumbi and Twinomurinzi (2020) conducted a systematic review on SMME readiness for smart manufacturing 4IR adoption using the tenets of Roger's diffusion of innovation theory. It was noted that only fewer studies are explicit on the smart manufacturing technologies that are relevant for different SME sectors. Even though most of the studies on 4IR and SMEs are coming from South Africa, we cannot review any study that examines the expected roles of SMEs in the era of the fourth industrial revolution across the African region. Our review shows that at the inception of the conversation on the fourth industrial revolution, most studies are particular about the challenge that small and medium enterprises may likely encounter (Matt et al., 2016). The future importance of fourth industrial revolution technologies to the business continuity of SMEs was also introduced, but the concept of 4IR was vaguely applied (Sommer, 2015). We observed that SMEs at this time are not sure if, when, and how they should start to introduce the technologies of the fourth industrial revolution in their firms due to a lack of clarity about the benefits smart manufacturing can offer the sector. Far fewer businesses, especially SMEs, are prepared and recognise the need to adjust since digitalization has been a major driver of change throughout the production value chain (Chen, 2019).

3. Fourth Industrial Revolution and SMEs in Africa

Africa perhaps will experience the revolution (4IR) in a form different from that of other regions (i.e. Europe, Asia, and America) majorly due to demographics, the pattern of international trade, the prevalence of informal economy, and many other contingent factors. No doubt, the 4IR presents the unique opportunities key of which are improvement and efficiency in production, consumer surplus (savings), enhanced demand for new services that can foster entrepreneurship and new jobs (Kamaruzaman et al., 2019; Menon & Fink, 2019; Trento et al., 2018). While many agreed that the fourth industrial revolution would play an important role in the economic transformation of Africa due to the potential market, young population, and growing entrepreneurship spirit among the youth; it is observed that the region is mostly ill-prepared as employers identified inadequately skilled workers as a major constraint to what the future organization would look like (Alqam & Saqib, 2020; Matt & Rauch, 2013).

Defined as businesses with up to 250 employees - micro (1-9 employees), small (10-49 employees), and 50-250 employees as medium (OECD, 2017). However, lower-income countries adopted 50-100 employees as the threshold for defining SMEs. Africa is characterized by a high level

of working poverty (Avila et al., 2017);. However, the region has more than 70 percent labour participation with about 31.7 percent extreme working poverty and over 69 percent vulnerable employment (AfDB et al., 2018; International Labour Organisation, 2018). From the foregoing, the fourth industrial revolution may worsen the current unemployment and poverty situation in the region with attendant poverty and increased inequality (Ndagi & Salihu, 2018; WEF, 2020). This is because the rate of expansion in job growth in Africa does not match the school graduation rate - youth unemployment continued to grow progressively (AfDB et al., 2018). Accordingly, many youths in Africa are often ill-prepared for job positions due to the lack of skill required by employers. In the past, policies were initiated to address the challenge of unemployment in Africa; however, at present, there are complications due to technological breakthroughs of the 4IR that is currently unleashing new capabilities and skillsets requirements (Akileswaran & Hutchinson, 2019; Gastrow et al., 2018; Naudé, 2017). The greatest and impending threat the full 4IR era will bring to Africa will be on the job, as many jobs and tasks will be automated with minimum human involvement in the production process. For instance, 41 percent of all job and work activities in South Africa, 44 percent in Ethiopia, 46 percent in Nigeria, and 52 percent in Kenya are susceptible to automation (Akileswaran & Hutchinson, 2019; Avila et al., 2017; Gastrow et al., 2018; ADB, & WEF, 2017; AfDB et al. 2018). The key question and challenge for Africa are whether the 4IR can enable structural and economic transformation or hinder the existing economic growth in the continent.

Unlike the developed economies, the developing countries, especially in Africa, will face a daunting future in attempting to harness the benefits of the fourth industrial revolution as efforts and policies must consider impending problems such as inadequate infrastructure, low level of industrialization, and unemployment in the continent. Weak infrastructural assets in most African countries, lack specialists in major areas of 4IR, weak collaboration between industry and academics are the major bottlenecks that must be addressed in the continent to harness the benefits of 4IR. One of the potential of the 4IR to SMEs is the opportunity presented by the revolution for impressed collaboration between the SMEs sector and knowledge institutions, especially in technology transfer knowledge (Searle & McWha-Hermann, 2020). There is, however, the challenge of energy poverty in Africa. Energy (electricity) is a big challenge for all known business activities in most African countries. Without exaggeration, there is no magic to adopting 4IR in Africa if the electricity problem continues. For instance, the sub-Sahara Africa region is said to have the lowest electricity generation capacity in the world, with approximately 630 million people living without reliable access to electricity (Avila et al., 2017). Again, it is important to emphasize that all the industry 4.0 (4IR) devices would be connected through the internet. Unfortunately, Africa has the lowest concentration of internet in the world. From 4.7 percent in 2009, the region struggles to increase its internet penetration to 24.4 percent in 2018, compared to Asia pacific (47%), Europe (79.6%), and Middle East 54.7 percent (Manda & Dhaou, 2019). For Africa, a reliable network with high internet penetration needs to be created in the region to connect all businesses to all components of the smart industry. There is a need for business leaders and government at the regional level to consciously create awareness on the potential of 4IR to SMEs and initiate a regional model to enhance the participation of small firms in the global digital transformation shift.

There seems to be among the leaders of business and government in Africa a lack of awareness and a coherent strategy to adopt the 4IR in the region. Much more than individual country effort, Africa needs a holistic, purposeful approach to adopting and implementing 4IR in the continent. At this infant stage of the revolution, what is important is to raise the bar through awareness-building programmes and provide an adequate training opportunity for the region's population. Besides, a comprehensive directory is needed to ascertain the availability of critical professionals in the region to initiate affirmative policy towards growing the pool of manpower towards the full transition to the 4IR. The sub-Sahara, which constitutes the majority of countries in Africa, has more than 95 percent of its firms as small and medium enterprises (Avila et al., 2017). Smaller firms are less willing to engage with the technology of 4IR as firm size appeared to be one of the major obstacles in the overall industrial development (Stentoft et al., 2017). Before the birth of 4IR, previous studies have

established that the lack of awareness of the potential of technology to SMEs, low financial capability to procure technology, lack of capacity to invest in R&D, and shortage of high skilled ICT specialized experts were major hurdles that need attention (UNIDO, 2018). Like other regions where the running-wheel of the economy is the small and medium scale enterprises, the African economy is rested on SMEs, representing more than 90 percent of businesses, which accommodates and creates about 60 percent employment (International Trade Centre, 2018). Beyond the contributions of SMEs to employment, small manufacturing businesses are well-positioned to shocks in the time of economic crisis and pandemics such as Covid-19. There are shreds of evidence that, more than large organisations, SMEs can withstand economic downturns due to their unique adaptiveness, product innovation, and manufacturing practices (Matt & Rauch, 2013).

To drive the economy of Africa beyond import destination, the SME sectors in the region must become net exporters of manufactured goods through linkage to the global value chain. For instance, the European-28 (EU-28) SMEs represent about 88.3 percent of all enterprises exporting goods, which enhances the capacity and increases the participation of the SMEs in the region by 13.8 percent within ten years – 2008- 2017 (Searle & McWha-Hermann, 2020). Through her youthful population, African can drive the global trade with about 40 percent of the region's population between 0-14 years. Another 900 million workers are expected to join the labour force by the end of 2050 (International Trade Centre, 2018). But what seems to be uncertain about Africa as the most economically viable investment destination soon is how the region prepares for the implementation of 4IR, especially from the perspective of SMEs, where most population earn a living. For instance, in South Africa, the most advanced economy in Africa, the SME sector accounts for about 91 percent of businesses with almost 60 percent of employment and 52 percent contribution to total GDP (Gastrow et al., 2018). In Nigeria, the most populous and largest economy in Africa, SMEs contribute around 48 percent to total GDP, accounts for about 96 percent of businesses, and contribute around 84 percent of employment (Akpan et al., 2020; AfDB et al., 2018).

Across the developing countries, despite the obvious benefits offered by the 4IR, the SMEs sector, to a large extent, appears not ready for the adaptation and implementation of the technologies of the 4IR (Gumbi & Twinomurizi, 2020; Stentoft et al., 2019). Studies have attributed the lack of readiness of SMEs in Africa to the lack of an organized environment and informality of small businesses in most region countries (Manda & Dhaou, 2019). Also, low capabilities and personnel costs are part of the main challenges in the transition (Horváth & Szabó, 2019). In Africa, digitization is very low, especially in SMEs (Akpan et al., 2020). Elsewhere, there are already efforts to build systems that will draw large SME participants in disruptive technology. A study conducted in Northern Netherland shows that most SMEs are already using disruptive technology in their production process, especially the use of the Internet of Things, Sensor technology, robotization, and Big data (Sevinç, Gür & Eren, 2018). Without exaggeration, given the financial resources required and level of risks involved in transforming the small businesses in Africa to SME 4.0, there is a need for regional institutions such as African Union to help SMEs adapt to the fourth industrial revolution by establishing favourable support infrastructure, regional coordination with an overarching longer-term vision on SME 4.0.

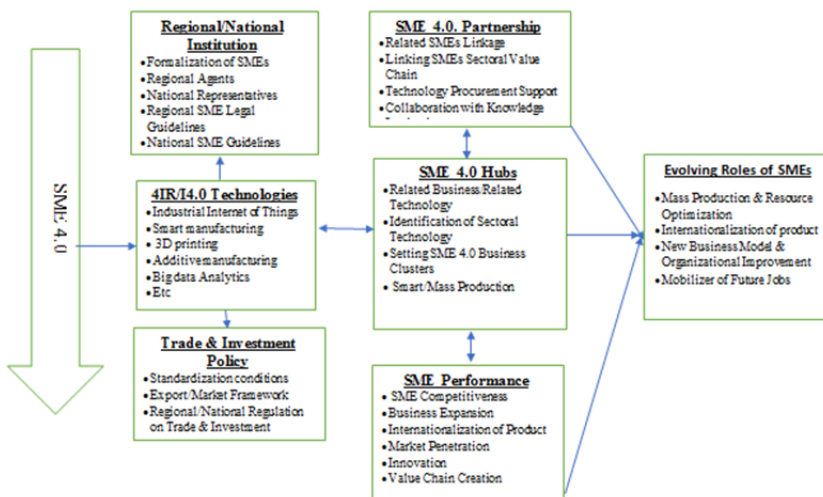
The low level of research in SMEs and industry 4.0 may suggest that attention is only directed to large firms. SMEs have peculiar specific challenges distinct from that of the large organisations regarding the 4IR (Müller, 2019). For SMEs, resource limitation, low bargaining power, and the existing business model unsuitable for 4IR are prime (Muller & Voigt, 2016; Muller, Kiel & Voigt, 2018). Further, the process of technology diffusion by large organisations differs from that of small and medium scale businesses (Mabotja, 2018; Manda & Dhaou, 2019; Xu et al., 2018). Like many scholars suggested, Menon & Fink (2019) added that developing countries like Africa have the opportunity to leap-frog and bypass the traditional phases of industrial development through the adoption of the technology of the 4IR.

4. Proposed Framework for Role of SME in 4IR in Africa

Through a unifying economic and public policy, Africa needs to properly classify the forms of SMEs that exist in the region to propose specific knowledge requirements and technology for inclusive growth in the era of 4IR. For SMEs, the cost of technologies required to function in the 4IR may be high to bear by individual businesses; as such, there may be the need for deliberate policy to create and structure hubs for SMEs in countries across the region through regional support. While big organizations may experience job loss, the convergence of manufacturing small businesses in the SME 4.0 hub will further increase efficiency, profitability, resource optimization, and faster product delivery. Like other production value chains in a large organisation, the cyber-physical system is expected to be deployed for the operation of SMEs to create mechanisms for human-to-human, human-to-object, and object-to-object interaction along the entire value-added chain (Kamaruzaman et al., 2019). Going forward, what seems close to how SMEs can be integrated into industry 4.0 is what experts termed smart manufacturing (Liao et al., 2018; Xu et al., 2018). These are components of industry 4.0 that would have their elements tailored-made towards the operations of SMEs. Accordingly, smart production deals with intelligent, personalized products and by-high-level collaboration through production networks (Sevinç, Gür & Eren, 2018; Xu et al., 2018).

Experts have reiterated that due to the relatively simple structure and lower power distance (owner-operator), SMEs can easily adapt their operational model and expedite the business decision-making process to take advantage of the 4IR opportunity to drive innovation in manufacturing SMEs (WEF, 2020). Muller (2018) noted that the fourth industrial revolution technologies (industry 4.0) specifically would affect three components of SMEs: value chain creation, value capture, and value offer. Due to incoherent interpretation of the roles and types of technology required by the SME to operate in the 4IR, studies have suggested that introducing industry 4.0 in SMEs requires a common understanding by stakeholders in the SMEs sector (both supplier and user). This will birth a uniform standard across all sectors of SMEs operating the technology of the 4IR (Horváth & Szabó, 2019; Morrar et al., 2017). Some scholars have suggested that SMEs' relatively low degree of readiness and application of 4IR technologies symbolizes an untapped potential for an innovative business model using industry 4.0 technology.

Figure 1: Framework for Role of SME in 4IR



Source: Our Elaboration, 2020

The technology of 4IR will raise the level of innovation and creativity of the manufacturing SMEs to create more growth for the informal sector in most economies, including Africa. Accordingly, with the industrial internet of things (IIoT) accompanied by data transparency, flowing-back of information from users to design, and retrofitting of machines, leading to a reduction in waste of materials and resources, the SME can reduce damage goods and delivery error waiting time (Müller & Voigt, 2018). Africa's SMEs are less productive and often struggle to survive due to low investment and lack of technology infrastructure (Akileswaran & Hutchinson, 2019; Gastrow et al., 2018). At this time of global industrialization, one of the main criteria for SMEs businesses for efficient production is to fulfil the fourth industrial revolution (Ganzarain & Errasti, 2016). According to Vrchota et al. (2019), industry 4.0 is expected to bring huge changes to the labour market and business model.

The formalization of SMEs is one of the critical areas that need attention if the region does not want the benefit of 4IR to elude her due to the perceived risk associated with informality across businesses operating in the SME sector. There are shreds of evidence from empirical research even within Africa that formalization and certification of small-scale businesses can further reduce working poverty and increase the household standard of living. Studies conducted in Uganda and Senegal on fair trade certification and formality raises export, increases income, and lower poverty (Chiputwa, et al. 2015). Undoubtedly, the adoption of 4IR in the SME sector will lead to the legitimization of economic activities by SMEs. On the other hand, the digitization of SME firms in Africa will reduce the challenge of rent-seeking and corruption in the informal sector. There are major economic issues related to the informality of SMEs in Africa, with which the consequences are tax evasion, unorganized business hubs, low export potentials, and slow growth. The transition from the traditional to industry 4.0 driven SMEs will promote automation and digitalization of tariffs and other public administration processes and procedures that could reduce rent-seeking practices by public officials (Menon & Fink, 2019). As suggested, the technologies of the 4IR will limit the potential of direct contact with the officials and business operators, especially when SMEs are integrated by technology into SME hubs and Clusters.

For SME 4.0, the regional and national governments need to embark on reforms to develop market liberalization in the region further. There is a need to entrench the legal, regulatory, and operational framework for small and medium enterprises especially targeting fourth industrial revolution technology to enhance productivity, trade capacity, and innovation. Most importantly, policies focusing on financial support for SME 4.0 procurement must also be attended to by the government through financial and development institutions; if possible, tax incentives should be introduced during the transition. For the successful implementation of SME 4.0, our framework suggests that small businesses should be grouped according to their relatedness in input-output in the production chain. Firms that manufacture inputs or by-products for the final production of a specific product within the same sector should partner using the same chain of technology along the production process to reduce delivery time, mass-produce, and improve the quality of the product. When related businesses are grouped in an SME 4.0 hub within the same sector, relevant industry 4.0 technologies for SMEs can be identified, developed, and deployed for manufacturing purposes.

5. Evolving Roles of 4IR in SMEs in Africa

In many countries, SMEs are key players in the economy and the wider eco-systems of firms. In the OECD area, SMEs are the predominant form of enterprise, accounting for approximately 99 percent of all firms; serving as the main source of employment with about 70 percent of jobs; and are major contributors to value creation (OECD, 2017). In emerging economies, SMEs contribute up to 45 percent of total employment and 33 percent to GDP (OECD, 2017). Small and medium enterprise development can contribute to economic diversification and resilience to a more sustainable economy. This is especially relevant for resource-rich countries (like Africa) that are particularly vulnerable to commodity price fluctuations (OECD 2017). According to World Trade Organisation (WTO) from a survey covering over 25,000 SMEs in developing countries based on World Bank

Enterprise Surveys, direct exports represent just 7.6 percent of total sales of SMEs in the manufacturing sector, compared to 14.1 percent for large manufacturing enterprises (WTO, 2016). Africa has the lowest export share at 3.0 percent among the developing countries, compared to 8.7 percent for Asia.

Before the 21st century, the general idea that large organizations are the greatest support for the economy was challenged. As reported by many studies, the significant role SMEs play in the economy's growth cannot be underestimated. Small and medium enterprises are the major job and employment creation sources globally. Ayyagari et al. (2011) reported from a study that SMEs with less than 250 employees are the main engine of growth in many countries. Evidence from the literature added that SMEs constituted over 60 percent of the total employment in the manufacturing sector in most developing countries. For the economy, the SMEs are launchers of new ideas and assemblage of new processes accelerating the increase based on the more effective use of resources. The fourth industrial revolution and ICT-enabled services have provided new opportunities for SMEs to access the international market and help circumvent obstacles to trade. In the current revolution (4IR), SMEs are expected to adopt and transit to smart manufacturing using the technology of industry 4.0. Within the current revolution orchestrated by the fourth industrial revolution, SMEs are expected to perform the following roles in the economy based on our reviews and the elaborated framework.

5.1 Mass Production & Resource Optimization via SME 4.0 Hub

The integration of the technology of 4IR presumably could lead to the creation of technology hubs or small-scale business solutions, the potentials of which are energy and resource efficiency in the 4IR workplace. SMEs, through digitization and functional interconnectivity, can create a specialized supply value chain in the form of small-scale solutions, the technology for which may be difficult to acquire by an individual firm. Small scale solution or SME 4.0 will lead to a productive SMEs sector. This will spur partnership and collaboration among related SMEs to improve quality and standard of product and reduce the bottleneck of export, which is a major problem militating against SMEs growth in Africa. Beyond productivity improvement, the technology of the 4IR, especially the Industrial Internet of Things (IIoT), can create value along multiple dimensions of SMEs. Accordingly, the IIoT is poised to drive growth through improved product, better customer service, and impact the firms' operations through better planning, more efficient management, and enhanced support function. In addition to the huge numbers of smartphones, tablets, and laptops users around the world, the global audience of internet users stands at about 3.5 billion people (Larysa et al., 2017); this has already created the needed communication infrastructure required for SMEs breakthroughs in the 4IR both for suppliers and customers. The hallmark of SMEs in the 4IR is the industrial internet of things; its successful adoption will create an opportunity for SMEs to offer their product and tailor-made services using digital platforms leading to internationalization of products, transforming them into micro-multinationals; the benefit for which to generate new jobs, improve production efficiency and enhance innovation (UNIDO, 2018). The fourth industrial revolution technologies will help improve efficiency and reduce waste of resources by the SMEs due to lack of proficiency and process standardization during production. A specific issue attributed to SMEs is the challenge of measuring and controlling resources across the production value chain. The deployment of 4IR technologies in SMEs via the industrial internet of things will improve the small manufacturing firms' analytic and metrics measurement capacity; as such, accurate data on inventory, turnover, workers' safety, and enhanced energy usage will reduce energy usage wastage. According to the World Economic Forum, the industrial internet of things and improved productivity will align firm profit with social and environmental benefits in the case of SMEs (WEF, 2020).

5.2 Internationalization of Product

Fourth industrial revolution (industry 4.0) technology has created space and opened up for SMEs to participate in global value chains (GVCs), in which the traditional value chains often evolve over long periods and tend to be relatively static (Chen, 2019). The transition of Small and Medium Enterprises (SMEs) to the fourth industrial revolution through SME 4.0 will increase the potential of export of the manufacturing SMEs. Creating the small-scale 4.0 solution will increase the involvement of the SMEs in the foreign market as productive partnerships using the 4IR technologies will lead to the internationalization of SME products. With increasing export drive and acceptance of the product in the international market, small manufacturers will experience improvement in sales, leading to business growth. As it stands, Africa only invests 23.5 percent of its GDP in SMEs instead of about 37 percent that will be required to meet the region's development agenda (International Trade Centre, 2018). Successful transition of SMEs into SME 4.0 will increase sector-to-sector and sector-to-market competitiveness. The low weight of Africa manufacturing SMEs, the regional contribution to global GDP, and the propensity of SMEs to create employment understandably explain why Africa is ranked at the bottom in global trade (International Trade Centre, 2018). Africa continuously loses its competitiveness as SMEs in almost all sectors and suffers from low-quality issues; most SMEs in Africa are considered sub-standard in the global market.

Adoption of smart manufacturing by the SMEs will improve the production efficiency, customer specification, and mass production by the SMEs will reposition the sector for better contribution to economic growth. Through the instrumentality of the recent African Continental Free Trade Area (AfCFTA), the economy of Africa is pursuing and creating a single market for the movement of goods and services within the region to deepen regional economic integration. This is to promote and attain sustainable economic development, inclusiveness, equity, and structural transformation in the region (AfCFTA, 2018). The treaty expectedly will increase the standard of product across the African region as competition is expected to drive the regional economic activities. In it, the region's manufacturing sector, including the SMEs, will enhance their operation and capture the regional market for accelerated economic growth. Already, the North African blocs that are closer to the European market are experiencing a digital transformation.

The technology of the 4IR will put an end to sectoral product interception and rejection faced by SMEs in Africa in the International market. For instance, product rejections are common to the agro-food trade like fish, tea, fruits, vegetables, etc., due to food safety regulations (Chiputwa, et al., 2015). Further, there are indications that SMEs in Africa, in general, have limited knowledge and understanding of the guidelines and regulations on the foreign market and international trade and low research and monitoring skills (Gastrow et al., 2018). Considering the strategic importance of SMEs to Africa in achieving food security, employment creation, reducing inequality and poverty, the 4IR and its adoption to the activity of the SMEs has been flagged as the effective strategy for the growth of the African economy. Evidence from the empirical study has suggested that successful integration of 4IR technologies can boost the capacity of manufacturing SMEs through the enhancement of quality of production, which could help to exit the vicious circle of over-supply of low-quality products (Stentoft et al., 2019). Also, this will enhance the traceability of products through the production process to differentiate between low and high quality for control purposes (Matt & Rauch, 2013).

5.3 Creation of new business model and Organizational Improvement

Several authors in business model research address the capabilities needed for digital technologies on business models. However, the specific impact of Industry 4.0 on business models remains a field scarcely investigated (Arnold et al., 2016). Furthermore, empirical investigations of business models in the context of the Industrial Internet of Things mostly have not focused on the special requirements of SMEs (Müller, et al., 2018). Meanwhile, the lack of an existing business model linking

the fourth industrial revolution specifically to SME may be attributed to the infant stage of the subject. Through the fourth industrial revolution technology, the manufacturing SMEs will be able to strengthen the business strategies within the opportunity provided by the advance in technology. This will enable the SME sector to assess, improve, and adapt their innovation strategies to align capabilities to the business environment, especially within industry 4.0, for sustained competitive advantage. Through the technologies of the 4IR (i.e. autonomous robot, simulation, additive manufacturing, cybersecurity, the cloud, big data analysis, etc.), the small and medium scale enterprises can improve productivity, transform into predictive instead of reactive maintenance, and monitor improvement to reduce the cost of error in the traditional production system. Unlike the large organizations with a higher driving force, small and medium enterprises have lower driving forces but with fewer barriers in terms of profitability expectation and organizational structure (Harvdth & Szabo, 2019).

5.4 Mobiliser of future jobs

Under the 4IR, SMEs must join the global value chain or other innovative value networks using the Industrial Internet of Things (IIoT) to gain a competitive advantage in supply chain systems (Chen, 2019). This can be achieved through strategic collaborative partnerships to deepen their existing customer relations and establish productive linkage and manufacturing activities (i.e. SME 4.0 hub). Investing in the informal sector in Africa through the digitalization of SMEs will open up and connect manufacturing SMEs in the region to the global value chain. This will enable small businesses to find new buyers and suppliers to improve access to knowledge and innovation (International Trade Centre, 2018). Suggestions and data point to the direction that if the SMEs sector in Africa can successfully transit to the 4IR using platforms such as small-scale solution 4.0, the region may eventually begin the journey to resolve Africa's most pressing challenge – unemployment. By the time small businesses are digitalized, the sector will experience more productive sales, revenue will increase through export, and more investment will commence. According to the International Trade Centre (ITC), this will create more jobs and reduce unemployment, inequality, and over-dependent region on importation. Already, African SMEs generates about 80 percent of new jobs in the region (International Trade Centre, 2018); therefore, a smart investment and regional coordination of SMEs to 4IR will yield positive outcome towards creating sufficient net jobs. Contextually, countries such as South Africa and most countries in the North African region (i.e. Morocco, Algeria, etc.) leading SMEs competitiveness in Africa are lagging compared with other regions (Avila et al., 2017). There is a need for caution as failure to utilize and harness the potential of small-scale 4.0 solutions will further disintegrate the African market that is already factionalized into North Africa – Europe Market, and Sub-Sahara – North America and Asia market (International Trade Centre, 2018). The technologies of 4IR, when integrated into SMEs, will facilitate small manufacturing businesses to join productive networks outside the African region (International Trade Centre, 2018), a situation that will foster regional growth.

6. Conclusion

Generally, now that the world prepares to fully go on fourth industrial revolution in which technology and innovation will guide operational activities and dictate the pace, small and medium enterprises in Africa, despite inadequate financial capacity should be ready to take advantage of low costs technologies to stimulate and undertake virtual operations. Small and medium enterprises are the main drivers of economic growth, job creation, and effective tools for poverty reduction. Its development is vital to the development of emerging and developing countries. This paper attempt to examine the evolving role of SMEs in economic growth as a whole. Following our reviews, we have identified some emerging roles expected of SMEs in the fourth industrial revolution. The interest devoted by policy-makers and researchers to the fourth industrial revolution topic has grown

exponentially during the last few years (Liao et al., 2017). Despite this increasing interest, the aspect relating to SMEs in terms of systematic approach and framework for implementing industry 4.0 technology in SMEs is still missing. The main objective of this study was to shed light on some of the emerging roles expected of SMEs on the transition to industry 4.0. Considering the novelty of the topic, we considered not only the studies on the role of SMEs in 4IR but also the broader literature on the state of research and the fourth industrial revolution and SME in Africa.

Through our review, we propose a framework for the role of SMEs in the 4IR (see figure 1). We contributed to the scientific debate in at least three significant ways. First, to the best of our knowledge, our study is among the first to initiate the debate on roles expected to be performed by SMEs in the fourth industrial revolution, especially in Africa. This way, we might open a debate on a topic expected to rise significantly in the next few years. Secondly, a framework was proposed to highlight the actors and factor requirements necessary to implement SME 4.0 in the Africa region successfully. Thirdly, we identified specific roles expected of SMEs in the fourth industrial revolution considering the need of Africa and its stage of economic development, thus calling for future research in this area. From the extant literature and our elaboration, expectedly, if SMEs is fully transited into industry 4.0, small businesses in Africa will serve as a mobilizer of future jobs, create a new business model, promote the internationalization of SME products, and through SME 4.0 engage in mass production while optimizing available resources.

7. Recommendation

A concerted effort should be made to encourage manufacturing SMEs to adopt and implement industry 4.0 or at least engage in a purposeful plan to invest, collaborate, and partner in this regard. As explained in the literature, countries and regions adopted a different approach to the fourth industrial revolution, though the technology of the revolution is the same; infrastructure, technological advancement and capability, and level of industrialization vary according to countries. Africa may need a unique approach to regional governance and cooperation on the fourth industrial revolution focusing especially on solving critical problems in the region using the technologies of 4IR to grow the activities of the SMEs for regional development. Most importantly, the region must follow through with a transformation plan. Some studies have already suggested that the greatest impact of 4IR will play out beyond the individual country's national level but at a regional scale in which trans-border economic integration is expected to be revolutionized. Manufacturing SMEs in Africa, more than before, need to use this opportunity of 4IR to scale up, embrace new business strategies, and adapt quickly by embracing digitization, computerization, robotics, and advanced technology throughout their business operations. Future research needs to address ways to overcome the challenges hindering SMEs' adoption and implementation of digital technologies in Africa.

Reference

- ADB, & WEF. (2017). ASEAN 4.0: What does the Fourth Industrial Revolution mean for regional economic integration? Asian Development Bank and World Economic Forum. Retrieved from <https://www.adb.org/publications/asean-fourth-industrial-revolution-regional-economic-integration>.
- AfFTA (2018). Agreement Establishing the African Continental Free Trade Area.
- AfDB, ADB, EBRD, IDB (African Development Bank, Asian Development Bank, European Bank for Reconstruction and Development, Inter-American Development Bank). (2018). *The Future of Work: Regional Perspectives*. Washington, DC.
- Akileswaran, K., & Hutchinson, G. (2019). *Adapting to the 4IR: Africa's development in the age of automation*. <https://institute.global/insight/governance/adapting-4ir-africas-development-age-automationon>.
- Akpan, I. J., Udoh, E. A. P., & Adebisi, B. (2020). Small business awareness and adoption of state-of-the-art technologies in emerging and developing markets, and lessons from the COVID-19 pandemic. *Journal of Small Business and Entrepreneurship*, 1-18. <https://doi.org/10.1080/08276331.2020.1820185>

- Alqam, H & Saqib, M. (2020). An Exploratory Study and Impact of Fourth Industrial Revolution (4IR) on SMEs in the Middle East. *International Journal of Integrated Engineering*, 12(7), 121–127. DOI: <https://doi.org/10.30880/ijie.2020.12.07.014>.
- Amiri, S., and J. M. Woodside. (2017). Emerging Markets: The Impact of ICT on the Economy and Society: Digital Policy, *Regulation and Governance* 19 (5): 383–396..
- Arnold, C., Kiel, D., and Voigt, K. I. (2016). How the Industrial Internet of Things Changes Business Models in Different Manufacturing Industries. *International Journal of Innovation Management*, 20(8), 1–25.
- Asghar, S., Gulmina, R., Ahmed, T. & Tamimy, M. I. (2020). *The Fourth Industrial Revolution in the Developing Nations: Challenges and Road Map*. Research Paper 102, Commission on Science and Technology for Sustainable Development in the South (COMSATS).
- Avila, N., Carvallo, J. P., Shaw, B. and Kammen, D. M. (2017). The energy challenge in sub-Saharan Africa: A guide for advocates and policy makers: Part 1: Generating energy for sustainable and equitable development. *Oxfam Research Background series* <https://www.oxfamamerica.org/static/media/files/oxfam-RAEL-energySSA-pt1.pdf>.
- Ayyagari, M., Demirgüç, K. A. & Maksimovic, V. (2011). *Small vs. Young Firms Across the World — Contribution to Employment, Job Creation, and Growth*. Policy Research Working Paper 5631 (The World Bank Development Research Group)
- Chen, C. L. (2019). Value Creation by SMEs Participating in Global Value Chains under Industry 4.0 Trend: Case Study of Textile Industry in Taiwan. *Journal of Global Information Technology Management*, 22(2), 120–145. <https://doi.org/10.1080/1097198X.2019.1603512>
- Chiputwa, B. A., Spielman, D. J. & Qaim, M. (2015). Food Standards, Certification, and Poverty among Coffee Farmers in Uganda. *World Development*, (66) 400–412.
- Eurostat (2018). Statistics on Small and Medium-Sized Enterprises. https://ec.europa.eu/eurostat/statisticsexplained/index.php?title=Statistics_on_small_and_mediumsized_enterprises&oldid=451334. Accessed on 29 Sept
- Ganzarain, J. & Errasti, N. (2016). Three Stage Maturity Model in SME's Toward Industry 4.0. *Journal of Industrial Engineering and Management* 9 (5): (5): 119–128. <https://doi.org/10.3926/jiem.2073>.
- Gastrow, M. H. (2018). Policy Options Framework for the Fourth Industrial Revolution in South Africa - SA-EU Strategic Partnership Dialogue Conference Disruptive technologies and public policy in the age of the Fourth Industrial Revolution.
- Gumbi, L. & Twinomurinzi, H. (2020). *SMME Readiness for Smart Manufacturing (4IR) Adoption: A Systematic Review*. Springer International Publishing. <https://doi.org/10.1007/978-3-030-44999-5>
- Horváth, D., & Szabó, R. Z. (2019). Technological Forecasting & Social Change Driving forces and barriers of Industry 4.0: Do multinational and small and medium-sized companies have equal opportunities? *Technological Forecasting & Social Change*, 146, 119–132. <https://doi.org/10.1016/j.techfore.2019.05.021>
- ILO. 2020. "COVID-19 and the World of Work: Impact and Policy Responses." ILO Monitor, 1st Edition. March 18, 2020. Downloadable at <https://www.ilo.org/global/topics/coronavirus>
- International Labour Organisation (2018). *World Employment and Social Outlook: Trends 2018* International Labour Office – Geneva: ILO,
- International Trade Centre (2018): *SME Competitiveness Outlook 2017 – The region: A door to global trade*. Geneva: ITC.
- Kademete, E. & Twinomurinzi, H. (2019). *The Role of SME Dynamic Capabilities on the Evaluation of Existing ICT*. In *Proceedings of ACM SAICSIT conference (SAICSIT'19)*. ACM, South Africa.
- Kamaruzaman, F. M., Hamid, R., Mutalib, A. A., & Rasul, M. S. (2019). Conceptual framework for the development of 4IR skills for engineering graduates. *Global Journal of Engineering Education*, 21(1), 54–61.
- Larysa, A., Iuliia, G., Vyacheslav, D., Polishchuk, Y. & Sybirianska, Y. (2017). Barriers and Opportunities for Hi-tech Innovative Small and Medium Enterprises Development in the 4th Industrial Revolution Era. *Problems and Perspectives in Management*, 15(4), 100–113. doi:10.21511/ppm.15(4).2017.09
- Liao, Y., Rocha, E., Deschamps, F., & Brezinski, G. (2018). *The impact of the fourth industrial revolution: a cross-country / region comparison*. 5411. <https://doi.org/10.1590/0103-6513.20180061>
- Liao, Y., Deschamps, F., Loures, E.F.R. & Ramos, L.F.P. (2017), "Past, present and future of industry 4.0 – a systematic literature review and research agenda proposal", *International Journal of Production Production Research*, Vol. 55 No. 12, pp. 3609–3629.
- Mabotja, L. L. (2018). Is South African Manufacturing SMMEs Ready for the Fourth Industrial Revolution? *Journal of Education and Vocational Research*, 9(2), 20–26.
- Manda, M. I. & Ben Dhaou, S. B. (2019). Responding to the challenges and opportunities in the 4th Industrial revolution in developing countries. In *Proceedings of the 12th International Conference on Theory and Practice of Electronic Governance (ICEGOV2019)*, Melbourne, VIC, Australia. <https://doi.org/10.1145/3326365.3326398>

- Matt, D. T., Rauch, E. & Riedl, M. (2018a). Analyzing the Impacts of Industry 4.0 in Modern Business Environments. Knowledge Transfer and Introduction of Industry 4.0 in SMEs: A Five-Step Methodology to Introduce Industry 4.0, *IGI Global*, 256–282. <https://doi.org/10.4018/978-1-5225-3468-6>
- Matt, D.T., Rauch, E. & Fraccaroli, D. (2016). *Smart Factory for SMEs: Designing a Holistic Production System by Industry 4.0 Vision in Small and Medium Enterprises (SMEs)*. ZWF Zeitschrift für wirtschaftlichen Fabrikbetrieb 111: 2–5. <https://doi.org/10.3139/104.111471>.
- Matt, D. T., & Rauch, E. (2013). *SME 4.0: The Role of Small- and Medium-Sized Enterprises in the Digital Transformation*. Springer International Publishing. <https://doi.org/10.1007/978-3-030-25425-4>
- Menon, J., & Fink, A. (2019). The Fourth Industrial Revolution and Its Implications for Regional Economic Integration in ASEAN. *Journal of Asian Economic Integration*, 1(1) 32–47, 2019 <https://doi.org/10.1177/2631684618821566>
- Morrar, R., Arman, H., & Mousa, S. 2017. The Fourth Industrial Revolution (Industry 4.0): A Social Innovation Perspective. *Technology Innovation Management Review*, 7(11): 12–20. <http://doi.org/10.22215/timreview/1117>
- Müller, J. M. and Voigt, K. I. (2018), "Sustainable industrial value creation in SMEs: a comparison between industry 4.0 and Made in China 2025", *International Journal of Precision Engineering and Manufacturing – Green Technology*, 5(5), 659-670.
- Müller, J., Voigt, K.I., (2017). *Industry 4.0- integration strategies for SMEs*. In: International Association for Management of Technology, IAMOT 2017 Conference Proceedings, (Vienna).
- Müller, J. M. (2019). Business Model Innovation in Small- and Medium-Sized Enterprises: Strategies for Industry 4.0 Providers and Users. *Journal of Manufacturing Technology Management*, <https://doi.org/10.1108/JMTM-01-2018-0008>.
- Naudé, W. (2017). *Discussion Paper Series Entrepreneurship , Education and the Fourth Industrial Revolution in Africa Entrepreneurship , Education and the Fourth Industrial Revolution in Africa*. 10855. Maastricht University, MSM and IZA.
- Ndagi, A. & Salihu, A. A. (2018). Fourth Industrial Revolution: Prospects and Challenges for Africa, *Dutse Journal of Economics and Development Studies (DUJEDS)*, Ibrahim Badamasi Babangida University, Lapai Niger State, Nigeria, 6(1) 2536-6130.
- OECD. (2017). *Enhancing the Contributions of SMEs in a Global and Digitalized Economy*. <https://www.oecd.org/mcm/documents/C-MIN-2017-8-EN.pdf>.
- Ogunsade, I. A., and D. Obembe. (2016). The Influence of Informal Institutions on Informal Sector Entrepreneurship: A Study of Nigeria's Hand-Woven Textile Industry. *Journal of Small Business & Entrepreneurship* 28 (6): 413–429.
- Omotosho, B. J. (2020). Small Scale Craft Workers and the Use of Social Media Platforms for Business Performance in Southwest Nigeria. *Journal of Small Business & Entrepreneurship*: 1–16. 1–16. <doi:10.1080/08276331.2020.1764732>.
- Peters, m. A. (2017). Technological unemployment : educating for the fourth industrial revolution. *Journal of Self-Governance and Management Economics* ,5(1), 32–41.
- Reuter, C. 2015. *Betriebliches Kontinuitätsmanagement in klei- nen und mittleren Unternehmen–Smart Services für die Industrie 4.0*. In Mensch und Computer 2015–Workshopband. <https://doi.org/10.1515/9783110443905-006>.
- Searle , R. H. & McWha-Hermann, I. (2020): "Money's too tight (to mention)": a review and psychological synthesis of living wage research, *European Journal of Work and Organizational Psychology*, DOI: 10.1080/1359432X.2020.1838604
- Segal, M., (2018). *How automation is changing work*. *Nature* 563, 132–135. <https://doi.org/10.1038/d41586-018-07501-y>.
- Seseni, L., Park, A., Mbohwa, C., & Park, A. (2019). *SMEs Managing Organisational Knowledge In The 4IR Era : A Case Study Of Developing Countries*. Proceedings of the International Conference on Industrial Engineering and Operations Management Bangkok, Thailand, March 5-7, 2019, 3014–3022.
- Sevinç A., Gür, S. & Eren, T. (2018). Analysis of the Difficulties of SMEs in Industry 4.0 Applications by Analytical Hierarchy Process and Analytical Network Process, *Process*. 6, 2-16. <doi:10.3390/pr6120264>.
- Sommer, L. (2015). Industrial Revolution-Industry 4.0: Are German Manufacturing SMEs the First Victims of This Revolution? *Journal of Industrial Engineering and Management* 8 (5): 1512–1532. <https://doi.org/10.3926/jiem.1470>.
- Stentoft, J., Jensen, K. W., Philipsen, K., & Haug, A. (2019). *Drivers and Barriers for Industry 4 . 0 Readiness and Practice: A SME Perspective with Empirical Evidence*. Proceedings of the 52nd Hawaii International Conference on System Sciences. <https://hdl.handle.net/10125/59952>
- Trento, S., Bannò, M. & D'Allura, G.M. (2018). The Impact of the 4th Industrial Revolution on SMEs' High-Tech Industry, *Symphonya. Emerging Issues in Management* (symphonya.unimib.it), 2, 145- 157. <http://dx.doi.org/10.4468/2018.2.trento.banno.dallura>.

- UNIDO (2018): *Industry 4.0 - the opportunities behind the challenge*. Vienna: Department of Trade, Investment and Innovation (TII).
- Vrchota, J., Volek, T. & Novotna, M. (2019). *Factors Introducing Industry 4.0 to SMEs*. *Social Sciences*, 8, 130; doi:10.3390/socsci8050130
- WEF (2017). *Technology and Innovation for the Future of Production: Accelerating Value Creation*, Geneva: World Economic Forum, Geneva Switzerland.
- WEF (2020). *Accelerating the Impact of Medium-Sized Enterprises: Industrial IoT in Small and A Protocol for Action*. World Economic Forum, Geneva Switzerland.
- WTO (2016). 106. *World Trade Report 2016. Levelling the Trading Field for SMEs*. https://www.wto.org/english/res_e/booksp_e/world_trade_report16_e.pdf.
- Wu, A. (2019). *Fourth Industrial Revolution: technological drivers , impacts and coping Fourth Industrial Revolution : Technological Drivers , Impacts and Coping Methods*. <https://doi.org/10.1007/s11769-017-0890-x>
- Xu, M., David, J. M., & Kim, S. H. (2018). The Fourth Industrial Revolution: Opportunities and Challenges. *International Journal of Financial Research*, 9(2), 90–95. <https://doi.org/10.5430/ijfr.v9n2p90>.