CONSTRUCTION INDUSTRY AND THE FOURTH INDUSTRIAL REVOLUTION: THE KEY IMPEDEMENTS IN DEVELOPING COUNTRIES

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Globally, the construction industry has a tradition of late technology adoption. This has been a significant challenge in optimal performance and productivity. The fourth industrial revolution has changed many sectors in recent times through the adoption of various emerging technologies. The construction industry is also tagging along in technological adoption in a bid to be more productive and smarter. However, little attention has been paid to the construction industry in developing countries. This study adopted a quantitative approach to articulating the key challenges to the implementation of the emerging technologies in the construction industry in developing countries. The study area adopted is Nigeria. Fifty-six structured questionnaires were administered to industry professionals through random sampling, and the data collected was analysed. The study findings revealed that the most critical impediments are classified under workforce, management and legislation. The study concluded with recommendations for overcoming the identified challenges and achieving construction industry 4.0.

Keywords: Construction 4.0, Barrier, Industry 4.0, 4IR.

1 INTRODUCTION

The fourth industrial revolution (4IR) is the current technological revolution changing the process and workflows of different sectors of the economy. Digital process transformation, intelligent sensors and systems, automation, digital twins, robotics, virtual reality and the internet of things, among other emerging technologies, characterise the fourth industrial revolution (Ejohwomu et al. 2021). These identified technologies in the 4IR are referred to as technological advances with a high impact on the current industrial landscape (Pereira and Romero 2017). The 4IR was introduced in Germany in 2011 (Lu 2017), and involves integrating processes (intelligent machines, physical objects and human actors) across organisational boundaries to achieve an integrated system and information sharing in real-time. Most firms, industries and countries are being transformed and rerouted to align with the tenets of the fourth industrial revolution.

The construction industry is not exempted from the 4IR inspired drive for technological adoption. Despite its reputation for the slow uptake of technology, the construction industry has been evaded in several ways by the fourth industrial revolution. Understandably this has been at different pace in terms of profession, project or geographical adoption. This unequal adoption rate is not peculiar to the construction industry. For instance, Vrchota and Pech (2019) designed an industry 4.0 index to assess the readiness of manufacturing firms to adopt Industry 4.0. The study
found that enterprises in the manufacturing sector were at different phases of adoption of industry 4.0.

Different efforts have been made to ensure the adoption and alignment with the I40 (Ryan et al. 2020, Gökalp and Martinez 2021). The ease or otherwise of adopting industry 4.0 is unique to industries and economies. Essentially, the context determines the ease of adoption. For instance, the building information modelling (BIM) adoption rate is not the same in developed and developing countries (Adekunle et al. 2021); the construction industry in developing countries has peculiar impediments that affect its adoption of emerging technologies. This study focuses on the key impediments to the adoption of industry 4.0 in the construction industry in developing countries.

2 INDUSTRY 4.0

Industry 4.0 is a very common topic today because of its massive transformation capabilities across sectors. It is fixated on generating "smart" and interconnected environment across processes and sectors. This will overcome the fragmentation associated with the construction industry (Nasrun et al. 2014), which has impacted the performance and productivity of the construction industry. Oesterreich and Teuteberg (2016) classified industry 4.0 technologies into simulation tools and modelling, smart factory and digitization and virtualization. The impact of these technologies across the project processes and its integration, according to Laitinen (1998) and Oesterreich and Teuteberg (2016) is a holistic end to end digital integration throughout the construction value chain.

Industry 4.0 impacts every aspect of the construction industry value chain. It also ensures an end to end integration across the value chain, thus breaking down the fragmentation inherent in the traditional construction industry value chain. This end to end integration also ensures real-time monitoring and information management, a characteristic of the 4IR. It impacts the construction industry vertically, horizontally and longitudinal across projects and professionals. The autonomous exchange of information is also a characteristic. Key features are standardization (organizations will effortlessly connect to one other), the management of intricate framework, an extensive infrastructure (high-quality data network), information protection, effective work organization and design (employees are more involved, productivity is better, continuous learning), regulatory system (harmonization of regulatory systems) and the effective resource use (sustainable use of raw material and energy). To harness these features, stakeholders in the industry must understand and be involved in adopting industry 4.0. In addition, stakeholders must understand how it impacts their roles in practical terms. The adoption and strategizing for adoption should be a constant exercise as industry 4.0 is constantly evolving and changing; Forcael et al. (2020) describe the geometrical progression in industry 4.0 as "rapid and intense".

Despite the various potentials of transforming the construction industry, especially in information management and enhancing productivity, there have been many barriers to achieving industry 4.0. These barriers are industry dependent. Integrating industry 4.0 into the construction industry has its peculiar barriers, which is connected to the peculiar nature of the construction industry. Furthermore, the barriers can also be geographical location dependent. Different countries have adopted different approaches to achieving industry 4.0 according to the geographical context. Tay et al. (2018) chronicled the various initiatives by the USA, Germany, France, UK, European Commission, South Korea, China, Singapore and Malaysia to achieve industry 4.0.

3 NIGERIAN CONSTRUCTION INDUSTRY AND 4IR

The construction industry is one of the major non-oil drivers of the Nigerian economy (AfDB 2012). Physical infrastructures are products of the construction industry, and the government has
been the main client of the construction industry for the construction of physical infrastructure. Over the years, various policy and reform agendas have focused on Nigeria's infrastructural development. For instance, critical to achieving vision 20: 2020 (Federal Government of Nigeria 2010), priority was placed on overcoming the shortcoming in the infrastructural network and rehabilitating the existing infrastructural stock. The Federal government is the primary financier and initiator of infrastructural projects in Nigeria through budget allocations. The construction industry is thus a priority and essential industry to the Nigerian economy.

Regarding implementing the industrial revolution and adopting technologies, Nigeria has been observed to be struggling. According to Inwalomhe (2018), Nigeria missed out of the first industrial revolution. Nigeria also missed out on the second, third, and is about to miss out on the fourth industrial revolution (Ajah and Chigozie-Okwum 2019). It is, therefore, not surprising that the country could not achieve its vision 20: 2020 as critical to achieving the milestone is the investment in technology adoption and ICT. Ajah and Chigozie-Okwum (2019) observed that for Nigeria to achieve industry 4.0, there will be increased use of AI and automation.

The construction industry is a critical sector of the Nigerian economy. Consequently, the Nigerian construction industry is required to be industry 4.0 compliant. Industry 4.0 has been touted as the ingredient for covid 19 recovery by the construction industry in Nigeria (Ebekozien and Aigbavboa 2021). As it stands, the sector is still struggling. It should be noted that the struggle is not peculiar to the Nigerian construction industry. For instance, Aghimien et al. (2019) identified the barriers to achieving industry 4.0 in the South African construction industry: lack of training for professionals, high cost of training professionals and acquiring technologies, and lack of digital culture within the construction industry. Others include psychological barriers and internal issues in companies. Similarly, to help the Nigerian construction industry be industry 4.0 compliant, this study aims to articulate the barriers and provide insight for stakeholders to overcome them.

4 RESEARCH METHODOLOGY

This research was carried out to assess the impediments to industry 4.0 in the Nigerian Construction Industry. A survey approach was adopted, and quantitative data were collected from construction professionals through random sampling in Lagos, Nigeria. The study area has been adopted severally in previous research studies due to its attributes as housing most of the organisations in Nigeria and a major commercial city in West Africa (Adekunle et al. 2019, Adekunle et al. 2020a). It thus provides a high pool of construction industry professionals required for the study. A structured questionnaire was administered to them containing close-ended questions. A total of 65 questionnaires were retrieved and analysed by the study. The questionnaire was divided into two sections; section A solicited the respondent background information, and section B solicited responses on the factors impeding the adoption of industry 4.0 in the Nigerian construction industry using 5 points Likert scale. Analysis was done using frequency and mean. Mean item score was adopted in ranking the barriers to 4IR adoption in the Nigerian construction industry.

5 DISCUSSION OF FINDINGS

5.1 Background Information

As presented in Table 1, the respondents of this study indicate that Quantity surveyors form the significant respondent base (60.7%), followed by Architects (12.5%). Other professionals who served as respondents are builders, civil engineers, mechanical and electrical engineers. The respondent base is well mixed and diverse. Thus, the respondents for the study are considered to be balanced and with the required professional background for the study. Respondents have between 0-10 years of working experience (75%), 12.5% have between 11-20 years of experience,
and the remaining 2.5% have above 20 years of working experience. Regarding their educational qualifications, respondents are mostly Bsc holders (71.4%) and MSc holders (19.6%).

Table 1. Respondent background information.

<table>
<thead>
<tr>
<th>Profession</th>
<th>percent</th>
<th>Qualification</th>
<th>percent</th>
<th>Experience(years)</th>
<th>percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Architect</td>
<td>12.5</td>
<td>PGD</td>
<td>1.8</td>
<td>0-10</td>
<td>75</td>
</tr>
<tr>
<td>Quantity Surveyor</td>
<td>60.7</td>
<td>HND</td>
<td>1.8</td>
<td>11-20</td>
<td>12.5</td>
</tr>
<tr>
<td>Builder</td>
<td>5.4</td>
<td>B.Sc.</td>
<td>71.4</td>
<td>21-30</td>
<td>12.5</td>
</tr>
<tr>
<td>Civil/Structural Engineer</td>
<td>5.4</td>
<td>M.Sc.</td>
<td>19.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M&amp;E Engineer</td>
<td>1.8</td>
<td>Ph.D.</td>
<td>3.6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Estate Surveyor</td>
<td>3.6</td>
<td>MBA</td>
<td>1.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Land Surveyor</td>
<td>3.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management</td>
<td>3.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IT professional</td>
<td>3.6</td>
<td></td>
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</tbody>
</table>

5.2 Impediments to the Adoption of Construction 4.0 in the Nigerian Construction Industry

The study adopted eleven factors that professionals in the Nigerian construction industry rated as impediments to 4IR according to their significance (based on the Likert scale provided: "extremely significant", "very significant", "significant", "slightly significant", and "not significant" on a scale of 1-5 respectively). The result is presented in Table 2. The study categorized the impediments under workforce, legislation and management. A critical look at the results shows that all factors achieved mean values above 3.00. This indicates that all identified impediments by the study are significant. The top five significant impediments to the adoption of construction 4.0 are the lack of qualified workforce, with a mean of 3.89, "they affect the financial resources" with a mean of 3.88, they affect standardization of the organizations (mean = 3.82), lack of understanding the interplay between technology and humans (3.79) and lack of employee readiness (3.79). The least significant impediment is "too few human resources (man power)" which has a mean of 3.43.

Table 2. Impediments of 4IR in the Nigerian construction industry.

<table>
<thead>
<tr>
<th>Impediments</th>
<th>Mean</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workforce: [Lack of qualified work force]</td>
<td>3.89</td>
<td>1</td>
</tr>
<tr>
<td>Management: [They affect the financial resources]</td>
<td>3.88</td>
<td>2</td>
</tr>
<tr>
<td>Legislation/Standard: [They affect the standardization of the organization]</td>
<td>3.82</td>
<td>3</td>
</tr>
<tr>
<td>Workforce: [Lack of understanding the interplay between technology and human]</td>
<td>3.79</td>
<td>4</td>
</tr>
<tr>
<td>Workforce: [Lack of employee readiness]</td>
<td>3.79</td>
<td>5</td>
</tr>
<tr>
<td>Workforce: [Lack of knowledge about Industry 4.0]</td>
<td>3.77</td>
<td>6</td>
</tr>
<tr>
<td>Workforce: [Requires continued education of employees]</td>
<td>3.73</td>
<td>7</td>
</tr>
<tr>
<td>Management: [Lack of understanding of the strategic importance of Industry 4.0]</td>
<td>3.64</td>
<td>8</td>
</tr>
<tr>
<td>Management: More focus on operation at the expense of developing the company (ambidexterity)</td>
<td>3.61</td>
<td>9</td>
</tr>
<tr>
<td>Management: [Lack of data protection (cyber security)]</td>
<td>3.57</td>
<td>10</td>
</tr>
<tr>
<td>Management: [Too few human resources (man power)]</td>
<td>3.43</td>
<td>11</td>
</tr>
</tbody>
</table>

Expertise is a significant factor in the adoption of new and emerging technologies. It has been observed that lack of technical know-how among professionals has been a critical factor, and its absence presents a vital impediment. Adekunle et al. (2020b) identified expertise as a critical factor in the adoption of technology in the construction industry while focusing on BIM. The absence of an industry 4.0 workforce affects the diffusion of industry 4.0 as the actor competence is an important factor. Another critical factor in the adoption of innovations is cost commitment.
Aghimien et al. (2019) identified cost as a critical impediment to the adoption of 4IR in the South African construction industry. Also, Stanley and Thurnell (2014) identified setup cost as a critical hurdle that must be overcome to achieve the adoption of new technology. Most stakeholders find it challenging to adopt innovations because of investment, maintenance, and operation costs. In addition, the cost of training employees is also a critical aspect for the adoption. Considering the fact that the study area is a developing country where most of the required infrastructure required for adoption are missing, it puts the stakeholders under more pressure in terms of the required financial resources. Mostafa et al. (2020) posit that a change in the business process to support innovation adoption is a critical impediment. Most stakeholders want to stick with the status quo; this is likely because they are afraid of change.

Regarding existing organisational culture and work process, many stakeholders are afraid to adopt innovations because of the fear of the disruptive nature of the technology on existing organisational culture and standardisation. The adoption of new innovations are mostly incompatible with existing industry standards. Exiting structures' non-alignment and incompatibility with new technology requirements is a critical barrier to new technology adoption (Stanley and Thurnell 2014, Mostafa et al. 2020). Consequently, the more the regulations in the construction industry remain the same (conforming to the traditional approach), the more difficult it will be to embrace industry 4.0 in the construction industry.

6 CONCLUSION AND RECOMMENDATION

The study examined the impediments to industry 4.0 in the construction industry. Quantitative data was collected from professionals in the construction industry. The data analyzed revealed that the impediments cuts across legislation, workforce and management—these three contained various impediments classified under them. The critical impediments identified under these three broad classifications are the lack of qualified workforce, they affect the financial resources, they affect standardization of the organizations, lack of understanding the interplay between technology and humans and lack of employee readiness. For the construction industry in Nigeria to achieve construction 4.0, there must be an intentional effort by stakeholders. Firstly, there must be an overcoming of the fear of change and the readiness to jettison the status quo. There must be a change in culture to align with the disruptive technologies. Secondly, there is a need to invest intentionally to adopt industry 4.0.- this should be perceived as value addition. Also, deliberate and planned investment strategies must be adopted by stakeholders. Additionally, a critical aspect that requires attention is training and making the workforce industry 4.0 competent. There must be training plans and paths for the construction industry workforce. Most times, this is dependent on the management. Hence the management of construction industry organizations must understand construction 4.0 and its benefits to their organizations. This is key as it determines mostly if they will support the adoption of industry 4.0 and achieve construction 4.0.

References

Adekunle, S. A., John, I., and Aigbavboa, C., Quantity Surveying Education for Sustainable Development:


