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Addressing the Impact of Fourth Industrial Revolution on South African Manufacturing Small and Medium Enterprises (SMEs)

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Abstract: The fourth industrial revolution (4IR) may fundamentally alter, not only the way people work but also, how Small and Medium (SME) manufacturing businesses operate. In the manufacturing sector, the 4IR may change the design; manufacturing; operations; services, products, and production systems; connectivity; and the interaction among parts, machines, and people. While the 4IR technologies may have many benefits, owing to innovation and technological progress, the manufacturing SMEs require their challenges to be addressed before they may benefit from 4IR technologies. To the best of the knowledge of the researchers, there is no conceptual 4IR manufacturing framework, specifically for a developing economy, which is necessary for addressing these challenges and the opportunities promised by the new industry. This research, therefore, intends to fill this gap by developing a conceptual 4IR framework to assist South African manufacturing SMEs in addressing some of these challenges. Following a comprehensive literature review, components of the 4IR and challenges in the manufacturing industry are elucidated, aimed at defining a set of qualitative propositions as our instrument to develop a conceptual framework for embedding 4IR technologies and opportunities in the manufacturing industry. Further aspects of the framework enable businesses to gain a competitive advantage and sustainable business performance. Future work in this area will validate the framework among stakeholders in the manufacturing industry within the context of a developing economy.

Keywords: competitive advantage; conceptual framework; developing economy; fourth industrial revolution (4IR); manufacturing; small and medium enterprises (SMEs); sustainability



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1. Introduction

The fourth industrial revolution (4IR) is set to disrupt numerous aspects of our technological society, for example, the manufacturing industry for small and medium enterprises (SMEs) in a developing economy such as South Africa. Despite disruptions, 4IR technologies are anticipated to assist with some of the challenges faced by these manufacturing SMEs to gain a competitive advantage and sustainable business performance. The early roots of the 4IR stem from Klaus Schwab [1], the founder and executive chairperson of the World Economic Forum. There are four main spheres of business that the 4IR affects; these are customer expectations, product enhancement, collaborative innovation, and organizational forms. The 4IR is also known as Industry 4.0 (I4.0), which is essentially changing how humans relate, live, and work [1].

Several writers concur with Schwab on the impact of the fourth industrial revolution phenomenon on SME businesses [2–5]. According to [1], this revolution is complex, scalable, and its scope has never existed in human history. Schwab advises that businesses should respond to it in a coordinated and thorough way, involving all partners globally, from private and public industries to the academic world and the public at large. The first

industrial revolution started with water and steam to power machines for manufacturing [2]; the second introduced electricity to create a mass-market of produced goods, the third later introduced electronics, computers, and information technology (IT) to automate the production of goods and services [1].

Building from the third, the 4IR embodies technologies that conceal the lines between the domains of biology, physical, and digital [1,6], and by extension, business domains, as well. Compared to the previous revolutions, the fourth is developing exponentially. Consequently, 4IR changes require governments, corporations, and individuals globally to adapt proactively.

This research aims to investigate the components of the 4IR concerning its influence on manufacturing SMEs, and to develop sets of qualitative propositions emanating from our analyses and, on the strength of these propositions, to develop a conceptual framework for embedding 4IR and related aspects in manufacturing SMEs in the context of a developing economy, in order to a gain competitive advantage and sustainable business performance.

1.1. The Use of Propositions

The research in this article is built around a set of qualitative propositions synthesized from a comprehensive review of scholarly literature on SMEs, the 4IR, and business aspects to assist SMEs in moving into this new technology. Throughout this article, we elicit numerous content propositions that are used to define our conceptual framework to facilitate the adoption of 4IR technology by SMEs in the context of a developing economy such as South Africa.

Our propositions have the following form:

Proposition $pCix$, for $i \in N = \{1, 2, 3, \dots\}$, the set of natural numbers, and $x \in Alp = \{\epsilon, a, b, c, \dots, z\}$, the English alphabet together with the empty (null) string, denoted by ϵ . This implies that a proposition may or may not have a letter as its last character. The propositions are used to identify the content-related building elements of our framework.

1.2. Manufacturing SME Readiness

For this study, a small and medium enterprise (SME) is defined as a business with up to 250 employees [6]. Globally, SMEs have been identified as the main drivers of production for economic growth and development. While the growth of the 4IR technologies promises improvements and efficiencies to drive economic growth and social upliftment, there are some challenges to the means of manufacturing production for goods and services, consumption of those goods and services, and how people are employed [7]. The 4IR is also setting socioeconomic and geopolitical change drivers in developing and developed economies including South Africa [8,9].

Although the 4IR promises several benefits because of its innovations and technological process, manufacturing SMEs remain faced with challenges [10]. Reference [11] elucidates these challenges as changes to inflation rates owing to the high impact of digitization of retail sales, and price instability, which all lead to demands for improved quality of goods and services [11]. Depending on an organization's size and age, these challenges reduce a manufacturing SME's readiness to adapt; hence, they cannot transform, and experience difficulty in committing resources. The researchers postulate there is a need for new strategic innovation to guide manufacturing SMEs in developing economies with scarce resources into opportunities offered by 4IR technologies.

1.3. Manufacturing SME Opportunities

Similar to previous revolutions, 4IR can improve and increase world salary levels of employees, in turn improving humanity's quality of life globally [1]. Reference [8] suggests that manufacturing SMEs can integrate into their supply chains with access to information about demand, commodity prices, and supply market information. New technologies can assist to process information faster, which in turn drives economic growth, empower

individuals, fuel entrepreneurship, and improve the health system. Technological innovation may also lead to a long-term increase in efficiency and productivity. Furthermore, communication and transport prices may drop, world supply chains and logistics may become effective, moreover, and new markets will open with diminishing cost of trade and improved economic growth [1]. Reference [12] on the other hand argues that the use of the 4IR technologies such as the Internet of Things (IoT), robotics, and three-dimensional (3D) printing in developed economies such as the USA is reducing the importance of low labor costs in determining overall production location and may in the long term, lead to a re-shoring of global supply chains. This may make it hard for developing countries to penetrate the global market and may make industrialization harder since many African countries lack essential technology and industry skills; and developing the relevant worker skills, infrastructure, and corporate capabilities are likely to be a gradual process. Reference [12] advises African policymakers to pursue different and relevant strategies to facilitate the moving of 4IR technologies into the industrial mainstream. These may be harder for the average manufacturing SME to achieve, hence, the need to develop a 4IR-SME framework as a first step in assisting these businesses. It should be noted that there are risks in using these technologies; these include cybercrimes, unsafe personal information, and loss of employment owing to a machine taking over the jobs of humans.

Reference [13] indicates some of the SME opportunities to be investigated in the 4IR context, as follows:

1. Locally produced, personalized and mass customized production of products.
2. Processes of cluster dynamics and networked manufacturing; end-to-end digital engineering; integration of shop floors and top floors; and real-time networks.
3. Business models from value chain fragmentation, service integrated offerings, and development and creation of services and products that are related to customer emotions.
4. Converging globalized competition frontiers with low cost, light footprint, and frugal innovation.
5. Interdisciplinary skills, being of the complexity of a higher degree.

Reference [10] notes there are three important aspects to consider. The first is the need for education systems to be reoriented from industrial skills to service needs; the second is related to new technology opportunities created for education and training; the third embodies the talent that may represent the decisive factor of manufacturing production. i.e., high-skilled employees will be paid more than low-skilled employees.

Reference [14] reports further benefits of manufacturing SMEs to be increased revenues, enhanced product quality, supporting innovation across many applications, energy-efficient and environmentally sustainable production, waste reduction, increased flexibility, and enhanced safety in the workplace. They project cost and revenue improvements of between 15–20% to be achieved with the 4IR, and even though the 4IR is surrounded by uncertainties, it is imperative for countries, especially emerging economies to endeavor to implement innovative 4IR technologies. As previously indicated, governments and regulatory institutions should respond rapidly to 4IR opportunities by establishing an enabling environment and policies to foster sustainable socio-economic development.

1.4. Manufacturing SME Organizational Changes

Organizational changes are imperative for implementing and effectively using 4IR technologies. The organizational change concept covers three primary categories [15,16], which are: Organization change processes (OCP), organization change structures (OCS), and organization change boundaries (OCB). Changes in processes involve modifications in processes of manufacturing production, internal routines, methods of distribution or service, human resource management, operations, communications, and supporting activities of the organization [17]. Structural changes refer to structural-elements modification or functional efforts, significant strategic changes, or introduction of new management methods (e.g., new forms of work organization such as delayering of hierarchies and authority

decentralization), while organization change boundary implies significant reforms in organization relations with others, e.g., its customers, competitors, public institutes, suppliers, or business partners. These changes exceed formal organization boundaries and manifest themselves in, for example, disaggregated organizations and boundarylessness [18,19] with increased reliance on subcontracting, outsourcing, and shared research and development partnership [20], the formation of joint undertakings and strategic alliances [21,22] together with the development of new sales/marketing channels (e.g., internet portals, franchisees, and call centers).

SMEs are affected by several change forces [23]. Educational, social, economic, technological, political, and cultural aspects are classified as external change forces on an organization. Internal change forces include worker activities, political, technology, and objectives of the organization. Both sets of forces change regularly and can lead to both internal and external changes affecting the organization [23]. Arguably, both external- and internal change forces will be redefined in a 4IR context.

Concerning our research, to the best of the researcher's knowledge, there is no identified conceptual framework to address challenges of and utilize opportunities for manufacturing SMEs in a 4IR context. Manufacturing SMEs are facing both social challenges, which include social responsibility as well as values and beliefs, and technological challenges, making it hard for a small organization to survive in a competitive environment. Concerning social challenges, [24] asserts that negative values in organizations, resistance to change, and/or acceptance of new technologies are due to fear of complexity in using the latest technology, unconstructive beliefs of workers, and an absence of confidence among workers to employ new technologies to improve business performance and organizational sustainability.

Cioffi et al. [25] conducted a comprehensive literature review on smart manufacturing systems to promote circular business models. They analyzed 31 conceptual, methodological, and application publications. Two main changes to a circular economy were identified—managerial changes and legislative changes. Digitalization aspects within smart manufacturing were investigated and they found the Internet of Things (IoT) and innovative business models to be key aspects. Other interlinked aspects found to be of importance include ethics, sustainability, and the role of society.

The benefits of Industry 4.0 for sustainability with respect to manufacturing companies were investigated by Brozzi et al. [26] through a survey of 65 companies located in the Marche region in Italy. The results indicated that economic considerations prevail for these companies, and environmental sustainability and social considerations scored lower. The companies surveyed, with SMEs included in the survey, appear to not perceive Industry 4.0 as an opportunity to enhance environmentally, neither social sustainability. Therefore, more awareness work as to the opportunities of the 4IR for environmental and social sustainability should be undertaken.

Florescu and Barabas [27] report on software enabling flexible manufacturing through an interactive tool useful in the design and management of flexible manufacturing lines in the area of intelligent manufacturing. They propose a mathematical model to analyze flexible manufacturing systems, which, among other functionality, assists with the optimization of both materials and information.

This article will proceed as follows: Beginning with the introduction, we then state our research questions and objective in Section 1.5. Section 2 presents a comprehensive literature review on aspects of SMEs, the 4IR, and business relationships with these technologies and changes. Our research methodology is described in Section 3, Materials and Methods, and the important deliverable of this work, namely, a conceptual framework for SMEs in the 4IR, is presented in Section 4. A brief theoretical validation is presented in Section 5, followed by a brief reflection on the contribution of this work in Section 6. A summary, conclusions, and directions for future work in this area appear in Section 7. A list of references concludes the article.

1.5. Research Questions and Objective

Our study aims to find answers to the following research questions (RQs):

1. What are the components of the fourth industrial revolution technologies? (RQ1)
2. What are the challenges faced by the manufacturing SMEs in South Africa in moving into the 4IR? (RQ2)
3. How can 4IR technologies address the challenges of South African SMEs? (RQ3)

Our objective in finding answers to the RQs is summarized as follows:

1. Develop a conceptual framework to guide South African SMEs into 4IR to gain competitive advantage and sustainable business performance.

2. Literature Review

In this section, we review scholarly literature concerning the impact of the 4IR on manufacturing SMEs. We continue with synthesizing propositions that are used in the development of the conceptual framework. We start with SMEs globally, then move to the South African context, followed by 4IR aspects.

2.1. Role of SMEs Globally

Globally, SMEs are vital to economies. According to the European definition, SMEs are companies employing up to 249 persons as indicated in Table 1 [6].

Table 1. European Definition of Micro, Small and Medium Businesses [6].

Business Size	Number of Full-Time Employees
Micro	1–9
Small	10–49
Medium	50–249

Note: The South African government has standardized the use of SMEs by grouping Micro and Small into one category [6].

The World Trade Organization [28] performed calculations on more than 25,000 SMEs among developing economies from surveys from the World Bank Enterprise and synthesized the information as in Table 2.

Table 2. Role of SMEs in Developing and Developed Economies (Synthesized by researchers from [28]).

Aspect	Percentages	Sector and Company Classification
Direct exports	7.6% of total sales 14.1%	Manufacturing SMEs Large manufacturing
Export share	3% 8.7	African developing economies Developing economies of Asia
SME participation in export share	0.9 of total sales 31.9%	Developing countries Large enterprises
OECD group	99% of all companies 70% of employment 50%–60% of the value created	SMEs
Developing economies	45% of employment 3% of the GDP	SMEs

The information in Table 2 and reference [29] pave the way for our first content proposition on the value chain and value creation.

Proposition pC1a: SMEs globally lead in the development and sustainability of a global economy, since they:

- i. Are the main source of employment and value creation.
- ii. Contribute to economic diversification and resilience.

Note that proposition *pC1a* is stated in a preliminary or developing format. Further propositions will add more information in the form of *pC1b*, and so forth.

Reference [30] notes that in analyses of scientific work as well as European Union (EU) projects on SME-4IR research, it is evident that these aspects are rather underdeveloped and under-researched. They have received concerted attention only since 2017. It will, therefore, require concerted efforts to develop appropriate instruments for embedding 4IR technologies in SMEs in the industry. Reference [30] also notes the absence of best practice examples of SMEs where a large part of the 4IR technologies has been successfully adopted, hence, the reason for our research and qualitative research choice. Reference [30] further calls for more attention to be paid to assist SMEs to adopt and, subsequently, use 4IR technologies in the future and highlights that scientists and engineers should, together with business, be brought on board.

Proposition *pC2*: Since best practices for employing the 4IR in SME operations are largely absent, such best practices for embedding the 4IR in SMEs should be developed.

A GDP of 524.5 billion US\$ was reported by the Polish economy in 2017. It is reported that about 50% of such revenue was generated by SMEs, while microenterprises generated around 30.2%. Despite their importance for economic growth, SMEs face some challenges. These include shortages of financial resources, as well as shortages in specialized support to procure new (4IR) technologies [31]. Reference [31] further calls for the development of platforms to amalgamate the efforts of role players to facilitate sustainable development [31].

Consequently, we arrive at:

Proposition *pC3*: Platforms to generate financial resources and introduce 4IR technologies into SMEs should be developed, all aimed at SME sustainability.

2.2. Role of SMEs in South Africa

As indicated, SMEs likewise play an important part in the South African economy in which an SME is defined as a business with up to 250 employees [6]. SMEs are bound to become a vital component in a 4IR developing economy, hence South Africa should embrace its technologies, amongst others, mobile connectivity, artificial intelligence (AI), big data analytics, machine-to-machine (M2M) communication, and the Internet of Things (IoT) which makes use of machines to optimize efficient manufacturing and production of goods [32]. The business report adds that efficient delivery and production of quality services and goods will become cost-effective and much faster which requires an enabling environment [32].

Proposition *pC4*: SMEs play an important role in the development and sustainability of a developing economy, specifically South Africa.

2.3. Manufacturing SME Sector

Manufacturing embodies the production of goods or products to be sold, or to use. Involved in such production, there are tools, machines, utilizing chemical and biological formulations and processes, being the essence of secondary industries. Naturally, these industries engage in the production of a variety of goods or products. Materials, subsistence, or components are transformed into goods or products using various chemical and biological processes. As indicated, the 4IR is anticipated to change the service of products, their design, manufacturing operations, the underlying production systems; the connectivity and interaction among humans, machines, parts, and ways of thinking about these. Amongst other things, the 4IR is anticipated to streamline production systems to be 25% more efficient and about 30% faster, thereby improving on mass customization peaks [33]. Therefore, South Africa can embrace the 4IR technologies for the efficient production of quality manufactured goods [32].

Globally, across industries, there is evidence that 4IR technologies are set to impact businesses significantly; naturally, this will also be true for manufacturing SMEs [34]. On the supply side, industries are anticipated to observe new technologies being introduced to create new and innovative ways of addressing existing needs and requirements, thereby, disrupting existing industry value chains. On the demand side, there would be increased transparency, changed consumer engagement, and consumer behavior patterns and needs would emerge. These would necessitate companies, likewise for SMEs, to rethink their designs, products, and service delivery [34]. Platforms (refer **Proposition pC3**) have made it easier for people to engage in using smartphones while creating new channels of access to services and products; and are making it easier for SMEs to generate profit and change the working environments for individuals and professionals [34].

The above discussions lead to three propositions:

Proposition pC5: The advent of the 4IR introduces new ways of addressing SME customer needs; hence, it disrupts existing industry value chains, such as disruptive innovation.

- i. To minimize downtime, a migration plan must be in place to transition smoothly to the new 4IR technologies.

Proposition pC6: New consumer behavior patterns emerge owing to the 4IR.

Proposition pC7: Enhanced industry value chains (VCs) ought to follow from the disruption of existing supply chains (SCs) owing to the 4IR.

Note how Proposition pC7 supports part of Proposition pC1.

2.4. Manufacturing SME Challenges

Manufacturing SMEs face challenges of skilled labor shortages that are strengthened by the new wave of technological revolution through additive manufacturing and service automation [10,35]. Large businesses can afford the new technologies while manufacturing SMEs are challenged by procuring these. If not supported by e.g., the government, they face recruitment challenges and are less likely to acquire technology and financial independence [36]. Some challenges facing SMEs, such as red tape, lack of innovation, labor legislation, the impact of crime, lack of funding, and lack of skills, can arguably be addressed through cloud or edge computing technologies [37].

Other challenges preventing the manufacturing SMEs from benefiting from the 4IR technologies include:

1. Inequality, particularly its potential to disrupt labor markets, as the labor force is substituted for automation across the entire 4IR economy [10].
2. Displacement of workers by machines might worsen the gap between returns to capital and returns to labor [1].
3. Talents in the future will be more valued than working capital, and this will give rise to a job market where high-skilled workers are paid more compared to low-skilled workers aggravating social tension [1].
4. Lack of sufficient financial means to procure the necessary 4IR technologies.
5. Manufacturing SMEs have difficulty in committing resources and may lack the capabilities to transform.
6. Challenges for technical skills relating to the increasing complexity of automated production systems arise, much of which has to be hidden from the end-user [38].

The above observations can be synthesized as our next content proposition:

Proposition pC6: Manufacturing SMEs face numerous challenges in their day-to-day operations. These include:

1. Automation substitution of labor across the entire economy.
2. Displacement of workers by machines worsening the unemployment gap (job insecurity).
3. High-skilled employees getting high pay as opposed to low-skilled with low pay aggravating social tension.

4. Lack of sufficient financial means to procure the necessary 4IR technologies (cf. interrupted supply chains—*Proposition pC5*).
5. Technical skills' challenges to operate automated production systems.

A further SME challenge is the lack of proper policies that require government support to accelerate the adoption of the 4IR technologies [37]. Some governments, e.g., Kenya, Rwanda, and Uganda have initiated several programs and policies to accelerate economic growth and development in the region [8], leading to our next content proposition.

Proposition pC7: Manufacturing SMEs require mentoring and government support through policies to assist with accelerated adoption and subsequent use of 4IR technologies.

The challenges confronting manufacturing SMEs also compromise their chances of addressing structural challenges within their 4IR economic space [36]. Such challenges include:

1. New business models that enable scientific forecasts and analysis as well as disseminating traders' and manufacturers' information are being developed. While Artificial intelligence (AI) technologies may cause the number of workers to reduce, [39] reports there is not a sufficiently skilled number of workers to implement these 4IR technologies.
2. Safety and security are increasing concerns for businesses owing to the increased complexities of production systems that are being automated [38].
3. Lack of technological progress prohibits manufacturing SMEs to reduce industrial wastes by redesigning consumption and production systems to be more efficient in using resources [35].
4. Fears of the poor, non-skilled, and the marginalized are feeling increasingly challenged in an ever-increasing digitalized world.
5. According to the report from the Department of Economic & Social Affairs [40], many occupations and professions have been significantly transformed by the growth of the current technological revolution; yet, while some occupations are growing fast while changing the requirements in skills and competencies, some professions and occupations are already threatened by massive occupation dislocations, redundancies, and skillset disruption, as agreed by [10,39,40].
6. Education and training have received less investment and the shortage of key technical skills may increase the failure of the manufacturing SMEs to fully participate in the 4IR [41–45].
7. Low-cost labor is no longer an effective strategy for attracting manufacturing investment from foreign investors. The cost of automation is expected to drop through the introduction of automation, mainly owing to the resources in developed economies. They might export their assembly operations back to developed economies, thereby creating less opportunity for employment in developing African economies [7,41].

The above list of structural adjustment challenges leads to the following proposition.

Proposition pC8: In moving into the 4IR, South African manufacturing SMEs would have to address structural adjustment challenges. These include:

1. New business models should be developed through Artificial Intelligence (AI).
2. Technological-progress programs with manufacturing SMEs reducing industrial waste need to be implemented.
3. Safety and security (Information Security) challenge for manufacturing SMEs needs to be addressed.
4. Increased investment in education and training to address shortages of key technical skills should be made.
5. Adoption in terms of infrastructure to facilitate a competitive advantage and enable sustainable business performance through highly adaptable structures and agile manufacturing should be investigated.

2.5. The Fourth Industrial Revolution

The 4IR or Industry 4.0 (I4.0) for manufacturing embodies numerous concepts. Apart from Automation, some of these are Cyber-Physical Systems (CPS), the Internet of Things (IoT), Human-Machine Interaction (HMI) (a variant of the 3IR HCI – human-computer interaction), and Advanced Manufacturing, all aimed at improved manufacturing [46–48]. It is anticipated that agile and highly adaptable manufacturing systems will increasingly be used in industry to replace traditional structures that are based on inflexible and centralized decision-making mechanisms. The new industry would offer interactive and collaborative decision-making for managers.

2.5.1. The Key Technical Elements of the 4IR

One of the key components in the 4IR is the cyber-physical system (CPS) embodying aspects of self-organization and self-control [46]. CPSs entail the use of networks consisting of small sensors embedded in materials, goods, equipment, and parts of machines, and interconnected via the IoT. CPSs are used as Cyber-Physical Production Systems (CPPs) in manufacturing for automated production. These are anticipated to disrupt the industry through new business models and similar processes.

The IoT has led to the integration of information to create the 4Cs (Connection, Communication, Computing, and Control) [49]. Reference [50] views the IoT as the foundation of the 4IR, embodying the latest trends in computing and software engineering, poised to have an impact in the manufacturing industry. Reference [47] adds that the IoT is effecting a step-change in the standards of the living quality of individuals and the productivity of organizations across various industries.

Concerning the technical advancements, the above discussions lead to:

Proposition pC9a: The Internet of things (IoT), one of the 4IR technologies can provide improvement in the productivity of the manufacturing SME organizations across various industries.

Proposition pC9a is stated in a preliminary form. Further propositions will enhance it incrementally.

2.5.2. Benefits of the 4IR

The 4IR and its technologies are expected to generate “higher-order benefits” [51], some being disruptive (arguably improved) innovation capability, facilitated monitoring, improved diagnoses of malfunctioning systems, increased self-awareness of intelligent machines, and subsequent self-maintenance, higher productivity coupled with environmentally friendly products, decreased costs through improved flexibility, faster and more reliable development processes through new service- and business-models, knowledge-based decision making in real-time, nationwide contributions to the economy, improved market spread and improved access to global markets through e-business, improved access to public services, for example, healthcare, education (training), and overall better quality of life. At the manufacturing level, more customized products for consumers are expected. Access to personal information should also improve, but this may come at the cost of known problems related to compromising one’s personal information and identity theft.

The anticipated higher-order benefits of the 4IR lead to:

Proposition pC10: Higher-order benefits promised by 4IR technologies include:

1. Improved, possibly interrupted innovation capability.
2. Improved monitoring and diagnosis of systems that multifunction.
3. Increased self-awareness of intelligent systems and subsequent self-maintenance.
4. Improved productivity with environmentally friendly and more customized products.
5. Improved flexibility with decreased costs.
6. Faster product development processes with new service models and business.
7. More market spread and access to global through e-business.
8. Improved access to public services, for example, education (training), health, local services, and personal information.

We view further analyses of health aspects related to the quality of life as beyond the scope of this paper for SME manufacturing, hence we do not consider these in our conceptual framework.

2.5.3. Challenges of the 4IR

Reference [52] elaborates on 4IR challenges. Large companies are addressing 4IR challenges and are working on the adoption of the underlying technologies. SMEs, particularly in developing economies may not have the human capital, neither the financial means to investigate the opportunities of the 4IR, neither the risks these might be posing for small businesses. However, as indicated, SMEs form the backbone of an economy, both for developing countries and developed economies; they account for the largest part of the gross domestic product (GDP) and employ large numbers of employees (cf. *Proposition pC4*). In this respect, the challenges, opportunities, and requirements of the 4IR in the context of an SME should be examined, to pave the way for the digital transformation of traditional SMEs into smart manufacturing.

Further, [52] urges that the 4IR would signal the end of traditional and centralized production control applications. They foresee smart factories as being inherently decentralized, having intelligent and autonomous shop-floor entities as the workers of the future. In these smart environments, the usual 4IR technologies, namely, 3D printing, the IoT, cloud computing (CC) coupled with mobile devices, and big data usage, among other technologies that create an intelligent environment, would be found. This paradigm shift is anticipated to dictate the smart manufacturing environment of the future.

The viewpoints in [52] lead to:

Proposition pC11: Manufacturing SMEs will move from traditional centralized applications of production control to decentralized smart factories having autonomous and intelligent and shop floor entities.

We also observe the next revision of a previous proposition:

Proposition pC9b: Customer's demand for tailored products is possible with the 4IR because it uses technology enablers such as 3D printing, the IoT, cloud computing (CC) coupled with mobile devices, and big data in a new, smart environment.

2.5.4. The Effects of the 4IR

Reference [35] writes that there are four main effects of the 4IR on business environments. These are impacts on consumer expectations, the quality of products, organizational norms (moving from centralized to de-centralized), and collaborative (possibly disruptive) innovation. Reference [53] likewise indicates that the 4IR holds the promise of increased manufacturing flexibility, coupled with mass customization (we already have mass production), improved product quality, and higher productivity. Therefore, the 4IR would enable organizations to cope with the challenges of producing increasingly individualized (customized) products having a shorter time to market (TTM) and of higher quality. Intelligent manufacturing is anticipated to play a vital role in the 4IR. Resources could be converted into intelligent entities that could sense, act, and behave in a smart environment.

The above 4IR effects lead to:

Proposition pC12: The 4IR increases SME manufacturing flexibility, enabling mass product customization for customers, improved product quality, coupled with higher productivity.

Proposition pC13: The 4IR introduces intelligent manufacturing which converts resources into intelligent entities that could sense, act, and behave in a smart environment leading to sustainability and improved performance.

According to [54], the 4IR leads to an increase in productivity using artificial intelligence (AI) and hyper-connectivity. The technologies of 4IR are being researched in order to integrate biological, digital, and physical worlds in amongst other the human body and mind (leading into the fifth industrial revolution – 5IR). Medicine and life sciences stand to benefit greatly from this revolution, unlike with the previous three revolutions, which

benefitted mostly the science and engineering worlds. The creation of new knowledge will be core in the new world, coupled with connections to transfer such knowledge to much-needed centers. Health data are concentrated mostly in hospitals; hence it is vital for the storage of such information and connections among these to be well-functioning.

These technologies lead to additional information in relation to an earlier proposition:

Proposition pC9c: The 4IR increases productivity by using artificial intelligence (AI) and hyper-connectivity while creating new knowledge based on various types of information collected.

2.5.5. The 4IR Technology Components

In addition to the technical components of the 4IR in Section 2.5.1, we note the innovative technologies according to the European Commission [55], to be the following: Information and communication technology (ICT) to digitize information and integrate systems at all stages of product creation and use, including logistics and supply, both inside organizations and across organizational boundaries and CPSs that monitor and control physical processes and systems. These may involve embedded sensors, intelligent robots that can configure themselves to suit the immediate product to be created, additive manufacturing or 3D printing devices; network communications including wireless and internet technologies that serve to link machines, work products, systems, and people, both within the manufacturing plant, and with suppliers and distributors; digital assistance systems for human workers, including robots, augmented reality, and intelligent aid systems.

We, consequently, add to a previous proposition:

Proposition pC9d: The 4IR technologies further include embedded sensors, intelligent robots, intelligent Wi-Fi communications, digital assistants, and intelligent aid systems for humans.

Evidence shows that 4IR technologies facilitate the complete automation of manufacturing facilities and the integration of an organization's supply chain partners, which encompass both software and hardware components [14]. Reference [14] further confirms the major 4IR technology components as big data analytics; AI; intelligent Simulations; the Industrial Internet of Things (IIoT), linking intelligent objects over the Internet; Additive manufacturing with 3D printing; Augmented reality (AR) and Virtual Reality (VR); Cloud/Edge (Fog) Computing (C/EC); and Blockchain technologies underlying Bitcoin.

We arrive at additional information to proposition 9:

Proposition pC9e: The seven main 4IR technologies/components are: Big data analytics, Artificial Intelligence (AI), intelligent Simulations, IoT with the Industrial Internet of things (IoT/IIoT), Additive Manufacturing (AM) embedding 3D printing, Augmented Reality, or Virtual Reality (AR/VR), and Cloud/Edge (Fog) Computing (C/EC).

2.5.6. The 4IR Technologies Useful for SMEs

Several technologies can be used by manufacturing SMEs, and nine technologies from the literature have been noted as transforming industrial production specifically for SMEs. These are big data analytics; Autonomous robots; Additive manufacturing; Augmented reality; Cloud/Edge/Fog computing; Cybersecurity; intelligent Simulation; Industrial Internet of Things (IIoT); and Horizontal and Vertical system integration.

We postulate the above holds equally for manufacturing SMEs, leading to additional information for proposition 9:

Proposition pX9f: Additional technologies of 4IR useful to manufacturing SMEs are autonomous robots; cybersecurity; and horizontal and vertical integration.

Strategically, technology continuously changes the way businesses work [56], while affecting entire business processes used to develop products and services, and affecting competition:

1. It creates a competitive advantage whereby rival companies are outperformed in new, innovative ways.

2. New businesses lines can be spawned, usually from within the organization's existing working operations.

These observations lead to:

Proposition pC14: The fourth industrial revolution is affecting competition:

- i. It creates a competitive advantage whereby rival companies may be outperformed in innovative ways.
- ii. New business models can be spawned up, usually from within the organization's existing working operations.

Education has also been identified as vital to upskill employees to deal with new 4IR challenges. For example, [35] advocates education, re-education, and training to prepare for 4IR impacts, since these are bound to affect income distribution and low-income earners the most. Furthermore, since pension incomes may become more unequal, adequate healthcare for the poor and the rich, for the young and the old should be provided for by governments, though this may be hard to realize [35], particularly for developing-economy governments.

The information on education and training leads to:

Proposition pX15a: Manufacturing SMEs need to focus on education and re-education to upskill the workforce to deal with 4IR technology requirements.

2.5.7. The 4IR Impact on Manufacturing SMEs

The seminal work on the 4IR in [1] elucidates that the development of platforms enabled by technology that combines both demand and supply to disrupt existing structures of the industry is a key trend, such as those that can be seen within the on-demand or sharing economy. The author states that platforms assist people to engage in using smartphones while creating new channels of access to services and products. These platforms facilitate SMEs generating profits and changing the working environments for individuals and professionals, consequently, we define:

Proposition pC16: Use of platforms facilitates access to manufacturing SME services and products using smartphones enabled by the 4IR technologies.

Turning to social and human aspects, the 4IR has deepened the fear of its consequences, particularly among developing economies in sub-Saharan Africa owing to its impact on job displacements, skills disruptions combined with existing lack of skilled workers, and mass unemployment already undermining economic sustainable growth and transformation [8]. The key to understanding how the 4IR will benefit and affect the sub-Saharan economies may be unique, and not enough research and attention to policy discourse have been given to it [8]. Moreover, the authors report that several sub-Saharan African economies are experiencing skill- and talent shortages and unemployment. Many sub-Saharan economies are overexposed to disruptions in their employment markets, composed of under-education and skills mismatch [8]. Other researchers add that family or small businesses (e.g., SMEs) have mainly fueled the informal economic activity, but are challenged by poor and limited infrastructure; slow growth; low levels of skills formation and education; and low advancements in innovation and technology [9,57,58].

The information on human and social challenges lead to:

Proposition pC17: Job insecurity and unemployment undermine SME economic sustainable growth and transformation brought by the 4IR.

Proposition pC15b: Education is key to address skills and talent shortages that are necessary ingredients for competitive advantage and sustainable business performance in manufacturing SMEs in the context of a developing economy.

Reference [8] also lists instability in politics, ethnic and religious divisions, tribalism, nepotism, traditional and modern culture clashes to be the root causes of challenged sub-Saharan economies. Coupled with these, businesses and governments ought to be prepared for disruptions in skills and jobs expected from 4IR technologies through service- and manufacturing-automation, leading to:

Proposition pC18: Politics; ethnic, cultural, and religious divisions; and nepotism may delay SMEs transitioning to 4IR technologies.

Despite the foregoing challenges, several sub-Saharan countries have made considerable efforts to increase technology utilization and penetration in the region [59], but investments by governments in high-speed internet technology infrastructure, research and development, and training remain low [45,60,61]. According to [8], the general lack of high-speed internet across the continent limits information access and business-processes efficiency. The authors report that the impact of the 4IR is leading to the reshoring of manufacturing back to the developed countries; global supply chains are expected to collapse as currently advanced economies tend to initiate most of the 4IR technologies and developing countries are perceived as being slow in adopting them. These are bound to harm manufacturing SMEs in sub-Saharan Africa.

The above challenges for sub-Saharan African economies lead to:

Proposition pC19: Increases in investments by governments in high-speed internet technology infrastructure; and research and development may facilitate 4IR technology utilization and penetration of 4IR technologies.

Reference [62] writes that while automation will replace some workers, new opportunities may open for a large percentage of the labor force as compensation for lost jobs; such opportunities may even be safer and better paid. Likewise, [1] believes that the job market will be separated increasingly into industries based on education level with low remuneration for some and others in positions of management and governance with higher remuneration. Automation is bound to employee types: those at the top with higher pay, while lower-skilled positions in factories or administrative positions of a repetitive nature may be the first to be replaced owing to automation.

These discussions lead to:

Proposition pC20a: It is evident that 4IR automation may replace part of the labor force, yet part of these will find new employment that is better, safer, and with higher remuneration as compensation for lost positions.

Proposition pC20b: The 4IR will create new jobs that will change employee characteristics that will improve manufacturing SMEs' competitive advantage and sustainable business performance.

2.6. Manufacturing SME Product Customization

Product customization is becoming the norm in manufacturing and [63] indicates that there is a market trend suggesting customers are growing tired of uniform products and are looking more for their customization; hence, factories may be moved to consider customized preferences for individuals. Consequently, manufacturing SMEs should introduce supporting 4IR technologies (cf. the versions of proposition pC9) to promote, deliver, and adjust designs as well as the service system for customers. Naturally, this new mode of operation may disrupt the current value chain of the design, production, and service in which the norm is for consumers to request changes to product specifications when ordering, during design, testing, and assembly, all enabling products to be customized for mass production [63].

In addition, [63] stresses that the 4IR effects critical changes to the networking of production lines, which, for example, may allow intelligent mainstream manufacturing SMEs to migrate from being product-centered to services-centered, allowing more manufacturing SMEs to succeed in the 4IR technology tide.

These result in:

Proposition pC21: The 4IR enables manufacturing SMEs product customization from new modes of operation that disrupts the current value chain of the design, product, and services.

2.7. Gaps in Literature

As for the gaps in the study of the 4IR and its impact, [64] reports that the 4IR is increasingly attracting attention worldwide, but a gap appears in the extant literature in respect to systematic reviews of the new technologies. According to [65], the 4IR focuses on

how to digitalize and adopt such technologies to affect SME manufacturing advantages and sustainability. Reference [65] visualizes a fully automated and adaptable manufacturing environment with improved quality for products and, at the same time, having minimal effects on the environment. It is anticipated that automated machines could be reducing costs, embedding predictive quality, and shortening lead times through predictive-failure models. However, it also emphasizes the challenges in attempting to implement the 4IR in practice and where theory still lacks practical support, motivating the reason for our research. Reference [65] concludes that research should, amongst other endeavors investigate how SMEs are implementing 4IR concepts to generate value.

Proposition pC22: The 4IR promises manufacturing SMEs cost reduction by using automated machines with predictive quality, shortened lead times, and a decreased environmental impact.

The implementation of 4IR has a far-reaching impact on industrial value creation, yet studies on its opportunities and challenges for organizations are still sparse [66]. The 4IR is continuously advancing science and technology, with the key player being the Internet of Things (IoT) and its components amongst other Cyber-Physical Systems (CPS) and smart machines being used to improve on production chains [67]. Such advancement facilitates agility and intelligence (smartness) and spans beyond the traditional territorial and organizational boundaries. These developments are anticipated to trigger government efforts to put in place policies, guidelines, and standards. Owing to the complexities and speed of change of these transitions, common understandings and coordination largely elude the manufacturing society, hence, the following propositions:

Proposition pC23: The 4IR promotes advances in science, engineering, and technology, amongst other developments in the IoT and supporting developments such as Cyber-Physical Systems (CPS) and smart machines to optimize production chains.

Proposition pC24: Proper guidelines and standards need to be defined by governments for manufacturing SMEs to facilitate the use of 4IR technologies.

Reference [65] advocates that the integration of horizontal and vertical manufacturing processes may facilitate the industrial performance of a company in the 4IR. Despite this, the view of emerging economies for these 4IR developments is not fully known. While, presumably, 4IR progress concerning these has been made, there appear to be uncertainties in the minds of SME owners and managers about the preparedness of businesses and industries in developing economies. Reference [68] reports that disruptive 4IR advancements are experienced widely at national, as well as industry and company levels in the South African industry. At the same time [8] views the 4IR as presenting valuable opportunities for economic and social growth across nations, and these are rarely independent of a country's global location or state of development, hence these opportunities also exist for sub-Saharan countries. Presently, the 4IR is paving the way for advances in, amongst other biotechnology, genetics, and nanotechnology.

We arrive at the following:

Proposition pC25: Manufacturing process integration for horizontal and vertical processes and product connectivity can assist in manufacturing SMEs achieving higher industrial performance.

Subsequently, we have additional information for proposition 9:

Proposition pC9g: The 4IR increases technological convergence that is driven by advancement in genetics, biotechnology, and nanotechnology.

Reference [69] notes that attaining higher levels of productivity and operational effectiveness as well as working towards automation goes hand in hand with improved performance. While it is accepted that the benefits incurred by the 4IR ought to be all-inclusive, it is noted that much of the discussions and research into the 4IR, and its effects focus on the needs and developments in developed economies. The 4IR provides lucrative opportunities for developing economies, in particular for the sub-Saharan countries to try to come on par concerning technological, social, and economic development opportunities

in that region [70]. At the same time, there is a risk for Sub-Saharan Africa to fall even further behind should these opportunities fail to realize.

We arrive at:

Proposition pC26: The 4IR may facilitate technological, economic, and social growth to achieve growth across national states, irrespective of their worldly location or state of development. These include the sub-Saharan region.

Proposition pC27: The 4IR can assist manufacturing SMEs to achieve higher levels of productivity, operational effectiveness, and automation.

Reference [71] found that the public remains optimistic regarding 4IR opportunities for sustainability. Reference [72] states that organizations need to be cognizant of the contribution of 4IR technologies to sustainability, but sufficient guidance is lacking in scholarly or practitioner literature. Reference [70] also writes that mobile technologies have a decidable impact on sustainability across industries, while advances in drones, simulations, and nanotechnology have high impacts on sustainability in electronics, the automotive industry, food, beverage, and textile industries, and footwear and apparel. Reference [72] likewise recommends that industries should take advantage of the 4IR to improve sustainability but warns that each technology should carefully be evaluated, since any specific technology, arguably, could influence the said industry and associated sustainability dimensions.

These lead to additional information to proposition 9 and a preliminary form on the next proposition:

Proposition pC9h: It is proposed that 4IR technologies, namely, simulation, mobile technology, and drones facilitate sustainability in electronics, the automotive industry, food and beverage; and footwear and apparel manufacturing industries.

Proposition pC28a: The manufacturing SMEs should consider appropriate 4IR investment and championship opportunities as contributing to sustainability.

Reference [73] agrees there is a need for practical studies on 4IR implementation procedures in organizations. Barriers are reported as being a lack of financial resources and infrastructure; the relocation of workers in the labor market; and challenges concerning essential technological requirements and management aspects in the 4IR.

A lack of knowledge of 4IR concepts is likewise a barrier, even in Germany, there are different perspectives of the concept of the 4IR, complicating knowledge acquisition of how to facilitate changes in an organization [74], even though cases about the assimilation of 4IR concepts have been documented. Arguably, the efficient and effective use of technology is possible only if the procuring organization fully understands the said technology [75].

The above discussions lead to:

Proposition pC29: Practical case studies, implementation procedures, and research and development (R&D) efforts are needed to augment the knowledge gap in implementation skills of the 4IR in manufacturing SMEs (cf. **Proposition pC2** on best practices).

Proposition pC30a: Manufacturing SMEs should embark on knowledge management (KM) principles to address their gaps in 4IR knowledge (refer also **Proposition pC29**).

Proposition pC31: Lack of infrastructure, linked with a lack of financial resources are challenges limiting the use of 4IR technologies by manufacturing SMEs.

The 4IR is already being implemented in several countries, e.g., Germany, coupled with sequences of national policies for 4IR applications in Brazil, France, China, Japan, the United States, China, and the United Kingdom, among others [73]. However, the authors warn that the adequacy and implementation of the 4IR technologies may prove challenging for many countries and their manufacturing industries. According to [76], there is little or no consensus on what constitutes the 4IR and to what extent South African companies, as developing organizations, are ready for the challenges and opportunities of the 4IR, since there are numerous combinations of technologies that enable the 4IR digitalization. Reference [76] reports that South African organizations (and by implication SMEs) have not yet implemented 4IR technologies and the driving forces for implementing these technologies are based more on operational aspects and not on strategic aspects per

se. Their findings suggest that South African organizations are largely immature for the implementation of the 4IR, so much so, that it is hard to determine their readiness [76].

We arrive at the following:

Proposition pC30b: The 4IR is becoming a reality in some developed economies; hence, developing economies such as South Africa can learn from them as mentees, thereby addressing their lack of sufficient 4IR knowledge.

Proposition pC32: South African manufacturing SMEs have shown insufficient readiness to adopt, subsequently, implement, and use 4IR technologies.

2.8. Business Considerations

This section addresses 4IR-SME aspects around business performance, competitive advantage with its sources, and concludes with strategic management.

2.8.1. Business Performance

Performance is often viewed by researchers based on functional specializations and experiences. For example, accountants approach performance by considering financial aspects, while a marketer may study performance from the view of customer perceptions, needs, and subsequent retention. Naturally, these diverse views make it hard to define a single, unified view of performance and its underlying measurements [77]. Reference [77] conceptualized business performance from the perspective of management in the sense that performance is viewed as a sequence of processes that moves the company forward. Business performance can be viewed from external achievements such as performance in the market; customer satisfaction index; internal achievement concerning policies in place and general staff well-being; the company's profit margin; return on investment (ROI); return on assets (ROA); and general wealth creation for the company's shareholders. [78,79]. We postulate that business performance can be operationalized and subsequently measured in comparison to the company's competitors by the resource-based view (RBV), instead of in absolute terms [80].

Accordingly, we propose the following:

Proposition pC33a: The business performance of manufacturing SME can be viewed from external achievements such as performance in the market; customer satisfaction index; internal achievement concerning policies in place and general staff well-being; the company's profit margin; return on investment (ROI); return on assets (ROA); and general wealth creation for the company's shareholders.

2.8.2. Competitive Advantage

The RBV of an organization is one of the frameworks that assist in understanding strategic management [81]. Reference [82] identifies four criteria that can be used to assess a resource's economic implications. These are rareness, inimitability, substitutability, and value. The rareness of a resource refers to how readily, or not, the resource may be acquired. Inimitability of a resource refers to the difficulty involved in obtaining the resource or recreating (copying) it, in other words, the cost involved in manufacturing it, in the context of this article. Substitutability refers to the degree to which a company's resources can be substituted by its competitors. Value summarizes all the aforementioned, in that, it indicates the fit of the resource with the goals of the company and how it exploits opportunities and largely neutralizes the competition.

Reference [83] states that potential resources can be categorized as physical, financial, legal, human, organizational, relational, and informational. Following these definitions, [84], considers an organization as having a competitive advantage should it be able to generate more economic value than its rivals [85]. Additionally, competitive advantages are those skills or factors that an organization ought to have to move ahead with their business [86].

These lead to further information for an earlier proposition:

Proposition pC28b: Using 4IR technologies, owners can give manufacturing SMEs competitive advantages by creating products and services that are rare, inimitable (for the organization, but not for competitors), non-substitutable, and valuable, thereby enhancing sustainability and business performance.

An organization can achieve a competitive advantage by asking higher prices for its products, while at the same time offering higher quality at lower costs, thereby improving on its so-called (triple) bottom line [87]. Reference [84] identifies three types of competitive advantage, namely cost leadership, focus, and product differentiation. Reference [88] adds that each of these three advantages creates a focus that can be utilized by an organization to create market competition, thereby enhancing its sustainable, competitive advantage. For example, unique and superior competencies let a company stand out among its competitors [89]. Unique competencies represent resources that can generate a unique and sustained competitive advantage for an organization among the competition with products or resources that may not be imitated. Core competence represents skills and abilities through which an organization's activities and processes deploy resources to create a competitive advantage in ways that may not be imitated or obtained by others [90].

The discussion on competitive advantages adds to a previous proposition:

Proposition pC33b: Manufacturing SMEs can benefit from four competitive advantages; cost leadership, differentiation, focus, and core competence resulting from applying unique competencies that are superior to competitors enabled by 4IR technologies.

2.8.3. Sources of Competitive Advantage

A competitive advantage may be achieved through an organizational strategy aimed at achieving superior performance relative to competitors. Hence, manufacturing SMEs should gain a competitive advantage through their internal and external financial resources. The competitiveness of the organization depends on the durability and difficulty-to-imitability of its resources, thereby differentiating it from its competitors [91]. According to the RBV theory, improvements to business performance depend on the availability and access to relatively immobile resources or resource bundles [83]. Resources may be tangible or intangible. Tangible resources include financials such as equity and debt-capital, retained earnings, and physical capital such as buildings and machinery. Examples of intangibles include organizational culture, training, and learning; networks (business and social); and brand reputation. These intangibles tend to be tacit, personal, and deeply embedded in an organization's culture and are likely to lead to a sustained, competitive advantage [92].

Proposition pC28c: Improved use of manufacturing SMEs' tangible and intangible resources can lead to competitive advantage and sustainability. Tangibles include physical-, financial-, and debt-capital, and retained earnings; while intangibles are, for example, organizational culture, training and learning, networks, and brand reputation.

In addition to immovable resources, financial resources, for example, cash (cash-in-hand); savings and/or bank deposits; and financial capital indicate an organization's performance and competitive advantage [93]. Reference [93] writes that an organization's physical resources, for example, their equipment, machinery, production systems (technology), plant, and capacity improvements on a manufacturing SME's competitive advantage, eventually leading to superior business performance. Other factors include human resources for trust, experiences, qualifications, capabilities, managerial skills; practices, and procedures followed by upper management, administrative, and production employees. Further aspects include experiential resources such as manufacturing experience, product reputation, and brand name and image [93].

These lead to additional information for each of three earlier propositions:

Proposition pC28c: Using immovable and financial resources such as cash (cash-in-hand); savings and/or bank deposits; and financial capital can lead to sustainability, competitive advantage, and high business performance of manufacturing SMEs.

Proposition pC33c: A good set of capabilities and experience for human resources, including trust, experiences, qualifications, capabilities, managerial skills, and a good

set of practices and procedures followed by upper management, administrative, and production employees, can lead to a sustained competitive advantage. Further aspects include experiential resources such as manufacturing experience, product reputation, brand name, and brand image.

Proposition pC28d: Using intangible resources such as organization culture, training and learning, and brand reputation that are tacit, personal, and deeply embedded in an organization's culture are likely to produce a competitive advantage for manufacturing SMEs.

Since tangible resources could readily be procured, they may offer little advantage to an SME in the long run. High-performance resources, for example, niche marketing, high-tech (4IR) technology, product-quality, and differentiation, synergy, low costs, vertical/horizontal integration, a good organizational culture, and good leadership style may offer a more sustained competitive advantage [94]. It is, therefore, important for manufacturing SME owners and managers to comprehend the factors that determine a competitive advantage coupled with sustainability, amidst 4IR economic, political, and social components.

Marketing contributes much to the performance of manufacturing SMEs for creating a sustained competitive advantage. Managers of manufacturing SMEs should identify the needs of customers and embed these into a new product or service planning. This helps them to satisfy customers' expectations.

Propositions arising from the foregoing are:

Proposition pC34: Niche marketing, high-tech (4IR) technology, product quality, and differentiation, synergy, low costs, vertical/horizontal integration, a good organizational culture, and good leadership style all strengthen a company's competitive advantage, facilitating sustainability.

Proposition pC35: Manufacturing SMEs can gain a competitive advantage by paying close attention to external factors such as technology, political and economic conditions, and social aspects.

Proposition pC36: Training and marketing can help the manufacturing SMEs to gain a competitive advantage by comprehending and translating customer needs into the planning of new products or services.

The RBV embeds two important aspects: resource heterogeneity and resource immobility of organizations [82,85]. Resource heterogeneity embeds organizations controlling unique bundles of resources [85] that stem from actions and decisions of the organization to gain a competitive advantage and gain the edge over their competitors [95]. It follows that an organization's resources are heterogeneously distributed and could lead to variations in performance. Resource heterogeneity can last for a long time provided that the resources are immobile or hard to copy [82,96]. Acquiring and deploying both resources and capabilities can lead to performance differences among organizations [95,97–99]. Theoretical aspects of the RBV are presented in Section 3.2.

Tangible Assets

Tangible assets are assets with monetary values shown in the organizational financial statements [99]. These include assets such as physical office branches, cash equivalent and reserve, computers, manufacturing facilities, raw material, and organizational property [100–102]. Tangible resources are current assets and fixed assets of an organization with a fixed long-term capacity [103]. Reference [103] elucidates tangible resources to comprise property, manufacturing facilities, capital goods, equipment, bank payments, stocks, and borrowers. Tangible assets are shown in organizational balance sheets, which are measured utilizing physical or financial values [104,105].

As indicated, tangible assets can improve an SME's competitive advantage, viz.:

Proposition pC28e: Tangible assets such as office branches, cash equivalent & reserve, computer, manufacturing facilities, raw material, organizational property, current assets, and fixed assets all serve to strengthen an SME's competitive advantage.

Intangible Assets

Intangible assets are resources that include human resources; organizational image and branding; intellectual capital; and the business's reputation in terms of customer service, resources of the organization, products, and services; knowledge of technicians; policies and structures of the organization; employee confidence and experiences [100,102,105]. Intangible resources are harder to duplicate, substitute for, and trade for, by competition than tangibles [106–109]. Furthermore, [107] classifies intangibles in terms of four types of capital: organization, human resource, relationship, and technology. These resources are not easily transferable between organizations due to several costs involved such as transactional, implied knowledge and transfer costs [110], and hard-to-elicited characteristics that are hard to transfer, trade, substitute, or imitate [111].

Despite the difficulties in distinguishing between organizational capabilities and the intangibles, references [99,105,112,113] all suggest if the intangible resources are things the organization possesses and do not depend on human resources, they are assets. If the intangibles depend on human resources, they are capabilities or skills. The intangibles that depend on human resources remain as organizational property even after the workers have left the company [107].

Consequently, we add information as follows:

Proposition pC28f: Intangible resources of a capital nature such as organization, human resources, relationships, and technology are rich sources of competitive advantage and business sustainability.

Capabilities

According to [99] and [101], there is a difference between capabilities and resources. Capabilities include employed knowledge and skill sets that form part of the organizational resources, whereas resources are productivity assets the organization owns, which together are used to produce services and products [114]. Organizational capabilities and resources and capabilities can be regarded as physical, finance, organization, and human resources [82,85,115]. Finance can be cash, capacity to borrow, and securities of an organization [85,99].

Raw material, technology equipment, property, and the location of the organization are regarded as physical resources [85]. Human resources include people skills, experiences, intelligence, training, relationships, motivation, capacity for collaboration and communication, whereas organization planning; hierarchies; systems; cultural setup; and the environment are organization resources [85,115].

Unless manufacturing SMEs can deploy resources through complex networks of processes and interactions, they may not be as productive in generating a competitive advantage [99,116,117]. Hence, these resources form the basis of capabilities that a manufacturing SME can activate to promote sustainability and competitive advantage [99]. Unlike resources, capabilities come from proper coordination of organizational resources and the employees [110,118,119]. These bind together organizational resources to improve efficiency and attain organizational goals [120]. The capacity of an organization to develop outputs from raw materials can measure an organization's capability efficiencies.

Owing to their tacit nature, capabilities are harder to imitate and substitute, thereby enhancing sustainability and competitive advantage for the host organization [106].

We add information to an earlier proposition:

Proposition pC37a: Capabilities in the form of financial resources, physical resources, human resources, and organizational resources that are hard to imitate, and substitute, create sustainability and competitive advantage for a manufacturing SME.

Dynamic Capabilities

Dynamism in the context of our research indicates an organization's (SME's) ability to rejuvenate its competencies to adapt to changes in the business environment [110] and dynamic capability implies change [121], referring to renewing and transforming the re-

sources of an organization [122]. Reference [123] defines dynamic capabilities as a business' ability to spot and then take advantage of innovative opportunities and to reconfigure and protect competencies, complementary assets, and knowledge assets to reach a sustained competitive advantage. Reference [124] views such dynamic organizational capabilities as higher-level (order) capabilities that enable organizations to acquire knowledge and act accordingly. Using its dynamic capabilities, an organization employs strategic processes during which its managers review and deploy resources to create new business assets as the business environment changes [125].

As indicated, dynamic capabilities embody higher-level functions that enable an organization to reconfigure its resources as the business environment changes [121,126]. Routines, on the other hand, are repetitive (refer to jobs above that may be lost in the 4IR), can be learned, and embody tacit capabilities together with change and growth using dynamic capabilities [121]. Dynamic capabilities are also viewed as an organization's ability to re-create (create and modify) its resource structure to respond to changes in the business environment [127]. Dynamic capabilities can be employed to develop, modify and later revise the capabilities and resources of an organization, again, to respond to changes in the business environment [114,128].

We arrive at the following:

- i. **Proposition pC37b:** To achieve a sustained competitive advantage, dynamic capabilities assist manufacturing SMEs to sense and take advantage of new opportunities,
- ii. protect and reconfigure core competencies, knowledge assets, and complementary assets, and
- iii. re-create (create and modify) its resource structure to respond to changes in the business environment.

Performance Measurement

Measures of organizational performance can be subjectively and objectively measured, can be based on the market, qualitatively measured, and finance or non-finance measured [129–131]. Finance measurements include per-share earnings, cash flows, profits, sales return, investment return (ROI), and equities return (ROE). Non-finance measurements include innovation, efficiencies in technology and marketing, quality of products, and introduction of new products [130,132–134]. Strategically, organizations can use finance and non-finance measurements to obtain improved performance since these measurements maximize relevant indicators of performance measurements [133].

Although an organization can achieve improved performance with finance and non-finance measurements, these have shortcomings, hence, it is useful to be holistic in using proper indicator measurements to facilitate a more reliable and balanced view of organization performance [135,136]. The business scorecard (BSC) can be used with its four perspectives: customers; innovativeness and internal organizations; growth; and finances. It measures performance comprehensively while addressing measurements of performance with traditionally functional views [135]. However, [137] and [138] suggest that the BSC lacks academic rigor, and its assumptions have flaws, giving inaccurate performance measurements. Finance measurement based on subjectivity reflects consequences in the economy because of organizational activities that include assets return (ROA), revenue growth, and profitability. To measure organizational performance, with a view from the customers, involves market share, satisfied, acquired, and retained customers as the measurement outcomes. The above concepts have been tested with empirical data and similar results were obtained [78,139,140].

We arrive at the following:

Proposition pC38: Manufacturing SMEs can use the business scorecard (BSC) with its four perspectives: customers; innovativeness and internal organizations; growth; and finances to gain a sustainable competitive advantage.

Literature shows that organizational competitor advantage and performance concepts are different [141–145]. Organizational competitor advantage follows performance [141,142].

Competitor advantage equates with an indication of the organization's profits, the share of the market, and payments [143,145–147]. Competitor advantage can be regarded as one of the ways organizations can obtain improved performance in profits measurement [148,149]. Reference [145] states that performance and competitor advantage can be related, as the relationship between competitive advantage and business performance could be formulated as:

- i. Organizational improved performance can be achieved from competitor advantage.
- ii. An organization enjoys a competitive advantage without necessarily gaining improved performance.
- iii. An organization may enjoy an improved performance with no competitor advantage.

In addition, [114] argues that an organization may obtain improved performance by cutting costs for a short period with no competitor advantage. It could also be a result of politics and governmental support, accessibility to improved distribution channels [145], and by chance [150].

In explaining the relationship between performance and competitive advantage, [149] states that an organization's performance, measured in terms of profitability, increases as its competitive advantage increases. In contrast to the RBV's proposition of heterogeneity, organizations having identical resources and adopting the same strategies [151] and even without implementing a resource-based strategy [142], could still generate higher performance than their rivals when there is industry protection and/or due to high entry barriers. Consequently, an organization that enjoys overall superior performance and appropriates its profit does not necessarily gain a competitive advantage over its rivals [98]. References [150] and [152] assert that organizations can gain a competitive advantage assessed by above-average non-financial performance measurements such as market share, customer satisfaction, employee income level, and environmental impact.

Finance provisions, lack of initiatives, managers' inadequacy, and management's lack of education are some reasons why manufacturing SMEs are incapable of obtaining a competitive advantage. Hence, managers of these SMEs should strategize by enhancing organization resources, such as tangibles and intangibles. Based on the RBV, organization resources of value, that are rare, difficult to substitute and inimitable, can be the main contributors of sustainable and organization competitor advantage [82,115,153]; those four attributes can be used for the creation and sustenance of organizational competitor advantage [143].

We arrive at the following:

Proposition pC39: Lack of financing provision, lack of initiatives, inadequate management, and lack of managerial education are some of the reasons why manufacturing SMEs fail to sustain a competitive advantage.

2.8.4. Strategic Management

Strategic management is a topic of interest among scholars and researchers alike who are interested in the determinant factors of organizational performance and competitor advantage [154]. Organizations benefiting from strategic management date back to the 1960s with its focus on organizations improving their internal strengths and minimizing their weaknesses in order to improve organization performance [155,156]. Strategic management assists mainly manufacturing SMEs' top management to analyze performances and competitor advantages across organizations [129,157].

We arrive at the following:

Proposition pC40: Strategic management assists top-level manufacturing SME managers to determine performance variations and competitiveness of their businesses by capitalizing on internal organizational strengths and minimizing weaknesses.

2.8.5. Business Relationships with the 4IR

Much of the discussion in Section 2.8 centered around aspects of business and management. The link with a manufacturing SME as a business follows directly, yet the relationship of the above business narratives with the 4IR might not be as evident, particularly the

discussion on intangibles and competitive advantage. Much of the effect of the 4IR on intangibles and the competitive advantage of a business will have to be researched during the time that the 4IR gains a foothold in the South African SME community. While there are qualitative and often intuitive frameworks for quality, namely, Quality 4.0, aspects around Competitive Advantage 4.0, or Intangibles 4.0 will have to be developed and are largely beyond the scope of this article. The section on future work touches on these aspects.

3. Materials and Methods

This section reports on the methodology used in this article as well as some of the underlying theories with respect to the application of the 4IR in manufacturing SMEs in the context of a developing economy.

3.1. Research Methodology

The research methodology follows Saunders et al.'s Research Onion [158] in Figure 1.

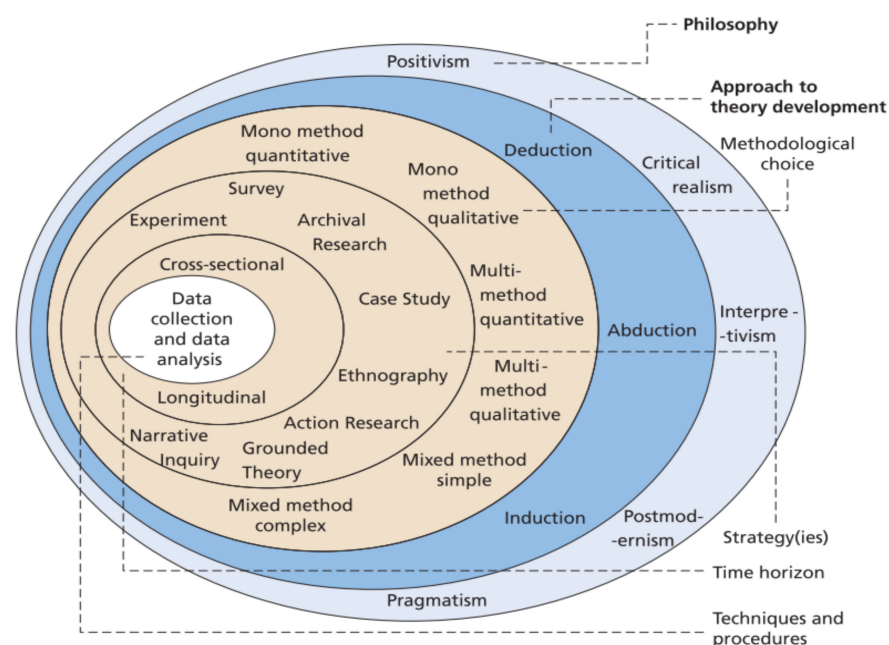


Figure 1. Saunders et al.'s Research Onion [158].

The outermost layer of the onion is the philosophy that has two major components, namely, epistemology, interpretivism, and ontology used in our work. Ontology is a systematic philosophy, analyzing the development of a conceptual framework for solving manufacturing SMEs' challenges by using the 4IR technologies in South Africa, coupled with business considerations discussed in Section 2.8. The propositions defined in Section 2 depict the instrument used in this research and are used to develop the framework in Section 4. Through interpretivism, we interpreted the 4IR, SME, and business theory literature qualitatively. Moving towards the inner layers, our research approach is inductive, starting at specifics in the literature and working towards a conceptual framework, hence, the strategy of a comprehensive literature review. We also have a small deductive component in that we conduct a theoretical validation of the framework in Section 5.

At the third layer from the outside, a qualitative research choice is followed through a rigorous analysis of the available literature, which included scholarly material. As future work, a qualitative survey among stakeholders in manufacturing SMEs to validate the conceptual framework will be conducted. The strategy followed as per the fourth layer is that of a survey as well as pseudo case studies. As indicated, we surveyed the extant literature on aspects of the 4IR, SMEs, and business theories (refer to Section 2.8). We further analyzed various writings on the 4IR and SMEs around cases as presented in

the scholarly literature. The time horizon as per the onion is cross-sectional since the research is undertaken over a shorter period than normally associated with longitudinal research. Following the innermost layer of the onion, the techniques and procedures of data collection and analysis are through scholarly literature in Section 2 of this article. As future work, data will be collected from stakeholders in South African SMEs, aimed at validating the conceptual framework in Section 4.

3.2. Theories Considered for This Study

The Agency theory, Resource-Based View (RBV) theory, and models for Public-Private Partnership (PPP) are used. The Agency theory [159] addresses the problems that occur in organizations owing to the separation of owners and managers. It emphasizes the reduction of the problem assisting in implementing the various governance mechanisms to control the agents' action in the jointly held organizations; The Resource-Based View (RBV) theory draws upon the resources and capabilities that reside within an organization to develop sustainable competitive advantages [160]. The RBV analyses and interprets the internal resources of the organizations and emphasizes resources and capabilities in formulating a strategy to achieve sustainable competitive advantages. The global initiative to create the internet for all is supported by the World Economic Forum, which intends to develop models for public-private partnership (PPP) to fast-track internet access and adoption in the sub-Saharan region, targeting approximately 75 million Africans within the short-term [7,61]. According to Schwab [1], low internet penetration has affected Africa's capacity to participate in economic digitalization. Schwab [1] further states that WEF initiated the Africa strategic infrastructure initiative in 2015 in partnership with the Boston Consulting Group (BCG) to attract private investment into public infrastructure development and develop appropriate projects to attract private financing and assist Africa to develop its poor infrastructure.

RBV considerations have been incorporated into the conceptual framework in Figure 2.

4. Results

Our framework synthesized from the propositions defined in the literature is presented in Figure 2. The framework centers around the 4IR, SMEs, and aspects related to business and meets our research objective in Section 1.5.

In addition to the numerous *content* propositions ($pCi, i \in \{1, 2, \dots, 40\}$) in the entities (essentially the cells) in the tables, we identified a number of implicit primary associations among the Figure 2 entities as indicated by the connecting lines. Secondary associations are indicated by the *italicized* entries in the framework. Such entries occur in more than one entity in the framework, indicating the interconnectedness of SME aspects, or any application area for that matter in the 4IR.

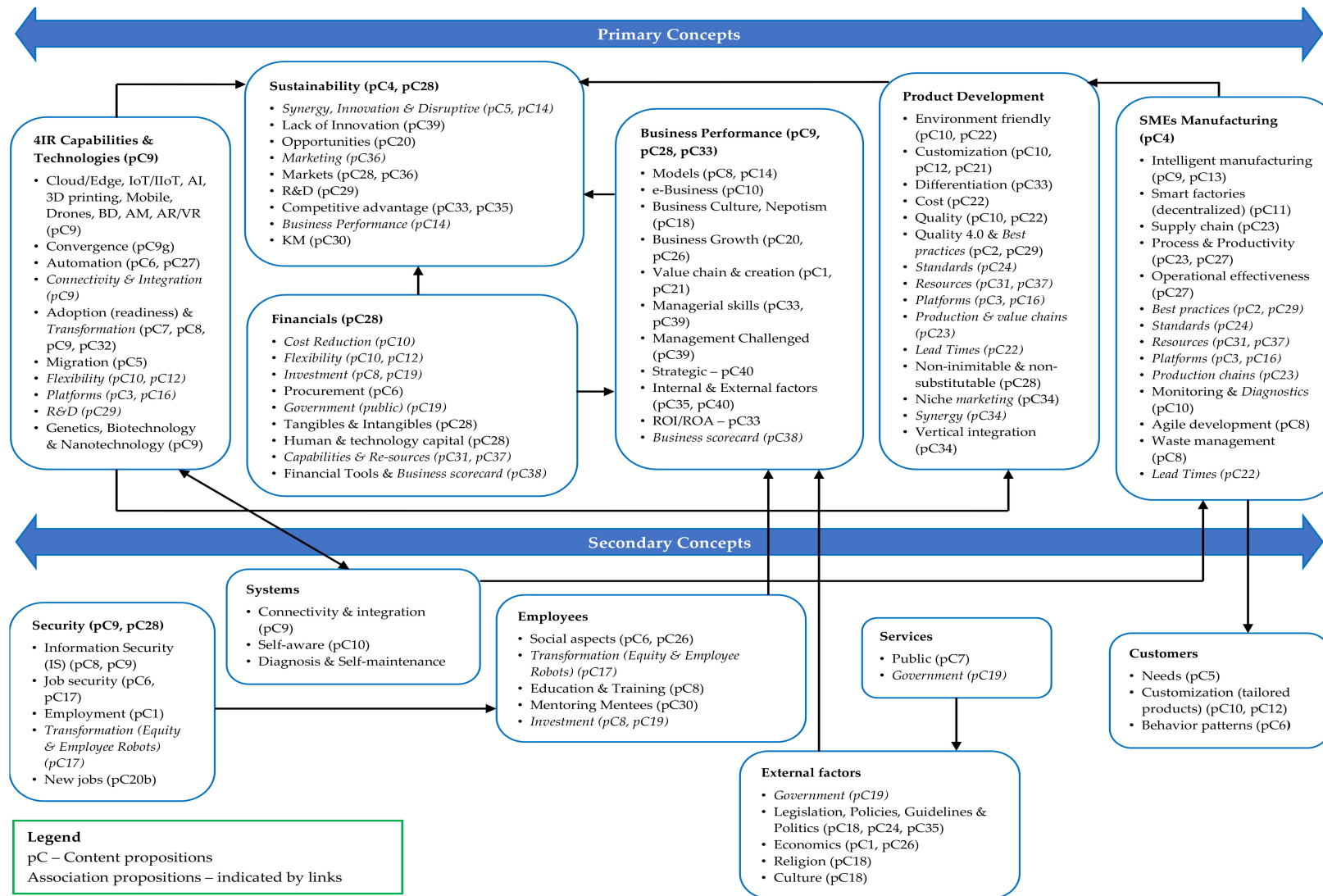


Figure 2. Conceptual SME-4IR Framework.

5. Validation of the Framework

Our framework is cognizant of the large number of propositions synthesized from the literature review in Section 2. As observed in the literature review, numerous content propositions embody intermediate forms, for example, proposition pC28 that has versions pC28a – pC28f, i.e., six amendments to the first definition pC28a. The framework is defined as primary entities, namely, Sustainability, SME Manufacturing, Product Development, 4IR, Business Performance, and Financials in Figure 2. These have been decided upon, considering the strength of the number of attributes identified in the literature for each, as well as the qualitative interpretation (cf. our interpretive research philosophy in Section 3) of the importance of these. Intuitively, sustainability, SME manufacturing, and the 4IR are important (primary) concepts in the context of this article. The second part of the framework represented below the 2nd thick, double-arrow line in Figure 2 describes the secondary part of the framework. These entities are equally important, but the literature review yielded fewer results for these, compared to the primary entities.

As expected, the sustainability of an SME in the uncertain world of the 4IR, specifically for a developing economy, linked to having a competitive advantage takes center stage in Figure 2. The role of innovation linked to business performance as elicited in the literature has been recognized. Other important aspects in the tables, center around technology adoption, standards, policies (illustrating the enabling role of government), numerous 4IR aspects, the well-being of employees who might be replaced by 4IR robots, and of course customer needs and patterns. The enabling or prohibitive role of management of a 4IR SME is likewise emphasized.

6. Contributions of the Research

The study contributes to this growing literature and the body of knowledge in general by proposing a conceptual framework to address the impact of the 4IR technologies on manufacturing SMEs to gain a competitive advantage and sustainable business performance. Such a framework is anticipated to benefit academics, researchers, and students in the area of ICT. It should also make a practical contribution to manufacturing SMEs by recommending strategies to use 4IR technology for sustainable competitive advantage and business performance.

7. Conclusions and Future Work

In this article, we conducted a comprehensive literature review on aspects around small and medium enterprises (SMEs), keeping in mind their important role in a developing economy. Aspects considered were their needs and challenges experienced compared to larger organizations with established infrastructures and large financial backing. The review was undertaken in conjunction with the vast literature on the fourth industrial revolution (4IR). Components of the 4IR were unpacked and we gave cognizance of how these new technologies may benefit SMEs given their limited resources. Aspects around the business concerning competitive advantage, assets, the role of management, and so forth were investigated. On the strength of the literature review numerous content propositions were defined, some of these embodying consecutive versions. Under the guidance of the propositions, we synthesized a conceptual framework in the form of Figure 2 divided into two parts, i.e., a primary part that includes primary concepts or entities, again guided by the propositions, and a secondary part that embodies fewer attributes of the entities therein. Owing to the sheer size and complexity of the 4IR, numerous cross-links among the entities and attributes of the entities emerged. The primary associations are indicated by the solid lines among the entities and the secondary associations are indicated through italicized entries.

Future work in this area may be pursued along several avenues. The Figure 2 framework is conceptual. Consequently, it must be taken through the usual validation steps (in addition to the theoretical validation in Section 5). Qualitative surveys among SME stakeholders who are keen to embark on 4IR technologies in their businesses can be undertaken.

It is anticipated that this exercise will confirm many of the aspects in the framework and additional items might be added. It would also be advantageous to spend time with a couple of SME owners in their businesses over a week or a month following a case study approach as a research strategy, as indicated in Section 3. On a more theoretical front, numerous concepts are bound to be redefined in the 4IR. While there are intuitive 4IR frameworks, e.g., Quality 4.0, aspects around Competitive Advantage 4.0, or Intangibles 4.0 will have to be further investigated in the context of SMEs in a developing economy.

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