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Impediments of the Fourth Industrial Revolution in the South African Construction Industry

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Abstract. The fourth industrial revolution (4IR) is upon us with evidence of its usage in the manufacturing industry of most developed and some developing countries around the world. Evidence of the concept of 4IR is equally evolving within the construction industry of developed countries and immense benefits are promised. However, the story is not the same for most developing countries as their construction industries face diverse challenges that impede the adoption of new concepts. Based on this notion, this study assessed the impediments of 4IR within the South African construction industry (SACI) with a view to positioning the industry in the 4IR. The study revealed the key impediments of the adoption of the 4IR concepts within the SACI. In the end, conclusions were drawn and possible directions that will help the construction industry in delivering better services to its clients using 4IR concepts were proposed.

Keywords: Construction 4.0, Digital technologies, Digitalisation, Fourth Industrial Revolution, Industry 4.0

1 Introduction

Technological advancements are advancing at an alarming rate, thus constantly altering the way in which the society lives and functions. One of such advancement is the fourth industrial revolution (4IR). Although several features of the 4IR have been adopted by different industries, its complete adoption has been met with resistance due to the level of uncertainty it breeds in relation to the type of changes that the phenomenon will provide. Particularly, the construction industry is known to be reluctant in the adoption of various technological innovations, while other industries such as banking, manufacturing and retailing have been open to adopting advanced technologies to boost their competitive advantage [1, 2].

The phrase “fourth industrial revolution” inclines that chronologically there have been three other revolutions preceding it [3]. According to Lu [4], the late 18th century marked the beginning of the first industrial revolution, represented by mechanical production plants propelled by water and steam power. It was followed by the second revolution that was initiated in the early years of the 20th century. Its production was symbolised by mass labour fuelled by electrical energy. Thirdly, the development of computer technology gave rise to the third industrial revolution which massively affected all functions of society. Thus, the 4IR is viewed as a natural extension from the technological advances of the third revolution that have progressively evolved throughout the past years [5].

Some key features of the 4IR phenomenon which initiated the digital transformation process within most industries are the Internet of Things (IoT) which implies an overall system of networks which are linked to each other, and uniformly addressed objects that are conveyed by means of standard conventions. Furthermore, it is mentioned that IoT can also be seen as Internet of Everything (IoE) which consists of Internet of Service (IoS), Internet of Manufacturing Services (IoMs), Internet of People (IoP), an embedded system and Integration of Information and Communication Technology (IICT) [6]. Building Information Modelling (BIM) which according to Ashcraft [7] "utilises cutting-edge digital technology to establish a computable representation of all the physical and functional characteristics of a facility and its related project/life-cycle information, and it is intended to be a repository of information for the facility owner/operator to use and maintain throughout the life-cycle of a facility". Augmented reality, which is an innovation with which one can be able to have an amplified view of objects [8]. Big data which is viewed as the most vital technology in relation to the large collection, preparation, and investigation of unorganised and organised information with savvy algorithms [9]. Autonomous Robots used in performing autonomous production methods, cloud computing, 3D printing and many more.

Despite the availability of these technologies and the mouth-watering benefits they propose, 4IR implementation as far as the SACI is concerned is still in its early stages. Thus far, only a few concepts of the revolution have been adopted by the industry [10]. It is based on the above knowledge that this study assessed the impediments of the 4IR within the SACI with a view to positioning the industry in the 4IR. Subsequent parts of this paper include the review of related literature, the methodology adopted for the study, the findings and discussion as well as the conclusion drawn from the findings and the recommendations made thereof.

2 Literature Review

The construction industry plays a crucial role in the economy of South Africa by providing more than one million jobs and generating revenue of approximately R267bn annually [8]. However, it has been observed that construction activities cause an impact on the environment through the process of construction and life cycle of development. These impacts start from the initial work on site, through the actual construction, operational or usage period and to the final demolition or re-use [5, 9]. According to Li and Zhang [10], the construction industry is responsible for the use of a very high volume of natural resources and the generation of a great amount of pollution. This is as a result of energy consumption during extraction, preparation, transportation, and usage of raw materials. The adoption of 4IT concepts offers possible solutions to some of these problems. However, its adoption is faced with several barriers that need to be addressed.

According to Vaduva-Sahhanoglu *et al* [11], the main barriers to the adoption of 4IR technologies include high cost of research and development (R&D) innovation, technology cost updates to the latest state of art, cost of training employees, incompatibilities with current practices and operations, challenges in finding the technologies needed, and psychological barriers referring the acceptance of the new technologies. Oke *et al* [12] also noted that the lack of training for professionals and skilled labour in using the digital tools at the institutional level as well as its high cost affects the construction industry in adapting 4IR concepts.

Moreover, according to Deloitte [13], one of the challenges of the 4IR is the right talent required. It was stated that numerous South African manufacturers will face a significant challenge in talent when restructuring their organisation for the digital change in the adoption of the 4IR. Diversity in IT skill sets as improved skills blend and the changeover of skills are required. A huge challenge for South Africa is not only with the shortage of talent in the country, but there is also a shortage worldwide in professionals with the talent for the 4IR. There is a need to train professionals, that will in turn train workers within construction organisations to be able to understand and work with the new and smart technological innovations. Furthermore, Oke *et al* [12] mentioned that the adoption of standards also affects the application of 4IR concepts in the SACI. According to the Deloitte [13], another challenge of the 4IR is the availability of IT infrastructure needed. It was observed that the costs needed for the implementation of the 4IR are key factors in determining the upgrade of current IT infrastructure system or getting new ones. Also, electricity limitations contribute to being a hindrance for the digital change towards the 4IR. Overall, new investments in infrastructure and new technological innovations are required for more prominent improvement and adoption of 4IR applications. PwC [14] share similar views as it was reported that there is a lack of digital culture with construction organisations. It stated that companies have to ensure that employees understand dynamic changes in the company and participate in these changes. These identified challenges and others were assessed in this study in a bid to determine the key impediments of 4IR in the SACI.

3 Research Methodology

This study assessed the impediments of 4IR within the SACI using a survey approach with quantitative data harnessed from construction professionals in Gauteng province. The choice of conducting the study in the selected study area is based on the premise that Gauteng houses the majority of construction organisations in the country with a high number of construction professionals available within the province. The instrument for data analysis was a questionnaire which was adopted based on its ease of use and ability to cover a large range of respondents within a short period of time [15]. The questionnaire used was designed in two sections with the first designed to harness information on the background of the respondents. The second section sought answers with regards to the impediments of 4IR within the study area using a 5 point Likert scale. A total of 60 construction professionals participated in the survey. In analysing the data gathered, information on the respondent's background was analysed using percentage. Mean item score was used to rank in descending order, the identified impediments based on their level of significance. Based on the different professional background of the respondents, Kruskal-Wallis h-test was further employed in testing the significant difference in the view of the different professionals. Kruskal-Wallis h-test was adopted based on its suitability in ascertaining the significant difference in the view of three or more group of respondents. The reliability of the questionnaire was also tested using Cronbach's alpha test. Cronbach alpha gives a range of value of between 0 and 1, and the higher the value, the higher the degree of internal consistency. The Cronbach's alpha value of 0.835 was derived which shows a high degree of reliability since the degree of reliability of an instrument is more perfect as the value tends towards 1 [16]

4 Findings and Discussions

4.1 Background information

Findings on the background information of the respondents revealed that 55% of the construction professionals involved in the study were male while 45% were female. Also, 50% of the respondents were Quantity surveyors, 18% were Construction managers, 24% were Engineers, and 8% were Architects. In terms of their academic qualification, 42% had a National Diploma, 33% had a Bachelor degree, 20% had an Honours' degree, 3% had a Master's degree, and 2% had a Doctorate. Majority of the respondents (55%) have up to 5 years working experience within the construction industry while the remaining 45% have above 5 years of working experience. Most of them (52%) work within a contracting firm, while 42% works for consulting firms, and 7% were government employees.

4.2 Impediments of 4IR in the South African Construction Industry

The result in Table 1 shows the construction professionals rating of the identified impediments of 4IR within the SACI based on their level of significance. The table also shows the chi-square value and the significant p-value derived from Kruskal-Wallis h-test conducted. A cursory look at the last column on the table shows that all the assessed impediments have a significant p-value of above 0.05. This implies that at 95% confidence level, there is no significant difference in the view of the various construction professionals as regards the significance of the assessed impediments of the adoption of 4IR concepts in the SACI. A look at the table also shows that all the assessed impediments have a mean value of above average of 3.0 aside electricity limitations that gave a mean value of 2.93. This shows that to a significant level all these 14 identified impediments affect the adoption of 4IR concept within the SACI. Chief of these impediments are lack of training for professionals (*mean=3.90, sig.=0.291*), high costs of training employees (*mean=3.82, sig.=0.256*), high costs of acquiring innovations (*mean=3.72, sig.=0.443*), lack of digital culture within the industry (*mean=3.68, sig.=0.646*), psychological barriers referring the acceptance of the new technologies (*mean=3.58, sig.=0.222*), and companies internal issues such as organisational culture and leadership style (*mean=3.50, sig.=0.179*).

It is no gainsaying that with innovations/new invention comes the need for trained professionals to handle same. Aghimien *et al.* [17] have earlier noted that a major challenge most construction organisations are likely to face with the adoption of new technologies is the issue of technical expertise. Embracing 4IR concepts and technologies comes with the training of personnel to handle these technologies. Oke *et al* [12] while assessing the challenges facing digital collaboration within the SACI made a similar observation. This need for trained personnel is not without its associated cost, which is coupled with the high cost of acquiring or adopting the technologies/features. Considering the fact that the SACI is saturated with small and medium enterprises that struggle with financial issues [17], this associated cost of adopting 4IR concepts might prove to be a significant impediment to the adoption of these concepts and technologies. Dimick [18], El-Mashaleh [19], and Oladapo [20] all made a similar observation regarding the huge influence of cost issue on the adoption of technologies and innovations in Canada, Jordan, and Nigeria respectively. Vaduva-Sahhanoglu *et al.* [11] also submitted that high cost of R&D innovation, cost of acquiring technologies, the cost for training employees in using these technologies, as well as costs associated with modifying of the construction operations are key barriers to the adoption of 4IR concepts in most countries around the world.

Issues surrounding the construction industry's fear of adopting new ideas have been noted in the past [17; 21]. Due to the nature of construction industries in most developing countries regarding the poor adoption of technology, embracing 4IR concept might be a problem for most construction participants. This can be because of the fear of changing from the norm or even the fear of the unknown outcome these concepts and features might bring. Dimick [17] noted that there is some level of distrust in new technologies among organisations. Change is challenging for humans, and in most cases, organisations tend to fall victim to this challenge. This resistance cuts across every level of these organisations, from workers to executive decision-makers. Thu, this tends to affect the culture within the organisation as regards the adoption of technologies and innovative concepts as noted in this study.

Table 1. Impediments of 4IR in SACI

Impediments	Mean	Rank	Kruskal-Wallis Chi-Sq.	Sig.
Lack of training for professionals	3.90	1	4.960	0.291
High costs of training employees	3.82	2	5.321	0.256
High costs of acquiring innovations	3.72	3	3.733	0.443
Lack of digital culture within the industry	3.68	4	2.491	0.646
Psychological barriers referring to the acceptance of the new technologies	3.58	5	5.704	0.222
Companies internal issues	3.50	6	6.281	0.179
Interoperability of systems	3.47	7	4.653	0.325
Incompatibilities with current practices and operations	3.45	8	6.588	0.159

Requires restructuring with organizations	3.42	9	4.017	0.404
Lack of standard in delivering the industry's products	3.40	10	2.371	0.668
Challenges in finding the technologies needed	3.33	11	1.873	0.759
Security Issues	3.28	12	3.629	0.459
Lack of commitment from clients	3.17	13	5.895	0.207
Legal concerns	3.07	14	7.536	0.110
Electricity limitations	2.93	15	6.108	0.191

5 Conclusion and Recommendation

This study assessed the impediments of 4IR within the SACI with quantitative data gathered from construction professionals in Gauteng province. Based on the analyses of the data gathered, the study concludes that there is no significant difference in the view of construction professionals within the study area regarding the impediments of 4IR adoption within the construction industry. The major impediments observed are lack of training for professionals, high costs of training employees, high costs of acquiring innovations, lack of digital culture within the industry, psychological barriers referring the acceptance of the new technologies, and companies' internal issues such as organisational culture and leadership style. Therefore, if the SACI is to enjoy the inherent benefits of the 4IR, then construction organisations must be ready to invest in technologies and innovations by acquiring these new technologies as well as training their workers in the use of it. Also, the teaching of some of these technologies can be inculcated into curriculums of institutes of higher learning so as to equip construction graduates right from the institution level. Similarly, construction participants must be ready to jettison the old ways of providing construction services for a more innovative approach with 4IR concepts.

Although this study contributes to the body of knowledge by bringing to light some impediments of 4IR within the SACI, care must be taken in generalising the result of the study due to some identified limitations. The study was limited to a single province within the country, thus, there is a need for further studies within other provinces in the country, in order to compare results. There is also the need for further studies conducted with a much larger sample size than what is obtained in this current study.

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