# Investigating the Applicability of 4IR technologies in the Foundry Industry – A South African case

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## Abstract

Adoption of Industry 4.0 unlocks new opportunities for the manufacturing industry. Smart factories, cyber physical systems, artificial intelligence, internet of things, cloud computing and big data constitute 4IR components that offer new possibilities relative to current technologies. It is important to determine which of these 4IR technologies are implementable in a specific industry/geographical setting. In this paper, we investigate applicability of the 4IR technologies and the consequent impact upon global competitiveness for the foundry industry in South Africa. We further evaluated through a survey, the degree of awareness of Industry 4.0 amongst decision makers in the same industry, as well as potential barriers to implementation. The results reveal the potential of 4IR to enhance global competitiveness for the South African foundry industry. Significant obstacles however exist.

## Keywords
Industry 4.0, foundry, technologies, and competitiveness

## 1. Introduction
Several studies have revealed that productivity is crucial for economic growth, wealth creation and innovation (Schwab 2017; WEF 2018). Various economies have realized accelerated growth and development through industrialization (WEF 2018). The main challenges confronting manufacturing industry today is advancing globalization, mass customization and emerging disruptive technologies (Porter and Heppelmann 2014). New technologies facilitate development of new production processes (Vanli et al. 2018). Technology has made new products and services possible.

The fourth industrial revolution (4IR), alternatively referred to as Industry 4.0 is progressively becoming a reality in various industries (Oztemel and Gursev 2018). 4IR is the modern trend of automation and data exchange in industries and is supported by modern digital technologies such as cyber physical systems (CPS), cloud computing, the internet of things (IoT), big data and artificial intelligence (Fatorachian and Kazemi 2018). Industry 4.0 enables smart factories and new manufacturing paradigms based on the adoption of new technologies (Robert et al. 2020). In addition, Industry 4.0 increases productivity and efficiency through smart and remote management (Felsberger et al. 2020). According to Oztemel and Gursev (2018), a smart factory constitutes an environment whereby production and logistics systems organize themselves without human interventions. Such facilities rely on Cyber Physical Systems (CPS) which links the physical and virtual worlds by communicating through an ICT infrastructure or IoT. According to Vanli et al. (2018), has the potential to effect complex transformation of the entire business. There are however significant challenges to overcome in the process of implementing 4IR (Schwab 2017). The more significant challenges include large capital investment, lack of skilled workers and IT security issues. Proper planning and preparation can assist to overcome these challenges (Skliton and Hovsepian, 2017). The transition remains complex (Hughes et al. 2020).

Foundries are factories that specialize in the production of metal castings. The adoption of Industry 4.0 in the foundry industry potentially gives rise to a smart foundry (Lewis 2016). According to Vanli et al. (2018) a smart foundry is an adaptable production system capable to produce small lot sizes with good quality and cost efficiency. Foundries have been slow in adopting Industry 4.0 (Vanli et al. 2018). The foundry industry in South Africa arguably employs traditional technologies. One of the challenge foundries are facing is managing change in order to remain competitive. The adoption of Industry 4.0 has the potential to address challenges the foundry industry is facing such as low productivity, rising operation costs, job losses, energy inefficiency, shortage of highly skilled workers and pollution. Vanli et al. (2018) suggests that the foundry future will depend on intelligent connectivity.

### 1.1 Objectives

The objectives of this study are:

- To identify Industry 4.0 technologies that potentially have positive impact on the foundry industry.
- To evaluate the level of awareness of Industry 4.0 technologies in foundries.
- To evaluate the willingness of foundries to embrace 4IR principles.
- To identify potential obstacles in implementing Industry 4.0.

## 2. Literature Review

Cyber physical system (CPS) is the merging of both virtual and physical worlds through the integration and networking of embedded system with the internet (Fatorachian and Kazemi 2018). According to Skilton and Hovsepian (2017) CPS have grown rapidly in the digital manufacturing and smart factory concepts within Industry 4.0. Such systems cooperate and interact with physical processes to add new abilities to the physical system (Skilton and Hovsepian 2017). Becker and Stern (2016) classified the current and future tasks that can be conducted by CPS instead of humans. Foehr, et al. (2017) provided a methodology for cyber physical automation system and components architecture for Industry 4.0.

Chui et al. (2010) stated that IoT uses networked sensors to remotely connect, track and manage products and systems. Skilton and Hovsepian (2017) found that IoT collects data and use decision making tools to provide actionable insight on the physical activity. Atzori et al. (2010) investigated IoT performance capability and concluded that IoT should be regarded as a section of overall internet of the future. Wang and Wen (2017) identified new trends about IoT applications and showed IoT system features.

According to WEF (2018) artificial intelligence is the development of machines that can be utilized to substitute for human thinking and increase tasks. The goal of AI is to develop machines that behave as though they were intelligent (Skilton and Hovsepian, 2017).

Oztemel and Gursev (2018) defined cloud computing as a system that accommodates all applications, programs and data in a virtual server. The cloud system gets rid of infrastructure complexity, extends work area, protects data, reduces costs and provides information any time (Hoffmann and Rush 2017). Hofmann and Rush (2017) claimed that the cloud system is a good source of solution to handle big data. The implementation of cloud computing in products and services enhances their capabilities (Dalenogare et al. 2018). Bellini, et al. (2017) conducted a cloud project that complies with Industry 4.0 standards and they proposed a knowledge processing engine capable of performing on cloud and handling big data. Chen (2018) studied a cloud system to support manufacturing activities.

Skilton and Hovsepian (2017) defined big data as the data that is difficult to manage, store and process using current technologies. Big data allows the huge volumes of data to be processed and analyzed collaboratively (Vanli et al. 2018). Hashem, et al. (2016) concluded that big data also enables employees to access relevant information about customers and production processes that has significant influence on performance.

## 3. Methods

The survey methodology was adopted to address objectives 2, 3 and 4. The approach affords the following advantages: (i) a high level of representativeness, (ii) standardized stimulus to all respondents and (iii) the research area is still new. The survey was exploratory in nature and close ended questions with a 4-point Likert scale ranging from strongly disagree to strongly agree was developed. To investigate anticipated Industry 4.0 benefits a mixed approach was used where both qualitative and quantitative information were collected. The mixed approach was chosen because Industry 4.0 is a complex topic which is being explored by both practitioners and researchers. The data collected from the respondents were loaded into excel for analysis. Semi structured interviews were arranged with senior managers. In total 5 structured interviews were held. To determine implementable 4IR technologies, benefits and barriers the following methodological approach was adopted. The current industrial revolution developmental stage of the SA foundry industry was determined. A literature review of 4IR implementation case studies applicable to the foundry industry on the global stage, and determination of current internet infrastructural development level in SA.

## 4. Data Collection

A questionnaire that involved closed ended questions with a 4-point Likert scale ranging from strongly disagree to strongly agree was developed. The questionnaire was emailed to participants. The sampling technique applied for the study was purposive sampling to collect qualitative data. A 61% response rate was achieved. The sample included a cross section of stakeholders in the foundry industry, ranging from senior managers, production supervisors and shop floor workers. The data was analyzed using excel.

## 5. Results and Discussion

### 5.1 Technologies

Figure 1 illustrates survey respondent perceptions on 4IR technologies that are potentially applicable to the foundry industry. Three technologies that were strongly recommended and considered extremely useful were flexible production systems, digital product service systems and integrated engineering systems. To achieve a flexible production system, foundries need to implement CPS and IoT. Flexibility enhances robustness and agility. Ninety-four percent of participants strongly agree/recommended that augmented reality and simulation will improve productivity in foundries, whilst 6% disagree.

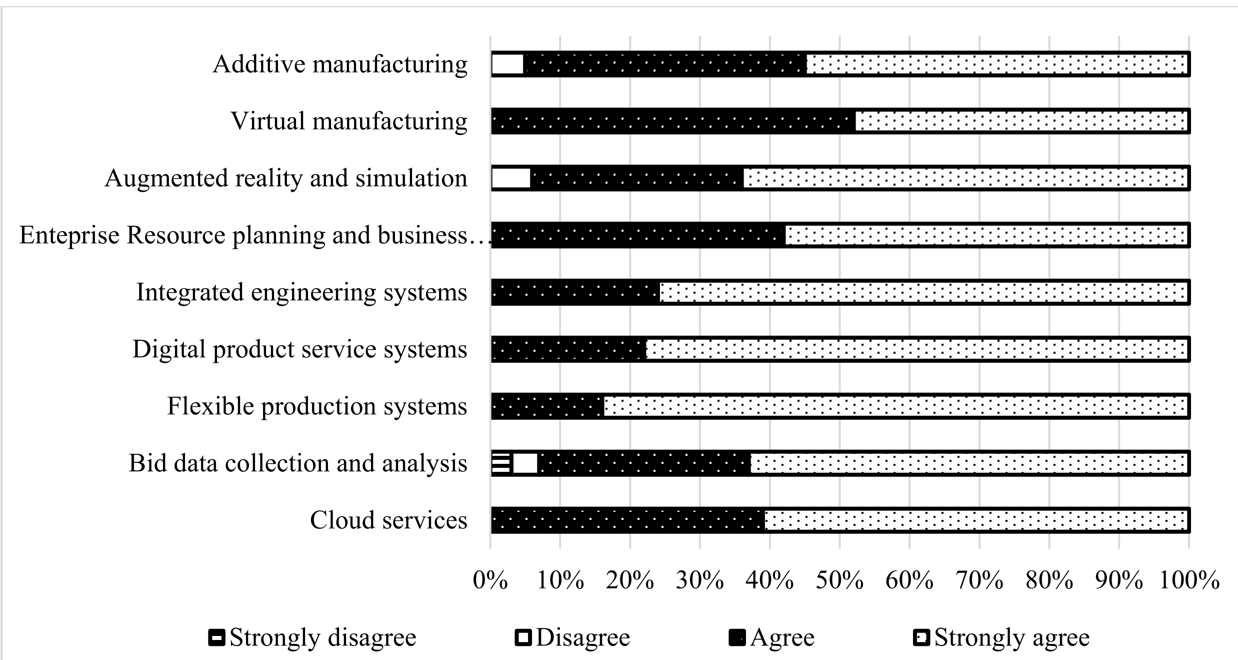


Figure 1. Industry 4.0 Technologies

### 5.2 Expected Product Benefits

Figure 2 illustrates respondent recommendations on the impact of 4IR implementation on quality and customer satisfaction related service elements inn industry. It is projected that 4IR would result in facilitated introduction of new/improved product customization, improved customer satisfaction and improved quality. Advantages of zero defects include  superior customer satisfaction, and reduced unit cost of production (Neef et al. 2018).

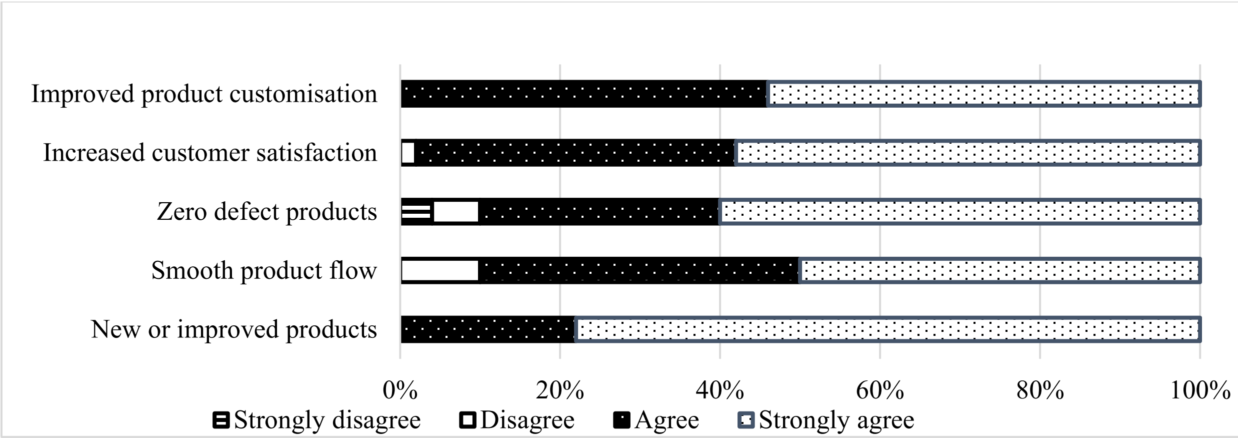


Figure 2. Expected product Benefits

### 5.3 Expected Operational Benefits

Figure 3 reflects respondent perceptions and recommendations regarding projected operational benefits associated with 4IR implementation. Higher productivity, optimized resource utilization, and improved plant efficiencies are projected benefits. Flexibility allows organizations to handle uncertainties and disruptions in the economic and technological environments.

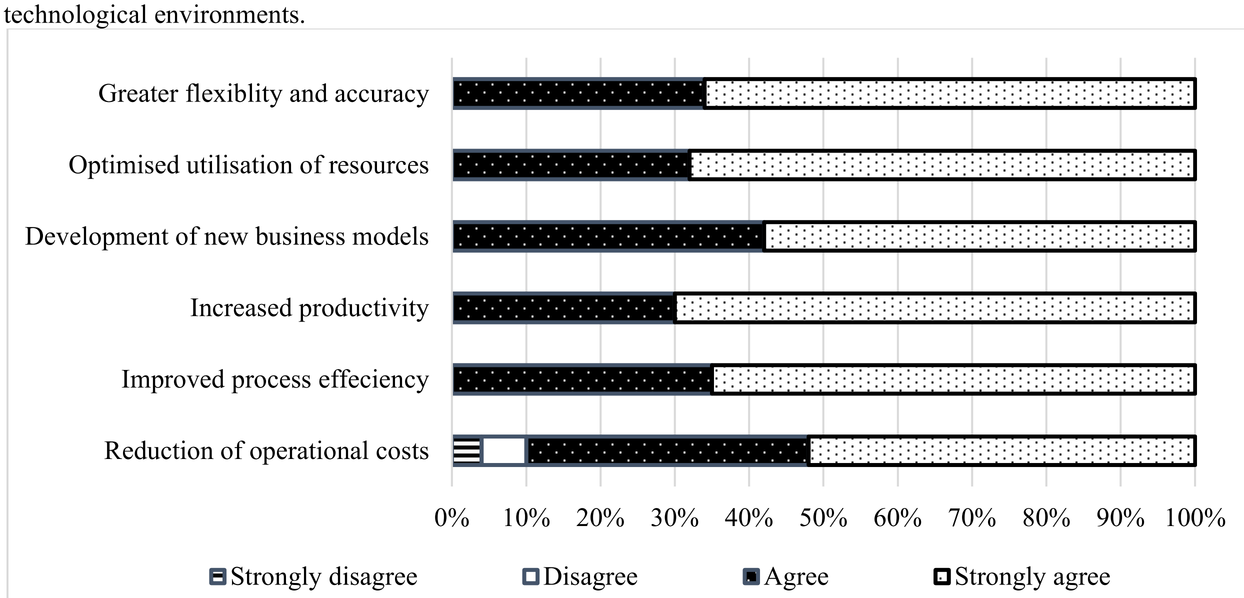


Figure 3. Expected operational Benefits

### 5.4 Organizational Barriers

Adopting Industry 4.0 can be subject to several barriers. Figure 4 summarizes industry recommendations on barriers to 4IR implementation. Appropriate skills and skilled worker deficiencies constitute significant barriers to 4IR implementation (Du Preez et al. 2006). Insufficient commitment by senior management and uncertainty regarding tangible benefits hamper support for industry 4.0 implementation.

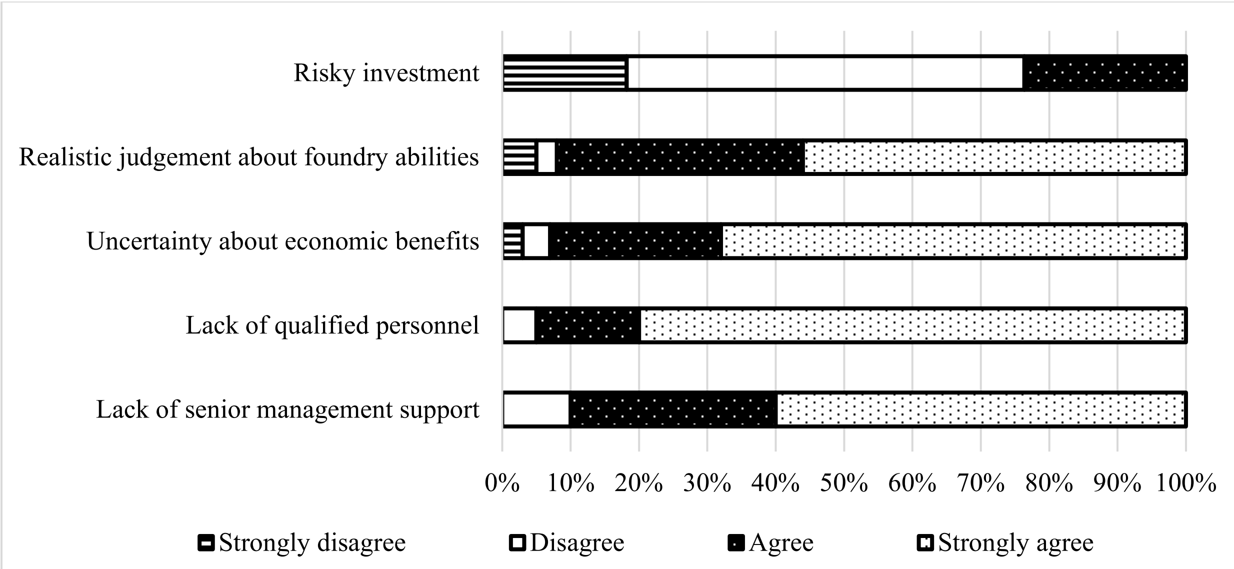


Figure 4. Organizational barriers

### 5.5 Technical Barriers

Figure 5 shows results of technical barriers. The study showed that different barriers prevail. The capital intensive nature of 4IR implementation programs consists a significant implementation barrier. The internet network infrastructure and cyber security platforms are relatively under-developed and constitutes an additional implantation barrier.

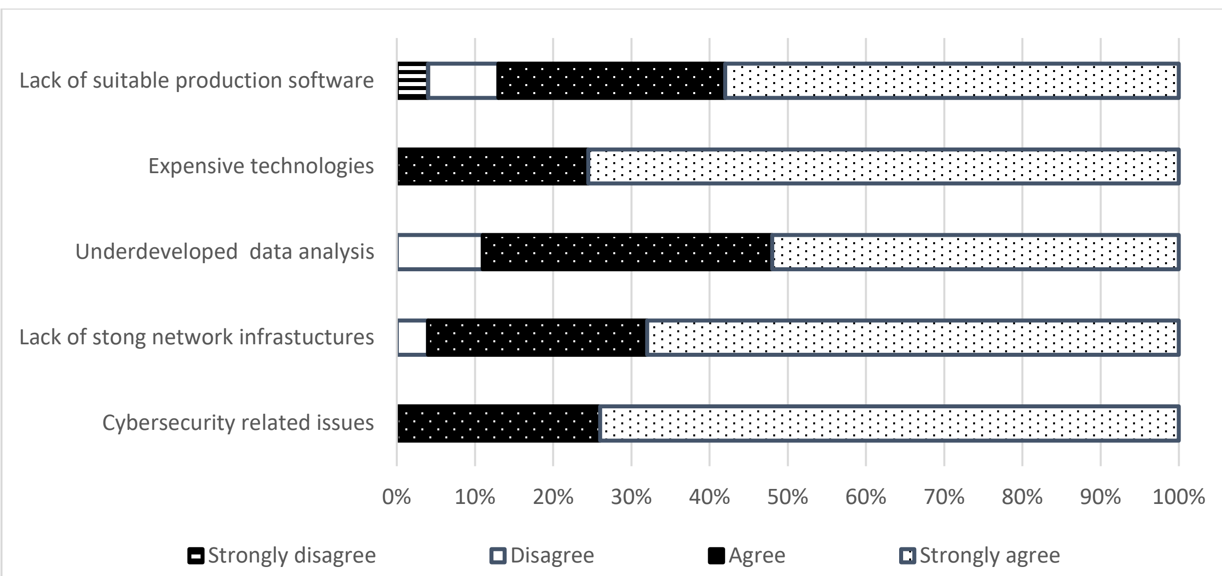


Figure 5. Technical barriers

### 5.6 Discussion

The adoption of new technologies is growing, and the foundry industry should make a deliberate effort to keep abreast with technology developments. AI is applicable in foundry process control and quality assurance. Foundry operations constitute many processes variables that influence the quality of the castings (Sata 2017). Accurate process control is critically important. AI is potentially useful in monitoring and control of casting properties.

CPS in the foundries optimizes the production process, reducing set up times, processing times, labor and material costs. Another important finding was that CPS and IoT can enable a highly flexible production system with small lot sizes. Machines and equipment in smart foundries can be monitored/controlled remotely through the cloud system. This provides remote access to data on the machine ad process inputs to the benefit of quality. Integrated ERP systems directly link suppliers and customers, automatically adjusting orders and production volumes in real time. CPS enables workers to access and optimize machine set up virtually allowing improved quality and reduction in machine set up times.

Augmented reality systems support additional provisions such as identifying product models on the production line and in warehouses as well as assigning equipment repair instructions through a mobile device. Smart foundries provide workers with real time information to enhance decision making and work procedures. Smart foundries can apply additive manufacturing such as 3D printing to prototype and manufacture components in small batches. Benefits of 3D printing include reduced production costs, shorter product development cycles and reduction of design errors.

## 6. Conclusion

Manufacturing companies including foundries encounter challenges in the process of implementing Industry 4.0 technologies. A different skills set is required to operationalize 4IR technologies. Companies need to invest in the training of the relevant skills. 4IR will assist companies improve product quality, improve cost efficiencies and enhance competiveness for foundries in SA. There are significant barriers to implementation of 4IR technologies, these are however surmountable.

Industry 4.0 assist foundries cope with flexibility requirements of the future. The working environment of the foundries is dangerous. Smart foundries will minimize human exposure to hazards such as extreme heat, dust, noise, vibrations and toxic fumes. Although it might take several years before smart foundries become widespread, it is crucial to work towards implementation of Industry 4.0 technologies.

Future studies could focus on proposing a framework for implementation of Industry 4.0 in SA foundries which will generate more insight to managers and investors.

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## Biography

**Yvonie N Mawane** is a PhD candidate in Industrial Engineering at the University of Johannesburg, South Africa. Her research areas are manufacturing, productivity, and quality management systems.