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Critical Success Factors for the diffusion of Artificial Intelligence in the Nigerian Construction Industry

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ABSTRACT

Adopting Artificial Intelligence (AI) in the construction industry can improve construction processes, enhance competitiveness and boost the overall performance of the industry. However, the use of AI in the construction industry particularly in developing countries such as Nigeria is limited. This study examined the critical success factors for the diffusion of AI in the Nigerian construction industry. The study adopted a quantitative research design with the use of questionnaire to elicit information from construction professionals in Lagos Island, Lagos, Nigeria. The study showed that institutional factors, behavioural factors and cost factors were the most critical success factors for the diffusion of AI in the Nigerian construction. Other factors included knowledge factors, infrastructure factors, technical factors and trust factors. The study offers some insights into the critical success factors for the diffusion of AI in a developing country such as Nigeria.

Keywords: 4th industrial revolution, Construction automation, Institutional theory, Project performance, Theory of planned behaviour

INTRODUCTION

Despite the significant potentials of the construction industry for social and economic development, its records of poor performance inhibit its growth capabilities. The literature is replete with reports of performance challenges including cost overruns, time overruns, poor quality work, material wastage and shortage of skilled labour in the industry. The uniqueness and inherent complexities of the construction industry make these challenges more daunting in comparison to other industries.

Artificial intelligence (AI) a core aspect of industry 4.0 can be used to solve most of the performance challenges encountered in work places. It is the adoption of machines to intelligently imitate human behaviour through the use of algorithms to solve complex day-to-day organizational problems (Salehi and Burgueño 2018; Adio-Moses, and Asaolu, 2016; Chen et al., 2012). AI has wide applicability and has been found to produce positive outcomes for social, environmental and economic sustainability (Vinuesa et al., 2020).

Specifically, AI can enhance the efficiency of construction processes (Afolabi et al., 2020), reduce waste (Pistorius, 2017) improve the planning, design, monitoring process and maintenance of construction facilities (Bharadwaj, 2018), predict project delay (Egwim et al., 2021), enhance the efficiency of construction logistics (Hsua, Angeloudis, and Aurisicchioa, 2018), improve site safety (Mohan, and Varghese, 2019), and predict property rates (Khobragade, Maheswari, and Sivagami (2018)).

Despite the significant benefits of AI for the performance and competitiveness of the industry, certain factors are crucial for its diffusion in the construction industry. Some notable works have highlighted these factors. For instance, Tjebane et al. (2022) evaluated the organizational factors that drive the successful adoption of AI in construction organisations in South Africa. Factors of innovative organisational culture, competence-based development, collaborative decision-making, and strategic analysis were found to be critical for the spread of AI in the South African Industry. Na et al. (2022) explored the factors necessary for the adoption of AI in construction firms and found that availability of AI-based technology, organisational support and culture were critical for the adoption of AI in the construction industry. Emmaminejad and Akhavian (2022) conducted a critical review of literature on trustworthiness as a significant factor for the adoption of AI in the architectural, engineering and construction industry. Louis and Dunston (2018) integrated IoT into operational workflows for real time automated decision making in repetitive construction works and noted that IT infrastructure such as internet connectivity and computing power are critical for successful adoption of AI in the construction industry. In their survey of systems and algoritms that reduce the technology gap in the construction industry, Blanco et al. (2018) noted that cost of AI technology is a critical consideration for the adoption of AI in the construction industry. Yampolskiy (2013) also made a case for ethical and regulatory issues connected with the use AI as critical for its successful adoption.

The potentials of artificial intelligence for the benefit of the construction industry cannot be overemphasized. Yet empirical evidence on critical success factors for the wide spread adoption of AI particularly in developing countries such as Nigeria remains limited.

Hence, this study attempts to fill this gap by assessing critical success factors necessary for the diffusion of AI in the Nigerian construction industry.

RESEARCH METHODS

The study adopted a quantitative research design with the use of structured questionnaires. The questionnaires were used to obtain information from construction professionals in Mainland Lagos, Nigeria. The study respondents comprised of architects, builders, engineers, estate surveyors, and quantity surveyors. The questionnaire was divided into two sections. The first section of the questionnaire contained questions on the background of the respondents while in the second section of the questionnaire respondents were required to indicate their agreement level on the factors critical for successful diffusion of artificial intelligence in the construction industry.

Table 1.

		Frequency	Percent
Gender	Male	40	75.5
	Female	13	24.5
	Total	53	100
Profession	Architect	12	22.64
	Builder	10	18.86
	Engineer	9	16.98
	Quantity Surveyor	15	28.32
	Estate/Facility Manager	7	13.2
	Total	53	100
Organisation	Consulting Firm	13	24.52
	Contracting Firm	22	41.5
	Client Organisation	12	22.65
	Government Agency	6	11.33
	Total	53	100
Management Level	Lower Level Management	4	7.5
	Middle Level Management	18	34
	Senior Level Management	21	39.6
	Executive Level Management	10	18.9
	Total	53	100

The questions in the second part of the questionnaire were based on a five-point Likert scale, of 1 - strongly disagree to 5 - strongly agree. Data obtained from the survey were analyzed using descriptive statistics of frequency, mean and standard deviation. In determining the critical success factors for the diffusion of AI in the Nigerian construction industry, a mean range, obtained from the mean analysis, was used for the categorization. The categorization is shown below:

$5.00 \geq x \geq 4.50$ = very critical
$4.49 \geq x \geq 3.50$ = critical
$3.49 \geq x \geq 3.00$ = slightly critical
$2.99 \geq x \geq 1.00$ = not critical

DISCUSSION OF FINDINGS

Profile of the Respondents

The Profiles of the respondents are presented in table 1. The respondents comprised of 75.50% males and 24.50 females. With regards to respondents' profession, 22.64% were architects, 18.86% were builders, 16.98% were engineers, 28.32% were quantity surveyors, while 13.2% were estate-/facility managers. Table 1 also shows that 24.52% worked with consulting firms, 41.50% worked with contracting firms, 22.65% worked with client organisations while 11.30% worked with government agencies. The table

further indicates that 7.5% of the respondents were lower level management staff, 34% were middle level management staff, 39.6% were senior level management staff while 18.9% were executive level management.

Critical Success Factors for the Diffusion of AI

The study assessed the critical success factors for the diffusion of AI in the Nigerian construction industry. From table 2, the three most critical success factors were support of professional association, belief that AI can improve construction performance significantly, and initial cost of purchasing AI tools and application with mean scores of 4.55, 4.54, and 4.51 respectively. These mean scores lie within 5.00 and 4.50 hence can be described as very critical success factors for the adoption of AI in the Nigerian construction industry.

These factors were also classified into institutional, behavioural and cost factors. As an institutional factor, support of professional association is very critical for the diffusion of AI in the construction industry. Although, most studies (Delgado et al., 2019; Adepoju and Aigbavboa, 2020; Bademosi and Issa, 2021; Na et al. 2022) noted the vital place of government for the adoption of digital technologies such as robotics, automated systems and AI, this study found support of professional association as very critical in the diffusion of AI in the Nigerian construction industry. Government and professional associations are institutions in a social system capable of exerting pressure on individuals or organisations to adhere to certain regulations. Greenwood et al. (2008) described institutions as social forces that shape people's behaviours and intentions to adopt a new practice. Through intentional and systematic initiatives such as capacity building workshops and policy recommendations to the government, professional associations can accelerate the diffusion of AI. Hence it has been identified as a very critical factor for the successful diffusion of AI in the Nigerian construction industry.

Regarding behavioural factors, belief that AI can improve construction performance significantly was also identified as a very critical factor for the diffusion of AI in the Nigerian construction industry. Hegemann (2015) and Lin et al., (2014) found that behavioral factors are critical for the diffusion of technology in the construction industry. The introduction of new practices affects individuals' perception and acceptance of the practice (Wu et al., 2017). The conviction that AI can outperform man and improve the performance of the industry is vital for its wide spread adoption. Hence, it is a very critical factor the successful diffusion of AI in the Nigerian construction industry.

Furthermore, cost factors such as initial cost of purchasing AI tools and application were found to be very critical for the diffusion of AI in the Nigerian construction industry. Oke et al. 2018 found cost to be one of the barriers to the adoption of digital technologies in the South African construction industry. Aghimen et al. 2020 also identified investment cost as a significant challenge to digitalization of construction organisations in South Africa. AI tools may be an additional cost burden to firms unless they are able to establish that the benefits derived from its application are worth the

Table 2. Critical success factors for the diffusion of AI.

Factor	Factor Category	Mean	Std. Deviation	Remark
Support of Professional Association	Institutional	4.55	0.765	Very critical
Belief that AI can improve construction performance significantly	Behavioural	4.54	0.542	Very critical
Initial cost of purchasing AI tools and applications	Cost	4.51	0.784	Very critical
High level computer literacy among project stakeholders	Knowledge	4.49	0.809	Critical
Cost of maintaining AI tools and applications	Cost	4.45	0.61	Critical
Knowledge of the benefits of AI in the construction industry	Knowledge	4.45	0.702	Critical
Constant power supply	Infrastructure	4.42	0.871	Critical
Personal interest in AI	Behavioural	4.41	0.537	Critical
Availability of skilled personnel to handle AI tools and applications	Technical	4.39	0.827	Critical
Management commitment	Institutional	4.38	0.667	Critical
Availability of reliable, affordable and fast Internet services	Infrastructure	4.37	0.799	Critical
Perception of the ease or difficulty in the use of AI tools and applications	Behavioural	4.36	0.827	Critical
Existence of an industry standard for the application of AI	Technical	4.31	0.895	Critical
Confidentially issues associated with AI tools and applications	Trust	4.30	0.814	Critical
High level of trust in AI tools and applications	Trust	4.29	0.782	Critical
Government legislation	Institutional	4.27	0.888	Critical
Reluctance to adopt AI	Behavioural	3.73	1.067	Critical

cost of installation. Hence, cost factors were identified as very critical for the diffusion of AI in the Nigerian construction industry.

Other factors identified as critical for the successful adoption of AI in the Nigerian construction industry include high level computer literacy among project stakeholders (knowledge factor), cost of maintaining AI tools and applications (cost factor), knowledge of the benefits of AI in the construction industry (knowledge factor) and constant power supply (infrastructure factors). These factors have mean scores of 4.49, 4.45, 4.45 and 4.42 respectively. All the factors identified were critical for the successful diffusion of AI in the Nigerian construction industry as mean scores lie between 5.00 and 3.50 (table 2).

CONCLUSION

This paper assessed the critical success factors for the diffusion of AI in the Nigerian construction industry. Institutional, behavioral and cost factors were found to be very critical for the successful adoption of AI in the Nigerian construction industry.

The findings have some implications for theory and practice particularly with regards to the adoption of AI in the construction industry. In terms of theory, the study shows the significance of institutional and behavioural factors in the diffusion of AI. Future studies can expand on factors affecting diffusion of AI in the construction industry from an institutional theory perspective, to assess the impact of other 'institutions' in the diffusion of AI. More studies on the theory of planned behaviour can also be carried out to improve understanding of how behavioural issues affect the diffusion of AI in the construction industry.

Practically, the Nigerian construction industry has to show that it beliefs in the potentials of AI to improve the competitiveness and performance of the industry through the provision of AI related capacity building workshop for its members. By this, the construction industry will be supporting the AI initiative. Also, the industry has to play an active role in ensuring that government policies favour accessibility and affordability of AI technologies.

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