SMME Readiness Framework for Smart Manufacturing Adoption in South Africa

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Introduction

Background of Study

Smart Manufacturing (SM) is a Fourth Industrial Revolution (4IR) paradigm for transitioning manufacturing firms from traditional legacy manufacturing to Digital manufacturing (Gumbi and Twinomurinzi, 2020).

SM is conceptualized as a fully integrated, collaborative and automated manufacturing system enabled by the convergence and integration of advanced DT (Cloud Computing, Cyber-Physical Systems, Big Data, Internet of Things, Smart Sensor and AI 2.0).

Figure 1: Smart Manufacturing Concept

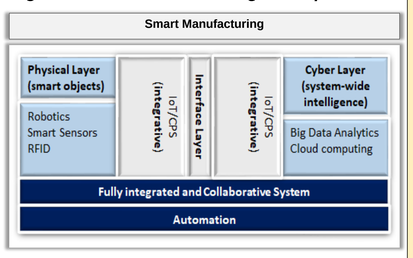


Figure 2: Smart Manufacturing Concept

SM is a key enabler for optimizations of manufacturing supply and value chains, business model innovations such as servitization, mass customization, customer participation, and flexibility in the manufacturing processes (Davis et al., 2012; Thoben, Wiesner and Wuest, 2017a; Yin, Stecke and Li, 2017).

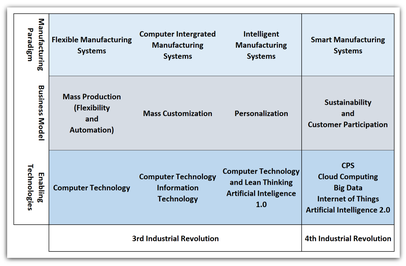
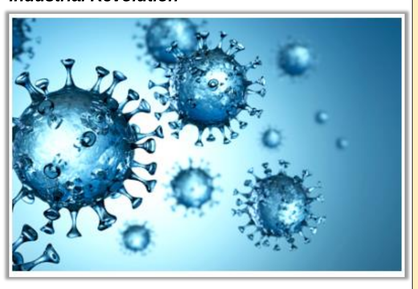


Figure 3: Smart Manufacturing in the Fourth Industrial Revolution

COVID-19 is disrupting various firm activities, is threatening to obliterate manufacturing firms in particular Small, Medium and Micro Enterprises (SMMEs) globally (Tairas, 2020) and is severely limiting traditional manufacturing businesses (Bragazzi, 2020; Priyono, Moin and Putri, 2020; Tairas, 2020).



The advent of **COVID-19** and the dawn of **4IR (SM)** are now a very compelling motivation for manufacturing firms to digitally transform to remain sustainable and viable in the current business environment (Priyono, Moin and Putri, 2020). However, only a small group of high tech large multinational corporations are adopting SM (Mittal, Khan, Romero, et al., 2019).

SMMEs are struggling and lagging behind in readiness for SM adoption (Jun et al., 2017; Mittal et al., 2017; Ramakrishna, Chen Khong and Leong, 2017; Mittal, Romero and Wuest, 2018).

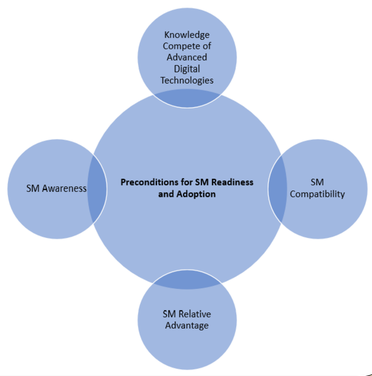
Problem Statement

The performance of the manufacturing sector in the past 2-3 decades has been poor and rapidly declining (Madonsela, Mbecke and Mbohwa, 2013; Black, Craig and Dunne, 2017; Kuhn, 2017) as a result of increasing *operational costs* and *declining productivity*.

SM is a solution to address the problem of increasing operational costs and declining productivity. However, SA Manufacturing SMMEs are not ready for SM due to context specific preconditions (Seseni and Mbohwa, 2018; Mbuyane, 2020)

- Lack of knowledge competence of advanced Digital Technologies (DT)
- Lack of awareness of SM
- SMME incompatibility to SM
- SMME lack of know-how in perceiving the relative advantage of SM for SMME specific context

Figure 4: SMME Smart Manufacturing Preconditions



Existing Frameworks are not suitable for SMME Readiness for SM adoption

- They do not address the aforementioned systemic SMME context specific preconditions (Mittal et al., 2018; Gumbi and Twinomurinzi, 2020)
- They assume SMMEs are at the same starting point as the large high tech firms

Research Objectives

Table 1: Research Questions and Objectives

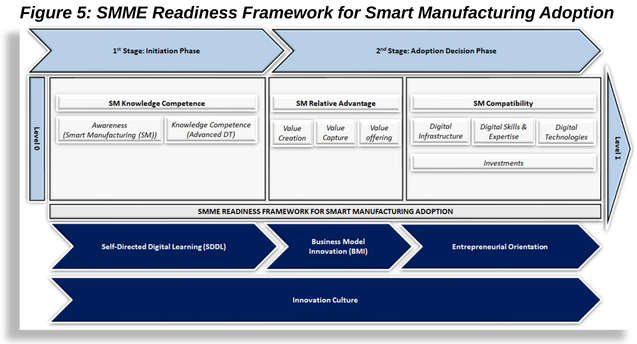
PRIMARY RQ: *HOW CAN SOUTH AFRICAN MANUFACTURING SMMES ADOPT SMART MANUFACTURING?*	PRIMARY RO: *DEVELOP AND EMPIRICALLY TEST AN SMME READINESS FRAMEWORK FOR SMART MANUFACTURING ADOPTION*
Secondary RQs	Secondary ROs
1. What is the level of manufacturing SMMEs Smart Manufacturing (SM) knowledge competence (SM awareness and knowledge competence of advanced DT), and how can this knowledge competence be developed?	1. Determine the level of manufacturing SMMEs Smart Manufacturing (SM) knowledge competence (SM awareness and knowledge competence of advanced DT), and what influences the development of smart manufacturing knowledge competence (awareness and advance DT) for manufacturing SMMEs
2. What are the benefits (relative advantage) of Smart Manufacturing for manufacturing SMMEs, and how can these benefits be perceived by manufacturing SMMEs?	2. Identify the benefits (relative advantage) of smart manufacturing for manufacturing SMMEs, and what influences the perception of manufacturing SMMEs in the identification of smart manufacturing benefits (relative advantage)
3. Which technologies are seen as key to the concept of smart manufacturing in relation to SMMEs?	3. Determine key core technologies for smart manufacturing in relation to SMMEs?
4. What is the level of Smart Manufacturing incompatibility to manufacturing SMMEs, and how can manufacturing SMMEs be compatible with Smart Manufacturing?	4. Determine the level of smart manufacturing incompatibility with manufacturing SMMEs, and key factors influencing manufacturing SMMEs compatibility with smart manufacturing
5. What is the level of smart manufacturing readiness for adoption by SMMEs in the manufacturing sector?	5. Determine the level of smart manufacturing readiness for adoption by SMMEs in the manufacturing sector

Methods

Innovation Adoption Theory

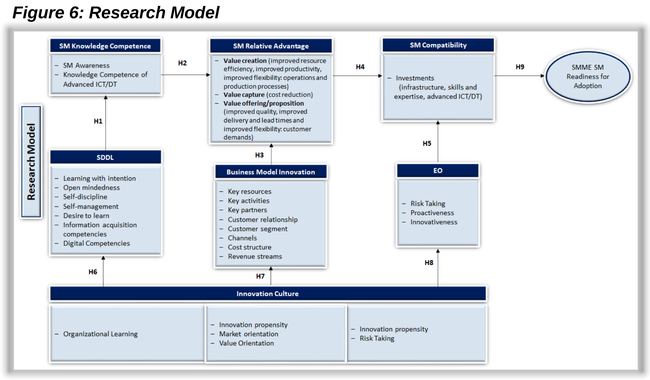
In this study, the Innovation Adoption Process Theory was used to develop the SMME Readiness Framework for SM Adoption (Nooteboom, 1994; Pichlak, 2015).

Figure 5: SMME Readiness Framework for Smart Manufacturing Adoption



A research model comprising of 7 constructs and 9 hypotheses has been developed to empirically test the framework.

Figure 6: Research Model



Research Design

- ❑ **Research Philosophy: Critical Realism**
  - Accepts the use of a scientific method (SMME Readiness Framework) approach to theory development based on some degree of objective reality;
  - While also allowing for context specific social structures and constructions (SMME Preconditions and Context) to emerge (Mcevoy and Richards, 2008; Modell, 2009; Saunders, Lewis and Thornhill, 2009; Maxwell and Mittapalli, 2010; Halcomb and Hickman, 2015)
- ❑ **Research Method: Mixed Method Research Design**
  - Two Phase Exploratory Research Design
- ❑ **Techniques and Procedures**
  - Interviews (semi-structured questionnaire) and an online survey (structured questionnaire) are used for this study
  - Structural Equation Modeling statistical technique is utilized for quantitative data analysis
  - Content analysis is utilized for qualitative data analysis

Figure 7: Research Methodology

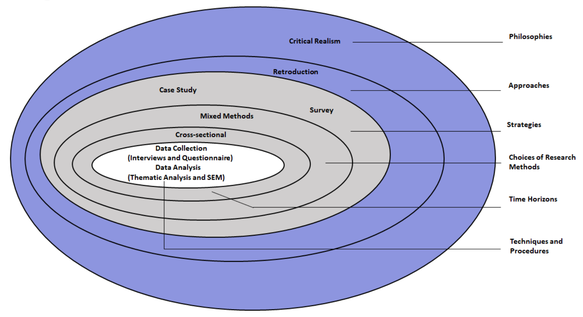
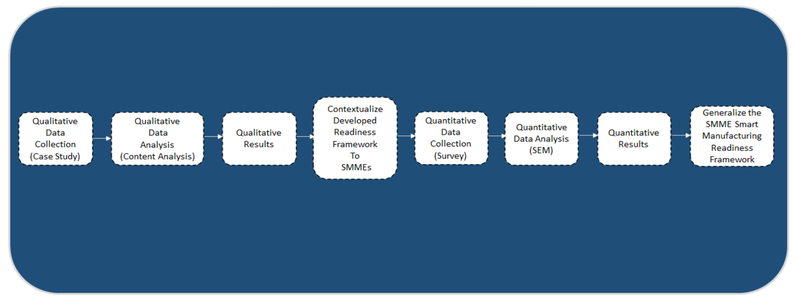


Figure 8: Two Phase Exploratory Mixed Method Research Design



Results

The author is currently collecting data through interviews to explore the research model's constructs and hypothesized relationships. The interviews are also assisting the authors in having a deeper understanding of the contextual factors and further unearthing new additional SMME context specific preconditions. Initial results support H1, H2, H3, H4, H6 and H7, however, the author is still in the initial stages of the data analysis process. The findings of the interviews will be used in phase 2 to refine the research model which will then be empirically tested using a quantitative survey.

Conclusions

SM has been identified as a 4IR viable solution to address the problem of manufacturing SMMEs increasing operational costs, declining productivity and unexpected pandemics such as COVID-19. However, SA Manufacturing SMMEs are not ready for SM due to context specific preconditions. Currently, there are no existing frameworks that are suitable for SA manufacturing SMME Readiness for SM adoption. As a result, an SMME readiness framework for manufacturing SMME SM adoption contextualized to the manufacturing sector preconditions in South Africa has been developed and proposed in this study. The objective of the framework is to support the digital transformation of the South African manufacturing sector, the national effort in the re-industrialization of the manufacturing sector and the development of South Africa specific SMME smart manufacturing national policies and strategies.

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