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The Discussion should interpret the findings in view of the results obtained in this and in past studies on this topic.

State the conclusions in a few sentences at the end of the paper. The Results and Discussion sections can include sub-headings, and when appropriate, both sections can be combined.

The Acknowledgments of people, grants, funds, etc. should be brief.

Tables should be kept to a minimum and be designed to be as simple as possible. Tables are to be typed in double-spacing throughout, including headings and footnotes. Each table should be on a separate page, numbered consecutively in Arabic numerals and supplied with a heading and a legend. Tables should be self-explanatory without reference to the text. The details of the methods used in the experiments should preferably be described in the legend instead of in the text. The same data should not be presented in both table and graph form or repeated in the text.

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Examples:

Aigbavboa (2012), Aigbavboa et al. (2012), (Thwala, 2000), (Aigbavboa and Thwala, 2012), (Aigbavboa, 2008; Lesito, 2007a, b; Aigbavboa, 2010, 2011), (Thwala et al., 2001)

References should be listed at the end of the paper in alphabetical order. Articles in preparation or articles submitted for publication, unpublished observations, and personal communications should not be included in the reference list but should only be mentioned in the article text (e.g., A. Kingori, University of Nairobi, Kenya, personal communication). Journal names are abbreviated according to Chemical Abstracts. Authors are fully responsible for the accuracy of the references.

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Aigbavboa CO (2010). Residential satisfaction in low-income housing: a South Africa perspective. Journal of Construction Project Management and Innovation. 1(2): 14 – 20.

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Productivity improvement framework for South African construction SMEs

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ABSTRACT
Contractors' productivity holds strategic importance for both long-term micro and macroeconomic performance. A significant number of small and medium-sized enterprises (SMEs) in the construction sector in South Africa are characterised by poor performance, which can be attributed, in part, to low productivity rates. This scenario contributes to a pessimistic outlook for the South African construction industry and undermines its potential for job creation. This study aims to investigate the primary obstacles that hinder productivity within construction SMEs and proposes an improvement framework. The study employed a qualitative research approach, collecting data from registered SMEs in South Africa through semi-structured interviews. Qualitative content analysis was applied to analyse the research data. The key factors identified as undermining SMEs' productivity include challenges related to workers' skillsets, directors' competencies, government interference, and workers' remuneration. The implications of this research are valuable for SMEs, offering insights to expedite project delivery and thereby mitigating the risk of construction business failure. Previous studies have often focused on the overall performance of construction SMEs, with limited attention to their productivity. Moreover, productivity-focused studies tend to lack a strong SME-centered approach. This research bridges these gaps and introduces interventions that have the potential to enhance productivity in small and medium-sized construction organisations.

Keywords: Construction industry, contractors, labour productivity, project management, SMEs

1. INTRODUCTION
The construction management literature extensively documents the myriad challenges facing the construction sector, with issues related to low productivity taking center stage. Over the past four decades, South African construction has grappled with persistent low productivity challenges (Chingara and Moyo, 2014). The country's construction productivity has reached its nadir (Bierman et al., 2016), attributing its poor performance to a combination of extrinsic and intrinsic factors (Adebowale and Smallwood, 2020). This situation undermines both the sector's contribution to the economy and the welfare of South African citizens. Current South African productivity concerns have spurred interventions from academia and industry practitioners, aiming to address these challenges (Isabirye and Orando, 2020; Orando and Isabire, 2018; Snyman and Smallwood, 2017; Bierman et al., 2016; Construction Industry Development Board, 2015). Bierman et al. (2016) addressed productivity management, dissecting factors that impact construction productivity. Isabirye and Orando (2020) delved into organisational equity as a platform for enhancing ethics and integrity, thus promoting construction productivity. The study examined perspectives from construction professionals and academics in the built environment. Snyman and Smallwood (2017) focused on contractors' perceptions and practices concerning construction business

productivity. Orando and Isabire (2018) explored skills development within South African construction to spur productivity growth.

While studies have explored the general performance of SMEs in South Africa, some have homed in on their productivity. Abor and Quartey (2010) advocated the involvement of governmental and non-governmental entities to enhance construction SMEs' performance. Wentzel et al. (2016) underscored the importance of management focus, competency assessment, and strategic planning for SMEs. Olawale and Garwe (2010) emphasised the necessity for financial support, while Aigbavboa et al. (2014) and Wentzel et al. (2016) highlighted the role of financial management. In South Africa, SME contractors comprise those with 250 full-time employees or fewer and an annual turnover of less than or equal to R170 million (Small Business Development, 2019). The underperformance of SME contractors undermines their potential to significantly contribute to job creation (Fatoki, 2014). Until 2016, construction SMEs constituted approximately 95.3% of South African contractors (Balogun et al., 2016), with more than 50% being owned by previously disadvantaged South Africans (George, 2016). Despite the strategic importance of SMEs for job creation and poverty reduction, research indicates that large contractors generally outperform SMEs in achieving project objectives (Wentzel et al., 2016). Notwithstanding substantial governmental spending to enhance performance, the current results do not justify such investment (Mafundu and Mafini, 2019; Aigbavboa et al., 2014). While studies have probed productivity within both SMEs and large construction organisations, investigations that specifically examine SMEs often explore their overall performance as opposed to their productivity. Although performance and productivity are sometimes used interchangeably, there is a distinction between these two management concepts, as elucidated in the following section. Besides, productivity studies have often made contributions that apply to the broader categories of construction organisations. This research narrows its focus to construction SMEs' productivity, seeking to uncover specific issues and interventions pertinent to contractors in this category. The study details current construction SME productivity, identifies systemic drivers, and presents a proposed improvement framework based on the research findings.

2. LITERATURE REVIEW

2.1 Productivity perspectives

Productivity growth is gaining increasing attention from economists and policymakers due to a growing recognition of the link between productivity and economic performance (Fadejeva and Melihovs, 2010). Efforts to understand productivity have yielded various perspectives on its definition. Academics have yet to arrive at a unanimous definition, as the concept often depends on the unique project control systems relevant to each organisation (Nasir et al., 2014). The term 'productivity' was first introduced in an article by Quesnay in 1766 (Jarkas and Bitar, 2012; Vaggi, 1987). Over a century later, in 1883, Littre expressed productivity as the ability to produce, implying the desire to do so (Jarkas, 2015). By the early 20th century, a more widely accepted definition emerged: productivity is the relationship between output and the resources used for production (Jarkas and Bitar, 2012). The Organization for European Economic Cooperation later formalised this definition, describing productivity as the quotient obtained by dividing output by one of the factors of production. The American Association of Cost Engineers contributed by defining productivity as a relative measure of production efficiency against an established benchmark, accounting for tasks performed in relation to a predefined standard (Nasirzadeh and Nojedehi, 2013).

Diverse studies have approached productivity definitions based on their specific objectives. In this study, productivity is assessed by the extent to which SMEs have optimised project resources to achieve project cost, quality, and time objectives. Studies have recognised the correlation of time, quality, and cost overruns with productivity (Raykar and

Ghadge, 2016; Enshassi et al., 2010). Enhancing production efficiency involves leveraging organisational resources to achieve optimal outcomes at minimal cost (Rane et al., 2017). A firm's productivity hinges on its ability to effectively coordinate its production process (Caliendo and Rossi-Hansberg, 2011) while ensuring product and service quality (Hanaysha and Majid, 2018). It is vital to distinguish between efficiency and effectiveness to grasp the productivity concept (Sumanth, 1998). Efficiency pertains to task speed, while effectiveness relates to achieving appropriate outcomes. Efficiency pertains to the swift delivery of construction tasks using organisational resources (Nasirzadeh and Nojedehi, 2013), while effectiveness revolves around meeting construction goals. Monitoring and improving both efficiency and effectiveness are crucial for achieving productivity growth in construction organisations. Research on construction productivity addresses three levels: activity, project, and industry (Yi and Chan, 2014). Activity-level studies delve into the productivity of construction tasks, primarily through quantitative methods (Shan et al., 2016). Project-level research quantifies and evaluates the productivity of construction projects (Zhao and Dungan, 2014). At the industry level, research focuses on productivity measurement (Vogl and Abdel-Wahab, 2015) and long-term productivity trends (Borg and Song, 2015).

2.2 Construction productivity research

Studies have identified factors influencing construction productivity, which may vary from project to project. Furthermore, the factors influencing productivity in developing countries can differ from those in developed nations (Adebowale and Agumba, 2022a; Adebowale and Agumba, 2021). As a result, there is a compelling need to explore productivity factors on a project-specific or geographical basis (Goodarzizad et al., 2021). El-Gohary et al. (2017) conducted a study on the factors impacting productivity in formwork and rebar fastening trades, specifically focusing on various types of reinforced concrete foundations. Among the 29 factors identified, critical factors for productivity in the formwork trade included work experience, incentive programs, material availability, leadership, and site management skills. Jarkas and Bitar (2012) investigated 45 factors influencing construction productivity, categorising them into four main groups. Clarity of technical specifications emerged as the most critical factor, with the technological group exerting the most influence. Kazaz et al. (2008) categorised 37 productivity-influencing factors into four groups: organisational, economic, physical, and socio-psychological. The organisational group held the most significance, with site management quality identified as the pivotal factor. Khan (2005) centered research on formwork installation, while Thomas and Sudhakumar (2013) identified 44 productivity-affecting factors, with material unavailability standing out as the most critical. Despite extensive studies on productivity-influencing factors, disparities in their classification and prioritisation persist across different studies. Some studies have employed qualitative models, including system dynamics, to address productivity factors (Jalal and Shaor, 2019; Nasirzadeh and Nojedehi, 2013), establishing relationships among these factors. Momade et al. (2020) utilised support vector machines and random forests to model construction productivity, offering insights for realistic budgeting, work scheduling, and human resource allocation.

Artificial intelligence has also been employed in productivity modelling. Tam et al. (2002) utilised an artificial neural network to predict excavator productivity, highlighting its capability to capture non-linear relationships. Fayek and Oduba (2005) introduced a fuzzy expert system to estimate pipe rigging and welding productivity, accommodating subjective judgment. Ezeldin and Sharara (2006) proposed artificial neural network models for formwork assembly, steel fastening, and concrete pouring activities. Oral and Oral (2010) utilised a self-organising map-based model to estimate crew productivity under specific conditions. Heravi and Eslamdoost (2015) employed a multilayer feed-forward neural network for productivity measurement. Mirahadi and Zayed (2016) devised a hybrid model applying the alpha-cut method for productivity prediction. Goodarzizad et al. (2021)

developed a hybrid model utilising an artificial neural network and a grasshopper optimisation algorithm to predict construction productivity and enhance project planning efficiency. Studies on productivity predominantly employ questionnaires, while some incorporate focus groups (Dai et al., 2009; 2007). Some studies resort to literature reviews for productivity factors identification (Jarkas et al., 2014; Jarkas and Bitar, 2012), and others explored detailed productivity drivers through industry practitioner input (Jarkas, 2015). In this study, qualitative inquiry offers comprehensive investigations among a select number of small and medium-sized construction organisations.

Table 1: Construction productivity influencing factors

Country	Factor	Source
Thailand	Lack of materials, incomplete drawings, incompetent supervisors, lack of tools and equipment, and absenteeism.	Rojas and Aramvareekul (2003)
Malaysia	Shortage of materials, non-payment to suppliers causing stoppage of materials delivery to sites, change orders by consultants, late issuance of construction drawings by consultants, and incapability of site management to organise site activities.	Abdul Kadir et al. (2005)
Uganda	Incompetent supervisors, lack of skills, rework, lack of tools/equipment, poor construction methods, and weather conditions.	Alinaitwe et al. (2007)
UK	Poor supervision, simplicity of building design, level of site experience, information flow, and communication with sub-contractors.	Chan and Kaka (2007)
USA	Construction equipment, project management, craft workers' qualifications, training, and foreman competency.	Dai et al. (2009)
Indonesia	Lack of materials, delay in the arrival of materials, unclear instruction to labourers, labour strikes, and financial difficulties of the owner.	Soekiman et al. (2011)
New Zealand	Reworks, level of skill and experience of the workforce, adequacy of the method of construction, buildability issues, inadequate supervision, and coordination.	Durdyev and Mbachu (2011)
India	Tool and equipment issues, poor labour motivation, improper supervision, poor material planning, and poor site management.	Thomas and Sudhakumar (2013)
Kuwait	Payment delay, rework, lack of financial incentive scheme, the extent of change orders during execution, and incompetent supervisors.	Jarkas and Radosavljevic (2013)
Palestine	Rework, lack of cooperation and communication between construction parties, the financial status of the owner, lack of labour experience, and lack of materials.	Ibrahim (2013)
Qatar	Lack of financial incentive schemes, slow decision-making process by owners, remuneration scale, delay in responding to requests for information (RFI), and shortage of skilled labour force.	Jarkas et al. (2014)
Egypt	Labourers experience and skill, incentive programs, availability of materials and their ease of handling, leadership, competency of construction management, and competency of labour supervision.	El-Gohary and Aziz (2014)
Oman	Errors and omission in design drawings, change to orders during execution, delay in responding to requests for information, lack of labour supervision, and clarity of project specifications.	Jarkas et al. (2015)

Bahrain	Labour skills, coordination among design disciplines, lack of labour supervision, errors and omissions in design drawings, and delay in responding to requests for information.	Jarkas (2015)
Iran	Supervision, proper coordination, effective communication, proper planning, and proper HSE programme.	Heravi and Eslamdoost (2015)
Jordan	Labour experience and skill, financial incentives, trust and communications, planning and scheduling, and job commitment and loyalty.	Hiyassat et al. (2016)
Nigeria	Availability of equipment and materials, supervision, payment method, welfare on-site, and weather conditions.	Afolabi et al. (2018)
Yemen	Labour's experience and skills, availability of materials on the site, leadership, and efficiency in site management, availability of materials in the market, and political and security situation.	Alaghbari et al. (2019)
South Africa	Excessive bureaucracy, late delivery of materials, industrial action resulting from political activities, inadequate project planning, and inadequate workers' skills.	Adebowale and Smallwood (2020)
Sri Lankan	Skills shortage, labourers' thinking abilities, work experience, knowledge in construction works, and discipline.	Manoharan et al. (2022)

Source: Authors's compilation

3. RESEARCH DESIGN AND METHODOLOGY

3.1 Research scope

The research was conducted among SMEs in Gauteng province, South Africa. Among the country's nine provinces, South Africa's construction operations vary significantly. Over the years, four provinces have prominently led in terms of both construction volume and capital expenditure. The focal areas for construction projects are Gauteng, KwaZulu Natal, Western Cape, and Eastern Cape provinces (Construction Industry Development Board, 2015). As of the close of 2021, the distribution of construction operations in these provinces stands as follows: Gauteng (25%), KwaZulu Natal (19%), Western Cape (18%), and Eastern Cape (12%) (Construction Industry Development Board, 2022). Collectively, these four provinces represented 76% of the total construction volume in 2014 (CIDB, 2015), and this dominance persisted in 2021, accounting for 74% of the total construction volume (CIDB, 2022).

Gauteng province has consistently held the highest capital outlay, largely attributed to the significant number of construction operations within the province. Over time, Gauteng has evolved into South Africa's economic hub, fueling a diverse range of construction activities. Given this context, the research population comprises contractors graded from 1 to 5 registered with the Construction Industry Development Board in Gauteng province.

3.2 Sample size

Guidance on determining a sufficient sample size for qualitative studies has been provided by various researchers. The importance of establishing an appropriate sample size before commencing data collection has been emphasised in the literature (Francis et al., 2010). Determining the ideal sample size in qualitative research is often regarded as both iterative and context-dependent. This decision is typically made during the analytical process as researchers gain a progressively nuanced understanding of research themes, their interrelationships, and the conceptual scope (Sim et al., 2018).

Ando et al. (2014) conducted 12 interviews and affirmed this sample size as adequate for qualitative studies. Similarly, Picariello et al. (2017) suggested a minimum of 12 interviews to achieve data saturation in qualitative research. Namey et al. (2016) propose that a sample size ranging from 8 to 16 interviews is necessary to comprehensively address a research question. In this study, 15 interviews were conducted, a sample size deemed sufficient as data saturation was reached, and no new information emerged.

3.3 Data collection

The list of registered SMEs was acquired from the CIDB headquarters in Pretoria on November 8, 2021. To ascertain SMEs' willingness to participate, contractors were randomly selected from this list. The chosen contractors were contacted via telephone, where the study's purpose was explained. Subsequently, the research questions were emailed to participating contractors, accompanied by a request to familiarise themselves with the queries. A purposive sampling approach was employed to select research participants from each construction organisation. This technique enables the selection of knowledgeable participants capable of offering pertinent insights into the investigated topic. As directors, site managers, and supervisors possess competence in addressing productivity issues, their viewpoints were actively sought.

Respondents were engaged through semi-structured interviews, allowing them to express their unique perspectives on the subject (Silverman, 1993). Both on-site and online interviews were conducted. Eight interview sessions were conducted on-site, while seven were facilitated online via Microsoft (MS) Teams. Owing to COVID-19 regulations on physical distancing, online interviews were employed to gather a portion of the research data. The interview phase spanned over four months (December 4, 2021 - April 8, 2022), with each session recorded and transcribed. The research questions were categorised into two sections. The first section encompassed socio-demographic details of the respondents, including their years of experience, their organisation's CIDB rating, and their organisation's duration of delivering construction projects. Before presenting the second part of the research questions, the study's specific definition of productivity was elucidated to prevent misinterpretation. Productivity was evaluated based on SMEs' utilisation of project resources to achieve project cost, quality, and time objectives. The second part of the inquiry involved three distinct questions. Respondents were prompted to succinctly depict labour productivity within their projects, pinpoint factors influencing the observed productivity, and share their perspectives on viable approaches to enhancing SME productivity.

3.4 Data analysis

Content analysis is a research technique employed to derive meaningful insights from written, verbal, or visual communication messages, either through qualitative or quantitative methods, contingent on the project's nature and research objectives (Krippendorff, 2018). This approach proves valuable for collecting and structuring information, as well as discerning trends and patterns within documents (Creswell, 2014). Qualitative content analysis organises data into relevant categories, while quantitative content analysis assigns numerical values to categorised data, such as frequencies, ratings, and rankings, by tallying mentions of specific topics (Chan et al., 2009).

In this study, qualitative content analysis was undertaken. On-site interviews were recorded using a recording device, while MS Teams interviews were recorded within the platform. Transcription of electronic data converted it into qualitative data. Following transcription, the data patterns were examined, leading to manual encoding. Data were subsequently categorised into relevant themes, formed by merging distinct codes under each theme. Content analysis assesses the presence, significance, and relationships of specific themes within qualitative data. It emphasises the essence of meanings over quantifiable frequencies, proving suitable for studies abundant in exhaustive information rather than predefined categories (Schutt, 2012).

4. RESULTS

Table 2 provides the sociodemographic characteristics of the study participants. Among the participants, site managers constituted 20%, directors comprised 26.7%, and forepersons accounted for 53.3%. Chosen as key players driving production on-site, these roles held crucial insights into productivity and its influencing factors. The participating organisations were classified according to the CIDB grade system, encompassing grades 1 through 5, which aligns with South African SME categories. Among the participants, 53.3% were registered within grades 1 to 3, categorising them as small contractors, while 46.7% fell under grades 4 to 5, identifying them as medium-sized contractors.

In terms of industry experience, 53.3% of respondents held a construction background of 16 years or more, while 46.7% had amassed 5 to 13 years of experience. The average construction experience of the respondents stood at 18.3 years. The organisational tenure data revealed that 33.3% of surveyed organisations had been operational for 16 years or more, with the remaining 66.7% operating within the 3 to 14-year range.

Table 2: Participants' information

Interviewee	Position	Years of experience	CIDB grading	Years of operation
Participant 1	Construction manager	30	5	16
Participant 2	Director	12	1	3
Participant 3	Foreman	25	4	11
Participant 4	Foreman	7	5	13
Participant 5	Foreman	16	2	9
Participant 6	Director	9	3	14
Participant 7	Foreman	13	4	8
Participant 8	Construction manager	23	5	13
Participant 9	Director	31	4	20
Participant 10	Foreman	8	3	12
Participant 11	Construction manager	13	2	13
Participant 12	Director	38	5	32
Participant 13	Foreman	25	2	20
Participant 14	Director	5	1	5
Participant 15	Director	20	2	20

Source: Authors's compilation

4.1 Productivity in construction organisations

This section presents the prevailing state of productivity within construction SMEs. Through an analysis of participants' responses, the findings are categorised into four themes: poor productivity, somewhat productive, experience, and unpredictable, as outlined in Table 3. A significant portion (46.6%) of participants conveyed their perception of poor productivity across construction operations. Expressions such as 'below average,' 'poor productivity,' 'not encouraging,' 'not impressive,' 'lowest level,' and 'below expectation' were commonly used by participants to articulate their viewpoints. Notably, Participant 1 spotlighted that merely around 20% of SME-executed projects adhere to the proposed completion dates and costs. Evidently, approximately 80% of SME projects encounter both cost and time overruns, underscoring the magnitude of the challenge.

Certain participants acknowledged some dimensions of productivity. Participant 12 noted that workers exhibit some level of productivity, but material shortages and government interference emerge as notable constraints. Conversely, Participant 14 primarily attributed productivity struggles to workers, while praising the performance of materials, tools, equipment, and management. Participant 15 highlighted noteworthy productivity within specific aspects of construction, although specific details were not disclosed. The significance of SMEs' experience in the industry was emphasised by multiple participants, indicating that longer-tenured contractors generally outperform their newer counterparts. This sentiment was echoed by three participants (P3, P6, and P9).

Notably, two participants indicated the unpredictability of SMEs' productivity. Participant 5 described instances of sporadic high productivity interspersed with periods of lower performance, while Participant 7 encapsulated this unpredictability using the term 'uncertainty.

Table 3: State of productivity in construction SMEs

Participant	Response
	Poor productivity
P1	"…contractors' productivity is below average. Only about 20% of projects are completed within actual completion date and budget…"
P2	"…many construction businesses suffer setbacks due to poor productivity, which is aggravated by the current pandemic…"
P4	"…the present productivity is not encouraging…"
P8	"…productivity on most construction projects is not impressive…"
P10	"…our projects usually experience low productivity due to a lot of delays…"
P11	"…productivity is at the lowest level…"
P13	"… my opinion, our productivity is below expectations…"
	Somewhat productive
P12	"…workers perform fairly well, but there are problems with materials shortage and government interventions…"
P14	"…tools and equipment, management, materials are doing better with respect to productivity, but workers are not helping matters…"
P15	"…will say productivity is good in some area of construction…"
	Experience
P3	"…contractors that have been in the industry for more years have higher productivity than the ones that are new in the industry…"
P6	"…one thing is important. The longer we stay in business, the better our productivity…"
P9	"…those who have operated in the construction business for a while have better productivity in their projects…"
	Unpredictable
P5	"…productivity is not stable, occasionally productivity is great, and some other time we experience the worst..."
P7	"…productivity is not always certain; productivity is high at a time and sometimes it is poor…"

4.2 Productivity influencing factors

Table 4 outlines the key variables exerting an impact on SMEs' productivity. The data revealed four pivotal themes: workers' skills, directors' competence, government interference, and remuneration. A notable 73.3% of respondents pointed to workers' skills as a substantial productivity impediment for SMEs. Phrases such as 'not good enough,' 'poor experience,' 'not qualified,' 'lack experience,' 'less experienced,' 'not skilful,' 'incompetent,' and 'inexperience' were commonly employed to articulate concerns about the skills deficit. Participant 9 remarked that approximately 70% of construction workers lack the essential job-required skills.

The competence of construction organisation owners was identified as a hindrance to productivity growth. A significant 66.7% of participants highlighted owners' inexperience in effectively managing construction businesses. Issues stemming from directors' competencies were conveyed through phrases like 'not qualified,' 'poor experience,' 'inadequate experience,' 'lack the experience,' and 'incompetence of director.' Participant 1 astutely observed that while most directors consider themselves competent, this belief does not always align with reality.

Government interference emerged as another significant challenge impacting SMEs' productivity. This category encapsulated challenges like unfavorable government policies and inadequate support systems for training programs. Participant 10 noted instances where contractors hired workers due to specific government policies. The issue of workers' remuneration emerged as a less pronounced productivity challenge. Approximately 33.3% of participants conveyed concerns about the low wages that SMEs offer their workers. Participant 1 attributed this to contractors' financial constraints, which consequently led to limited recruitment of workers (P9). The predicament of insufficient funds among SMEs may stem from both inadequate funding (P8) and suboptimal fund management by contractors.

Table 4: Factors affecting construction productivity

Participant	Response
	Workers' skills
P1	"…majority of the workers that contractors employ are not good enough…"
P3	"…inexperience of workers…"
P5	"…poor experience of workers is a critical factor…"
P6	"…some contractors hire workers that are not qualified..."
P8	"… primarily due to workers skills shortage…"
P9	"…employ less experienced workers. 70% of the workers lack skills for their tasks…"
P11	"…majority of workers do not have the right skills to deliver…"
P12	"…some workers lack experience and they are difficult to manage…"
P13	"…large number of the worker is also not skilful in their jobs…"
P14	"…will say it is majorly incompetent workers…"
P15	"…inexperienced workers…"
	Directors' competence
P1	"…most owners lack the experience. 80% think they are competent, but they are not…"
P2	"…poor planning by business owners…"
P3	"…poor business management skills of owners, particularly those that are new in the industry…"
P4	"…. competence problem…. ready to learn business management strategies…"
P5	"…poor experience of business owners..."
P6	"…owners are also not qualified to deliver their responsibilities…"
P7	"…some bosses are not well versed to conduct a construction business effectively..."
P8	"…inadequate experience of directors…"
P13	"…shortage of capital arising from poor management of funds by company owners…"
P15	"…incompetence of directors leading to poor management of process and funds…"
	Government interference
P1	"…poor productivity is largely due to government policies…"
P3	"…there is no right law in place that can guarantee the productivity of contractors…"
P8	"…inadequate support from the government for training, coaching, and mentorship programs…"
P9	"…government enforces unqualified workers on us…"
P10	"...regulation requires us to recruit within project location. The majority of the people do not have experience for the job, but we must hire them…"
P11	"…workers know the government has provision for them for jobs whether they are competent or not…"
P14	"…inadequate support from the government…"
P15	"…insufficient government intervention and bad policies…"
	Remuneration
P6	"…sometimes contractors pay workers less because of inadequate funds…"

P8	"…poor funding of small contractors …"
P9	"… also, we usually don't employ the right number of people due to low capital to pay workers. We usually employ workers who can be paid lower rates…"
P14	"…most of the contractors pay their workers lesser amount…"
P15	"…payment of low rates for workers…"

4.3 Strategies for productivity improvement

In this section, strategies aimed at enhancing productivity within SMEs are elucidated (as indicated in Table 5). Participant responses have been systematically grouped into three distinctive themes: skills development, government intervention, and contract rates. An overwhelming consensus emerged among participants, emphasising the pivotal role of skills enhancement for both directors and workers through robust training initiatives. Notably, 69.2% of participants advocated for training programs encompassing both directorial and staff levels. A subset of 15.4% believed that directors' competence alone would suffice, while a parallel 15.4% echoed the importance of comprehensive staff training in bolstering SMEs' productivity. Participants identified corporate management and cash flow as key competencies for company owners. Strategies, including enhanced interactions among directors and formal training interventions were also identified as potential avenues for amplifying SMEs' success rates (P3; P8). Some participants underscored the value of on-the-job mentoring and training facilitated by more experienced workers to elevate the skills of their less-experienced counterparts.

Additionally, the government's potential contribution to boosting SMEs' productivity was underscored by the findings. Three prominent areas emerged where government intervention could be impactful: policy reviews, heightened commitment to training, and improved access to funds. Each of these factors garnered endorsement from 30% of study participants as essential catalysts for SMEs' productivity enhancement. Furthermore, three participants pinpointed the significance of contract rates in the pursuit of heightened productivity. Noteworthy areas illuminated by respondents encompassed the necessity to augment SMEs' contract rates and expedite payments. These measures could enable SMEs to attract skilled workers and fulfil their financial obligations with increased efficiency.

Table 5: Productivity improvement strategies

Participant	Response
	Skills development
P1	"…training for owners and workers on skills and competence…"
P2	"…contractors must learn about business management and cash flow. Train their workers using more experienced workers…"
P3	"… directors should learn the nitty gritty of business management through interaction with other contractors. They must improve their workers' skills through training…"
P5	"…owners must subject themselves to continuous training and champion the system that promotes skills acquisition for their employees…"
P6	"…directors should ensure skill development in their companies across the board…"
P7	"…owners need more training to operate construction works…"
P8	"…directors should get formal training on construction operations and business management…"
P9	"…company owners and their workers must should acquire the right skill and qualifications..."
P10	"…workers should be allowed to learn from more experienced colleagues…"
P12	"…owners of construction organisations must imbibe mentorship for upskilling in construction"

P13	"…owners are not above training and should also be committed to their workers training…"
P14	"…workers should be trained on the job to become more competent…"
P15	"…directors must go for training to manage their companies, employ experienced workers, and train those that are less experienced…"
	Government intervention
P1	"…the South African government should review her policies through consultations with necessary construction stakeholders…"
P3	"…the government should develop and monitor better operation frameworks for contractors…"
P4	"…our government must organise training for directors and improve on the current skills development initiatives for workers…"
P8	"…. more funds like soft loans should be made available to contractors by the government, banks usually give requirements that we are unable to meet…"
P9	"…government should improve access to funds with proper monitoring…"
P10	"…and the government must cancel the law forcing us to recruit incompetent people…"
P12	"…skills development funds from government must be properly utilised to train enough workers for the industry…"
	"…increase commitment to skill development by the government..."
P14	"…we need the government to make funds more accessible to us…"
P15	"…our government must expunge policies of imposing on contractors whom they must employ and they must support contractors to get loans for efficient operations…"
	Contracts rate
P6	"…our contracts rate must be improved to enable us to hire qualified individuals…"
P10	"…contractors' rates should be reviewed because it is important to their production efficiency…"
P13	"…contractors should be well paid to hire the right workers…"

5. DISCUSSION OF THE FINDINGS

The study delves into the state of productivity within SMEs, delving into the key influencers of productivity and outlining pivotal strategies for fostering desired productivity growth. Notably, SMEs form a substantial presence in South Africa's construction sector (Wentzel et al., 2016). By enhancing their productivity, these enterprises stand to not only fortify their own viability but also amplify the construction industry's contribution to the broader South African economy.

Through qualitative investigation, the research underscores the prevalence of inadequate productivity within SMEs. Respondents collectively identify poor productivity as the most daunting challenge confronting contractors. This outcome resonates with findings from a recent Malaysian study, wherein low productivity has remained an enduring concern over the last decade, impacting job creation and economic advancement (Kamal et al., 2022). It's a trend observed across developing countries, with productivity setbacks recurring over time (Agrawal et al., 2020; Alaghbari et al., 2019; Hiyassat et al., 2016; Alinaitwe et al., 2007). The ramifications of this deficiency cascade into cost and time overruns, jeopardising SMEs' survival and tarnishing the industry's reputation. Poor productivity emerges as a pivotal challenge in the construction landscape (Jarkas, 2015; Gupta et al., 2018), with fluctuating worker productivity exacerbated by inadequate management and government intrusion. Evidences of erratic productivity underscore the challenges of predictability, hinting at organisational limitations in steering productivity trajectories.

Crucially, an inverse relationship emerges between SMEs' productivity and their duration of operation in the industry. SMEs boasting longer operational histories tend to exhibit superior productivity, contrasting with their newer counterparts. This dynamic accentuates the correlation between productivity and cumulative experience in project delivery. To stimulate sustainable productivity growth, particularly in nascent players, a systematic identification and rectification of factors hindering initial productivity are imperative.

Key factors undermining SMEs' productivity encapsulate worker skill deficiencies, directors' competence, government intervention, and remuneration shortcomings. Despite substantial strides in construction technology, skilled labour remains a fundamental requirement due to the partial realisation of construction automation. Instances of incompetent and inadequately skilled workers were reported, aligning with the persistent challenge of skill shortages in the industry (Alaghbari et al., 2019; Jalal and Shoar, 2019). A crucial facet of directorial competence surfaces, demanding a balance between capital investment and managerial proficiency. Some directors misconstrue capital as the sole requisition for effective construction business management, neglecting the imperative of skill enhancement. Ineffectual policies and limited support for training programs also emanate from the government sphere, with discontent voiced against policies mandating the employment of locally-sourced workers. This policy yields a pool of inadequately skilled labour, negating its intended impact. Surprisingly, workers' remuneration emerges as a relatively minor influence on SMEs' productivity. Many SMEs offer lower remuneration compared to larger contractors, potentially dampening workforce morale. This phenomenon intertwines with issues such as low contract rates, limited access to finance, and suboptimal financial management.

Addressing these intricacies, participants underscored critical strategies for fostering SMEs' productivity growth. The framework presented in Figure 1 encapsulates a comprehensive approach. It emphasises the pivotal role of both in-house and inter-organisational training and mentoring programs, synergistically reinforced by targeted government intervention through policy refinement and financial backing.

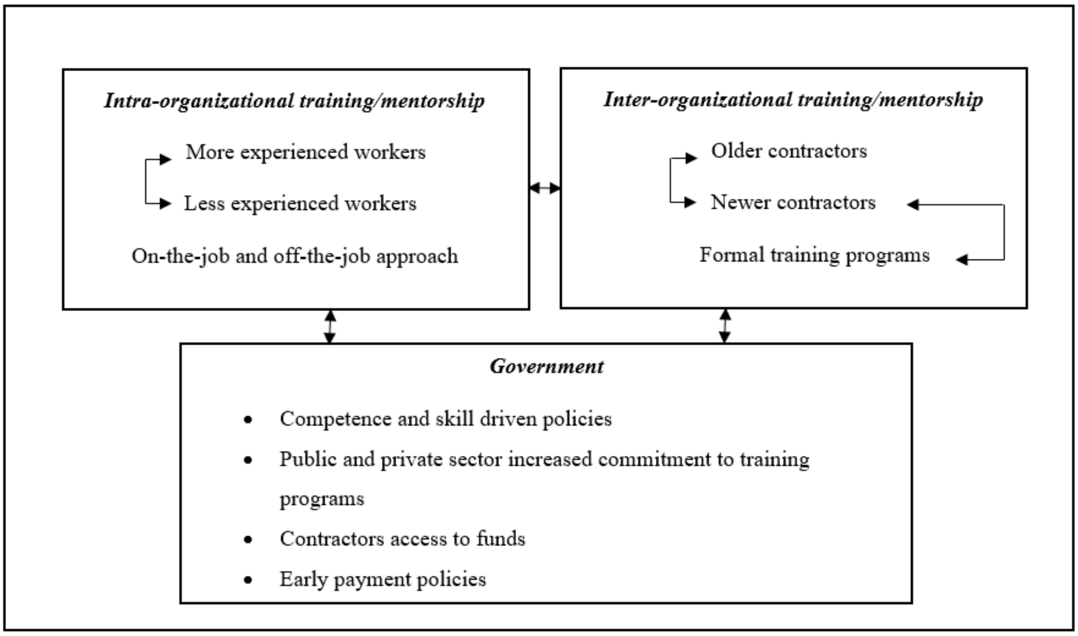

Figure 1: Construction SMEs productivity improvement framework

Source: Authors' compilation

Strategic enhancements for SMEs' productivity entail a triad of initiatives: ongoing skill development for workers and directors, judicious government intervention, and equitable contract rates. Diverse training methodologies are pivotal for fostering competence at various organisational tiers. For employees, on-the-job training stands as a potent vehicle for cultivating a proficient workforce. Additionally, leveraging the expertise of seasoned workers through mentoring – be it on-the-job or off-the-job – resonates as a pragmatic approach to amplify skills. In parallel, directors' efficacy could be bolstered through peer interactions within the industry's seasoned cohort. Substantive gains could be derived from formal training regimens, elucidating strategic management nuances germane to construction enterprises. Aghimien et al. (2019) spotlight the significance of directors' holistic growth, particularly in the spheres of business acumen and financial management.

Government intervention merits strategic recalibration through policy reviews to unshackle SMEs' productivity. Rigid employment stipulations ought to evolve, favouring competency-based hiring over undue curtailment. Such reforms could kindle the pursuit of skills, enhancing job prospects for less proficient workers. Concurrently, a concerted impetus from both the government and the private sector toward artisanal training programs is imperative. The metamorphosis is heightened access to finances. Escalating interest rates and stringent collateral requisites pose mounting challenges for small contractors (Aghimien et al., 2019). Remedying this calls for streamlined loan accessibility, ameliorating contractors' capacity to navigate financial encumbrances. Prudent implementation mechanisms and preventing misuse should be integrally woven into these efforts.

Furthermore, coherency within South Africa's construction landscape beckons harmonised monitoring of contract and labour remuneration. Propitious governmental policies mandating prompt contractor remuneration bolster industry resilience, ensuring optimal operational cadence.

6. CONCLUSION

In today's rapidly changing business environment, entrepreneurs across industries are reevaluating how they operate. In South Africa, the role of Small and Medium-sized Enterprises is crucial due to their large numbers. The productivity of these SMEs holds significant sway over the industry's overall output and its contribution to the economy. Unfortunately, many SMEs are facing a productivity challenge, which has led to business closures and increased unemployment. Given the importance of SMEs in South Africa's economy, it's essential to understand the problems affecting their productivity and suggest solutions. This study uses a qualitative approach to look closely at SME productivity issues, examining the factors that are causing problems and suggesting strategies for improvement. The results align with existing studies, showing that some SMEs struggle with low productivity. It is noteworthy that the length of time SMEs have been in business affects their productivity.

The main challenges affecting SME productivity are the skills of their workforce, the abilities of their directors, and government involvement. To address these issues, an evidence-based framework designed to boost SME productivity was developed. The framework can be adjusted to fit the unique circumstances of South African construction SMEs. Its practical use is expected to improve the skills of contractors and enhance business owners' understanding. At the same time, it aims to counteract government practices that hinder productivity in SMEs, leading to sustained improvements and fewer business closures. This positive shift has a ripple effect across society. Improved SME productivity leads to more jobs, benefiting South Africa's development. However, the study acknowledges its limitations, as it focuses on a select group of SMEs, making it unsafe to generalise the findings. Nevertheless, similar challenges faced by contractors in other developing countries suggest the potential applicability of these findings to different regions of South Africa. This study underscores the importance of conducting further research centred on SME productivity. Acknowledging the distinct nature of SMEs, the study emphasises the need for tailored approaches to boost their productivity, as general methods may not be suitable. Therefore, exploring strategies that cater to SME dynamics becomes crucial, ultimately fostering a more resilient and vibrant SME sector.

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Public Sector Contracting Model for Management of Construction Tender Price Volatility

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ABSTRACT
Construction tender price volatility threatens desirable infrastructure push in the public sector. The damaging effects of escalating tender prices outweigh the socioeconomic benefits of such infrastructure. If not addressed, this harmful effect destroys construction sector productivity, causing it to lag behind other economic sectors, thereby decreasing its value in the national economy. Contractors use price to mitigate procurement and client-related risks at the tendering stage. The trend requires developing and implementing procurement strategies that consider price control implications at the project tendering phase, leading to the development of contract delivery models that inadequately address the impact and potential value of pricing in construction projects. This research focuses on implementing procurement strategies by developing a public sector contracting model considering price reduction implications at the project tendering phase. The study investigates pricing behaviours regarding implementing current contracting delivery models in Zambia and develops a conceptual model for managing tender price variability in the public construction sector. The study achieved this through a comprehensive literature review followed by semi-structured interviews with 14 purposively and snowball-sampled industry experts. The study utilises person-to-person interviews to collect data from interviewing 14 purposive identified respondents to attain relevant research results. The findings show that governments can maximise social gains from an infrastructure project by deriving accurate technical parameters and optimising procurement. The study identifies four pricing behaviours demonstrated by contractors during tendering: resistance, reactive, anticipatory, and Consultant-based. Consultant-based pricing was the least practised behaviour, whereas reactive was the most established among all behaviours. Emergent patterns for turnaround strategies include cost estimating and financing, mitigating external and internal interferences, providing incentives, providing training, and encouraging innovations. Others include revising legislation, contextualising procurement functions, improving project management practices, predicting market forces, and guaranteeing sustainability. The study further proposes the conceptual Negotiated Construction Approach (NCA) for public projects that summarises and weaves together identified strategies.

Keywords: Construction, contracting model, public sector, tender price

1. INTRODUCTION
Despite the spate of studies aimed at improving construction management practices in Zambia, difficulties still plague the construction industry (Zulu and Muleya, 2018; Zulu et al., 2022; Tembo et al., 2023a; Aigbavboa et al., 2018; Silwimba and Mwiya, 2017; Cheelo and Liebenthal, 2018; Chilongo and Mbetwa, 2017; Chiponde et al., 2017). Notable studies (particularly those by Zulu et al., 2022; Sibanyama et al., 2012; Tembo et al., 2023b) have identified challenges associated with implementing public projects. The public construction sector in Zambia formally exhibits relationships governed by contracts. However,

accompanying these relationships between the government and the contractors are informal practices that progress to characterise unforeseen project implementation difficulties.

Tender price variability profoundly influences the financial sustainability of the construction sector. Joukar (2016) and Tembo et al. (2023a) discussed the challenges associated with tender price variability in construction. Tembo et al. (2023a) demonstrates that the effects of the management of tender price volatility are across multiple fundamental dimensions, including the government, the contractors, the industry, the procurement, and the legal framework. Public sector project delivery does not realise how to use the synergies between procurement or contracting activities and existing market risks to manage the tender price. Therefore, public sector institutions use generic procurement and contracting strategies that do not reflect specific national responses to challenges regarding construction price volatility. These contracting strategies often lack precise specifications, reflecting national construction tender price difficulties, among other things. The study aims to develop a unique contracting model for public sector construction project procurement in which price and quality control are critical. This research, therefore, adds to the scientific knowledge, eventually informing management practice in the public construction sector and consequently providing strong empirical and theoretical support to tender price-oriented research. The study investigates factors affecting tender price determination in construction and current tender price controls in practice. The paper carries with it a particular focus on contractors' prices for construction at tendering and highlights influential risk-related factors.

The study predicates that contractors use price to mitigate procurement-related risks at the tendering stage. Further, this research focuses on implementing procurement strategies considering price reduction implications at the project tendering phase. Ignoring this construction attribute leads to the development of contract delivery models that inadequately address the impact and potential value of pricing in construction projects. Therefore, they fail to establish possible strategies to overcome tender pricing variability.

2. LITERATURE REVIEW

The construction sector uses construction cost or tender price indices to monitor price movements. This monitoring measures relative change over time in construction materials prices. Cruywagen (2014, p. 25) argues that several "factors influence the establishment and composition of the relevant tender price index." Such factors include the availability of data, selection of items to consider from the bills of quantities, selection of base year or period, choices of weights, and construction method. All these factors begin to affect the accuracy of the index. Once established, the index works as a deflator for construction prices. In a free market, the bidder presents an item price uniquely dependent on the construction technique (Cattell, et al., 2010). Through a literature review, this paper aims to identify better, more effective, and more informed scientific fundamentals for price management by contractors and clients.

2.1 Tender price inflation and volatility in Zambia

Zambia struggles with construction price inflation, hallmarked by a general increase in prices of works over time (Olabisi, 2022). Historic perceived increases in construction prices and project spending contribute to unsustainable infrastructure development costs in the country. While drivers of variable construction tender prices need further documentation and studying, impacts are already noticeable. Trapped in the government's push for development are citizens of whom too many question the benefits of, or who benefits from, undertaking these public projects. In addition, society is concerned about how a government affords such spending considering the complexity and diverse nature of the sector, making it challenging to address variable tender prices while encouraging infrastructure development programs. Over nine years, Tembo et al. (2023b) identified and analysed tender pricing behaviours for upgrading roads to bituminous standards. They noted between 2012 and 2021, tender prices for periodic maintenance of feeder roads increased by an average of 49.7% per annum. For unpaved roads (periodic maintenance), construction tender prices increased by K1,461,018.8/km from K1,438,825.8/km in 2012 to K1,623,899.1/km in 2021, as shown in Figure 1.

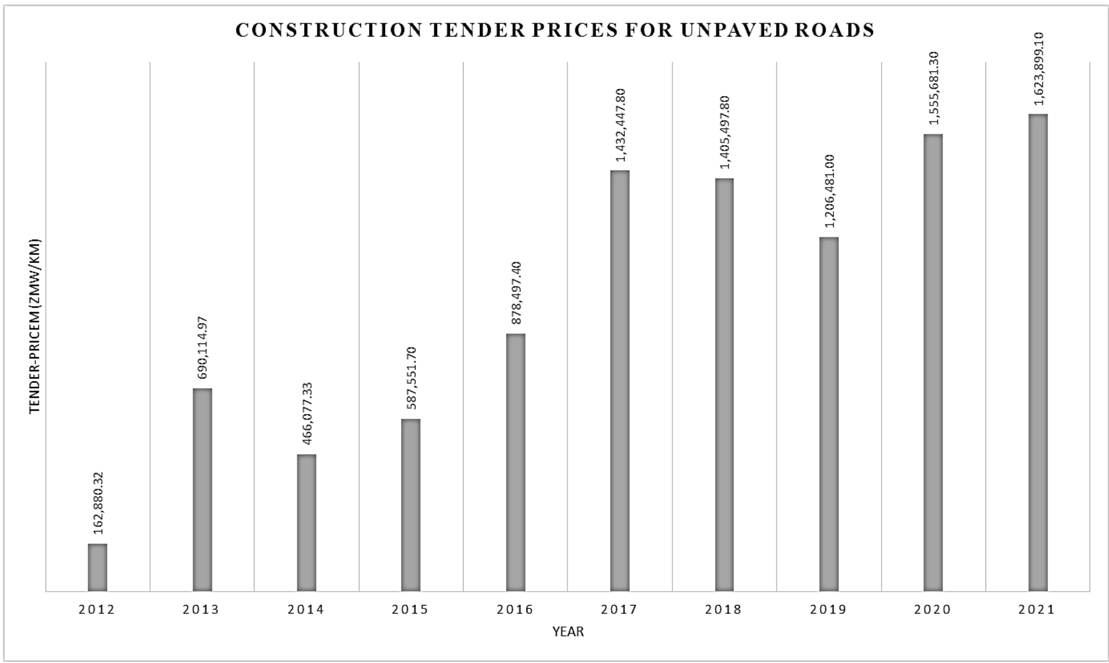

Figure 1: Construction tender prices for periodic maintenance of feeder roads (2012-2021) (adapted from Tembo et al. 2023b, p. 35)

2.2 Factors affecting tender price management

Tender price management is an essential consideration for bid success; however, complex pricing interrelationships make it much easier to generally express construction project success in terms of cost and budget variance (Yismalet & Patel, 2018). This trend, over time, has shifted the long-term focus to project cost management processes. In addition, research shows that project success depends on mitigating factors affecting tender pricing at the procurement stage. Aje et al. (2016) determined fifteen (15) factors that influenced the success rate of contractors in competitive bidding concerning tender price, which included material availability, labour productivity, and profit as the most significant. These factors highly influence construction tender price (at the tendering stage) and later significantly affect contractors' performance.

Construction projects face numerous unpredictable factors. Gudienė et al. (2013, p. 397) identified and classified these factors into seven influential groups: "external factors, institutional factors, project-related factors, project team management-related factors, project manager-related factors, client-related factors, and contractor-related factors." To investigate how these factors influenced the success of a construction project, they developed a conceptual model that grouped the project success factors. However, they did not perform a factor analysis to investigate the underlying relationships among the elements. Project price is not among the factors identified for a possible multi-criteria analysis of alternatives for selecting a successful project.

Table 1: Factors affecting tender price in construction

Factor(s)	Postulation	Author
Nature of competition	Firms raise prices in competitive markets	Chalkidou, et al. (2020)
Inflation rate	The inflation rate helps predict the bid price	Oghenekevwe, et al. (2014)
Macroeconomic factors	Price volatility is dependent on macroeconomic factors	Alireza, et al. (2016)
Material cost	Construction prices are a function of many factors, including material costs	Gransberg and Kelly (2008), Al-Zarrad, et al. (2015), Tembo-Silungwe and Khatleli (2017), Ramanathan et al. (2012)
Profit margin	Adopting high prices has a direct and positive impact on profit margin	Toni et al. (2017)
Size of a construction company	Larger companies have a greater capacity to influence prices in the industry	Toni et al. (2017)
Reputation of client	Contractors inflate tender prices for clients reputed for delayed payments	Ye and Abdul-Rahman (2010)
Level of construction activity	A boom in construction activity is significantly associated with a general increase in construction prices	Cruywagen (2014)
Unbalanced bidding	The practice of unbalanced bidding comes as a possible added cost to the project	Skitmore and Cattell (2013)
	Unbalanced bidding contaminates the database of previous tenders that clients often use to establish and estimate the cost of a project	Molenaar, et al. (2011)
	Unbalanced bidding is a common practice by contractors in determining prices in construction	Cattell, et al. (2007)
Degree and level of competition	The level of competition has an impact on the bid price	Lawrence (2003)
Nature of construction work	The nature of construction is critical in the development of bid price	Lawrence (2003)
Number of competitors	The number of participants has a direct impact on the bidders' final price	Raventós and Zolezzi (2015)
Pricing policies	Pricing policy can influence the profitability of an organisation	Toni et al. (2017)
Experience in a construction company	Emerging contractors exhibit inadequacies in tender price estimation	Seeletse and Ladzani (2012)
Engineer's estimate	Benchmarking engineer's estimate during the evaluation of bids	Su et al. (2020)
Project quality level	The increase in price offered by the client encourages contractors to provide a better-quality product	Yu et al. (2013)
Direct cost drivers (Labor, equipment, plant, etc.)	Cost drivers are crucial in the compilation of tender price	Seeletse and Ladzani (2012)
1. Reduced bureaucracy, 2. higher corruption rate, 3. poor business environment	It is hardly possible to construct lower prices with a higher corruption rate, high bureaucracy, and poor business environment	Grega and Nemec (2015)
Procurement method	The procurement method is a significant qualitative factor affecting project cost	Ali (2018)
Exchange rate volatility	The exchange rate is the leading indicator that influences the price of goods and services	Morina, et al. (2020)
Regulation and control	Price floor regulations have long-term effects on the structure of the market by creating endogenous barriers that can even lower prices	Carranza, et al. (2015)
Dependency on imported materials	Import tariffs have an almost immediate effect on prices	Amiti et al. (2019)
Interest rate	Changes in the interest rates affect macroeconomic variables such as price level	Li Suyuan and Khurshid (2015)

Globalisation	The integration of world markets has general equilibrium implications on product's relative prices	Farahane and Heshmati (2020)
Location and control of the site	1. Cost estimating is used more for project control than planning and evaluation 2. The project location is one of the significant factors affecting the accuracy of cost estimation	Akintoye and Fitzgerald (2000)
Tender duration	If the timeframe is inadequate, contractors will lack time to carry out a proper analysis of the project, thereby leading to contractors overpricing their tender to make up for unforeseen risks	Knowles (1997)

Source: Authors' compilation

2.3 Risk-related factors during pricing in construction

Evaluating bids is through a variety of criteria, but the key shared among the criteria is the total bid price; usually, considerations are that choosing a bidder with the lowest price is most beneficial to the client (Jaśkowski & Czarnigowska, 2019). All while overlooking facts that the practice results in low quality of works, claims, disputes, time overruns, bid-rigging, increased costs, unrealistically low prices, and collusion. There are related factors in the pricing of each item in construction (Azizi & Aboelmagd, 2019). The main challenges to contractors come with identification methods by which the risk rate can be measured within an item price loading and achieving the highest profitability while accepting the most negligible risks (Azizi & Aboelmagd, 2019). Another concern when pricing for a bid is that the awarding of a construction contract depends on the total bid price. Especially without considering the variations in the item's unit price, a scenario in which contractors deliberately manipulate unit actors (Nikpour, et al., 2017). Olawale and Sun (2010) found that price inflation was one of the significant factors that affected cost control on a project. Furthermore, they argued that price fluctuation and inaccurate estimates were the top variables causing cost overruns on a project.

The ability to deploy strategies productively and effectively has a cost-decreasing impact. In the public-construction sector, developing and setting appropriate tender conditions following an in-depth investigation of how the factors affecting pricing mechanisms correlate enhance this ability. Table 1 show factors obtained through the literature review that affect bid pricing decision in the construction sector. When risk factors are uncertain on a project, contractors face the challenge or problem of deciding the bidding price for construction. The existing theoretical principles of project risk management lack more realistic considerations. This situation leads to unclearly allocated and unreasonably priced risks at the project onset (Zhang, et al., 2006). At the tendering stage, one of the main risks for consideration is the financial position of the client in such a manner as being unable to pay the contractor on time, A scenario often leading to project delays and wrong cost estimations (Naji & Ali, 2017). The failure of a construction firm to fully consider or estimate the risk event on a construction project could have a disastrous impact. Construction enterprises are conscious of this scenario, and due to a lack of appropriate knowledge on risk pricing and mitigation measures, they often subsequently overestimate their markups. This practice causes construction prices to escalate over time.

Laryea and Hughes (2008) found no evidence suggesting that construction project pricing was systematic. Therefore, they doubted the justification of pricing models for contractors as their final price depends on a varying range of complex microeconomic indicators and risk factors. The argument is on efficient pricing for risk while encountering and estimating various contingencies. Contractors remain aware of the nature of the construction industry in which all competitors are "hungry for a job" such that if they were to consider and price for all realistic contingencies, they would remain uncompetitive. Table 2 shows some risk factors contractors must contend with during bidding pricing.

Table 2: Risk-related factors during pricing in construction

Risk factor(s)	Author
Value of liquidated damages	Towner and Baccarini (2012)
Clients' financial state	Naji and Ali (2017)
Project cost risk (range between 2.7% and 8.7% of project cost)	Xu (2014), Brokbals, et al. (2019)
Technical information or detailed specifications	Nketekete, et al. (2016)
Practical knowledge of the construction process	Akintoye and Fitzgerald (2000)
Contractor size	Dulaimi and Shan (2002)
Market competition	Laryea and Hughes (2008)
Contingency additions	Dada and Jagboro (2007)
Apportionment of contractual responsibilities	Al-Ajmi and Makinde (2018)
1. Material availability 2. Labor productivity	Aje et al. (2016)
Project scope	Dziadosz et al. (2015)

Source: Authors' compilation

2.4. Contracting delivery models in construction

Paek and Lee (1993) proposed a risk pricing method for analysing and pricing construction projects, which consisted of identifying risk factors and pricing for their consequences. They suggested using a fuzzy set approach to quantify the implications and directly incorporate them into the bid price. Their research developed a framework for assisting contractors in making valid estimations in uncertainty through their risk-pricing method. They adopted a fuzzy set theory to present a risk-based pricing algorithm and computer-based software. However, since the selection of risk factors is project-specific, the algorithm could not formulate generalisations. Therefore, it is advisable to price all risk elements whose consequences might fatally flaw the project identification during the tendering phase (Paek & Lee, 1993). However, Laryea and Hughes (2008) argued that most models and pricing methods are desk-based and lack knowledge of what contractors do during the bid pricing stage.

The dilemma with competitive bidding is that the bid price must be low enough to win the bid yet high enough to ensure the contractor's profitability and reasonably sufficient to guarantee the quality of work. That is when the cost estimation function becomes essential, as it is the basis for most contractors to build their tender price (Akintoye & Fitzgerald, 2000). It is equally imperative to note that the availability of funds influences the client's decision to award a contract, the contractor's price, as well as prices of other contractors. Excessively, the parties in construction view construction price through the understanding of and emphasis on project cost. Hence, related approaches to price control are cost control measures through contracting delivery models (Table 3). Clients resort to employing delivery models such as EPC to manage construction prices and are slightly more regular (Zhong, 2011).

2.5. Effects of a contracting model on cost level

Initiating procurement quality controls generates improved competitiveness from a price viewpoint through the value-added competencies of the procurement function. In construction, procurement quality controls allow for significantly high procurement performance, leading to the best possible price to meet the client's needs (Munyimi, 2019). However, procurement functions in the public face numerous challenges. Unique challenges include a significant lack of empirical research on the impact of public procurement systems on price or cost levels in the construction sector. However, Gray et al. (2020) argue that current procurement decisions are too focused on cost minimisation at the expense of stakeholder value. They propose a new approach known as "total value contribution" as an extension of "total cost of ownership" methods that broaden the factors during a procurement exercise. They argued that putting value first through procurement would increase organisational outcomes. The effects of a contracting model in construction are summarised as follows (Gray et al., 2020; Munyimi, 2019)

i. Improved organisation outcome
ii. Improved firm interrelations
iii. Betterment of society
iv. Improved project performance
v. Improved value for money

Table 3: Contracting delivery models in construction

Contracting model	Practice	Success factors	Cost control measure	Author(s)	Constraints
Engineering, procurement, and construction (EPC) model	The contractor takes control of engineering, procurement, and construction and takes full responsibility for the quality, safety, construction cost, and construction period	1. Address time constraints in project delivery 2. Utilisation of contractors' design capabilities and technical experience 3. Single point responsibility	Preventive	Zhong (2011)	1. Enhanced difficulties in client's control of project price due to reduced participation
Engineering, procurement, and construction management (EPCM) model	The contractor takes control of the designing and management of the project for the client on a reimbursable basis	1. Pays on actual costs basis at pre-agreed rates 2. Multiple point responsibility	Organisational	Fentona, et al. (2016), Altemirova and Burenina (2021), Chattopadhyay and Mo (2010)	1. The client bears responsibility for cost overruns and outturns 2. Not ideal if social and technical issues characterise the client
Project Management Contractor (PCM) model	The client engages a contractor or a project manager to assist with management aspects of the project delivery process	1. Efficient project management 2. Efficient cost estimation strategies 3. Efficient knowledge-sharing management 4. Realistic correlation between cost and quality	Organisational	Tatum (1979), Golini, et al. (2017)	1. It does not guarantee the overall price or quality of the project
Early Contractor Involvement (ECI) Model	Involves procuring a contractor in the preliminary design stage of the project	1. Allows for contractors' contribution and influence on a major decision 2. Transfer of manageable risks to the contractor	Organisational	Wondimu, et al. (2016), Walker and B. Lloyd-Walker, (2012), Finnie, et al. (2018), Penn, et al. (2017), Opoku and	1. Late consideration of price elements creates an opportunity for price manipulation in the second stage

		3. Enhanced understanding between client and owner		Ibrahim-Adam (2018), Botha, et al. (2020), Lefebvre and McAuley (2019), Sanchez, et al. (2015), Botha and Scheepbouwer (2015)	2. The approach focuses on establishing better relationships and increased understanding among parties 3. The contractor's interest in participating is dependent on compensation amounts

Source: Authors' compilation

Initiating procurement quality controls generates improved competitiveness from a price viewpoint through the value-added competencies of the procurement function. In construction, procurement quality controls allow for significantly high procurement performance, leading to the best possible price to meet the client's needs (Munyimi, 2019). However, procurement functions in the public face numerous challenges (See Table 4). Unique challenges include a significant lack of empirical research on the impact of public procurement systems on price or cost levels in the construction sector. Gray et al. (2020) argue that current procurement decisions are too focused on cost minimisation at the expense of stakeholder value. They propose a new approach known as "total value contribution" (TVC) as an extension of "total cost of ownership" (TCO) methods that broaden the factors during a procurement exercise. They argued that putting value first through procurement would increase organisational outcomes.

Table 4: Challenges faced by public procurement

Challenge(s)	Author
Failure to implement a procurement system	Fourie and Malan (2020)
Inadequate policy and lack of innovation	Uyarra and Flanagan (2009)
Inability to implement change management	Ateto et al. (2013), Mohamed (2016)
Poor organisational structures and processes	Tsuma and Kanda (2017)
• Poor procurement planning • Lack of procurement competence	Onyango (2014), Musa, et al. (2014), Ambe and Badenhorst-Weiss (2012)
Inadequate specifications	Munyimi (2019)
Corruption	Eyo (2017), Ambe and Badenhorst-Weiss (2012)
• Excessive Bureaucracy • Political interference	Boatemaa-Yeboah (2019), Sukasuka and Manase (2016), Musa, et al. (2014)
Inadequate or lack of ICT infrastructure	Riziki (2018), Modisakeng, et al. (2020), Maleki, et al. (2020)
Failure to ascertain value for money	Sukasuka and Manase (2016)
Poor organisational culture	Musa, et al. (2014), Kiama (2014)
Lack of project management skill	Kabanda, et al. (2019)
Poor resource allocation	Hamza et al. (2016)
Lack of transparency	Anane and Kwarteng (2019), Pooe, et al. (2015)
• Lack of training • Lack of capacity • Failure to comply with procurement policies	Pooe et al. (2015)
Procurement malpractices	Kedir and Ganfure (2020)
• Lack of knowledge • Knowledge gap	Rais, et al. (2018), Ngunjiri (2019), Ambe and Badenhorst-Weiss (2012)
• Inadequate monitoring and evaluation • Noncompliance with regulations	Ambe and Badenhorst-Weiss (2012)

• Over-decentralisation of a procurement system • Lack of accountability	
• Instability generated by electoral cycles • Lack of prioritisation	Delmonico et al. (2018)
• Tendency to maintain current practices • Lack of long-term planning	Durdyev et al. (2018), Blanco-Portela, et al. (2018)

Source: Authors' compilation

2.6. Conceptual framework

The literature shows that tender price volatility is influenced by a host of qualitative factors that include but are not limited to the construction price level, procurement strategy, project management practices, project-related risks, corruption, political interferences, adopted pricing models, stakeholder management strategies, political policy, and extant legislative framework (Zulu et al., 2022; Tembo et al., 2023b). Price volatility is propagated further by a situation in which contractors have become more informed than the client (government). Contractors have an exaggerated understanding of cost impacts that create information disproportionateness with clients (Tembo, et al., 2023a). Contractors skew unit prices and enhance profits by increasing the unit price of a quantity expected to go up and lowering the unit price of a portion expected to decrease. This predicament requires the government as a client to optimise trend detection using already developed models. However, this requires empirical studies that capture the magnitude of the problem in Zambia's context. Unit price contracting is widely used in Zambia's public construction sector. Unbalanced bidding is one potential pitfall of unit price contracting (Nyström, 2015). It manifests by the client/government paying too much for the final construction product. The research will use the frameworks (both abstract and theoretical) to ascertain its academic position and make the findings more appreciable as contributing to the body of knowledge. Figure 2 presents the conceptual framework guiding this research.

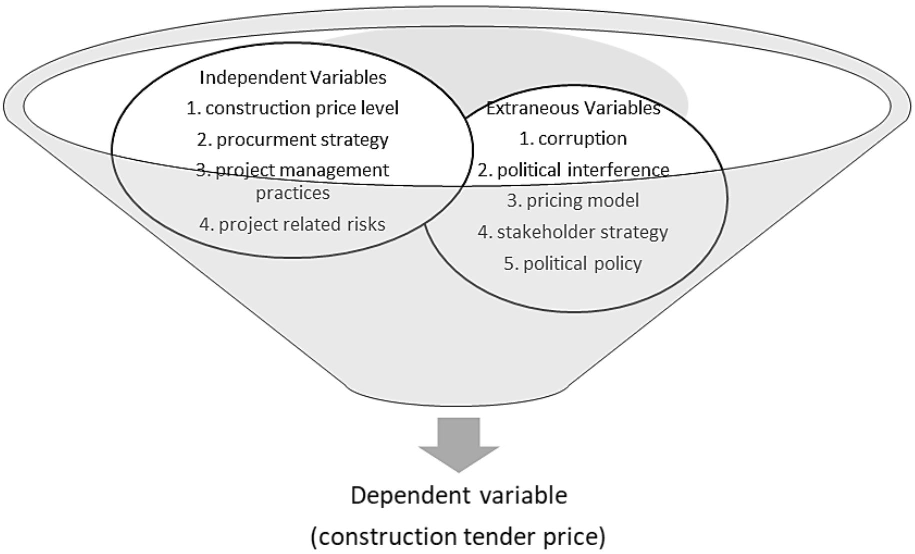

Figure 2: Conceptual Framework (Source: By the authors)

3. METHODOLOGY

The study concepts a novel public construction approach for making consistent mitigatory procurement decisions for tender price volatility. The study aims to investigate pricing behaviours regarding implementing current contracting delivery models in Zambia and develop a conceptual model for managing tender price variability in the public construction sector. The study achieved this through a comprehensive literature review and semi-structured interviews with 14 industry experts.

3.1 Sampling and sample size

The study employed a purposive sampling method to identify possible interview participants (Martínez-Mesa et al., 2016). In addition, the research utilised snowball sampling in which existing respondents recruited or referred other respondents from among their professional acquaintances. The study ensured that the nominated subjects and the generated pool of participants exhibited traits similar to the purposively sampled ones. Table 5 shows the details of the interview participants. The study utilised person-to-person interviews to collect data from 14 interviewees identified respondents through purposive sampling for better insights and a more thorough investigation. It allowed information collection from the best-fit participants to attain relevant results for the research context. The adopted method presented the study with information-rich participants and cases regarding issues of central significance to the phenomena of inquiry. The study transcribed recorded interviews for coding and eventual analysis.

All respondents were construction project managers with a holistic understanding and experience regarding the construction sector and its various aspects. The selection of respondents reduced the selection bias while improving the representativeness of the sample categories. Among the respondents, one had a PhD, two had bachelor's degrees, and eleven had master's degrees. Practical research shows that a qualitative sample of twelve (12) interview participants was adequate to reach theoretical data saturation (Braun and Clarke, 2016; Boddy, 2016; Guest et al., 2006). The selection method for the inclusion of participants for research interviews defined the characteristics of potential participants in the study. The criteria ensured the participants were relevant enough to provide the necessary information to address research objectives. The requirements were as follows:

i. Age of the participant – All participants were required to be old enough to provide legal consent, typically above 18 years old.
ii. Professional past of the participant – The study considered relevant construction-sector details about participants' professional and personal lives. Ensured that participants were essentially actively practising professional aspects related to the construction sector
iii. Academic qualifications – The study verified participants' academic qualifications or educational background to ensure they had at least a bachelor's degree related to aspects of the construction sector.
iv. Active years of practice – The study included participants with at least ten years of practice within the construction sector. Therefore, the study evaluated people in the construction sector-related fields for more than ten years.
v. Management position of the participant - The participant owns a construction-sector-related company or has been in senior management for a period longer than five years

3.2 Data collection technique

The study adopted qualitative research that followed an exploratory design to understand decisions and opportunities regarding construction-tender price inflation. The technique allowed the study to focus the collection of data on a small number of respondents by asking questions through open-ended person-to-person interviews and observing the behaviour of respondents. This approach was essential in ensuring timely data collection and accuracy and gaining rich-preliminary insights. The exploratory research design was significant for the study to understand the phenomenon and define the problem precisely (Sreejesh, et al., 2014). The study deployed unstructured procedures for primary data collection, including in-depth interviews and project procurement techniques. The discussions used direct techniques to obtain data on respondents' beliefs, feelings, and attitudes. The design assisted the study in probing for attitudinal and behavioural data encompassing all past, present, and future periods by turning respondents' answers into related detailed questions. The interviewing techniques utilised in this study included:

i. laddering – which allowed the study to discover meanings and psychological and emotional motives that affected the respondents' decision-making behaviours (Veludo-de-Oliveira, et al., 2006)
ii. hidden-test questioning – which focused on finding share-social values, personal beliefs, and attitudinal concerns (Buschle, et al., 2021)
iii. symbolic analysis – which utilised deductive reasoning to unravel symbolic meanings associated with construction-tender prices (Lune and Berg, 2017; Bengtsson, 2016)

The study utilises an ontology of a social world populated by human beings with thoughts, meanings, and interpretations. Thus, the study used interviews as an interpretive design to obtain respondents' experiences, inner thoughts, and feelings. The study assumed a realist ontological (inner-world focus) assumption of a physical world influenced by cause and effect (Berryman, 2019). The research believed in the existence of realities that affect construction tender price inflation and hence emphasised exploring circumstances related to what happened or what was happening to seek explanations. The study intends to predict what might happen in the future of construction following certain-specific interventions.

3.3 Data analysis

The descriptive data analysis utilised abductive and deductive reasoning through systematic, iterative searching and integrating data, as shown in the detailed research onion in Figure 3. The research attempted to describe the meaning of findings from the respondents' perspective and develop significant generalisations from a limited number of experts and specific experiences. The study attempted to explain specific factors, away from those in the broader economy, contributing to construction tender price volatility and underscore how such connections or relations occurred. To propose strategies for addressing construction tender price inflation demanded providing a factually accurate viewpoint of participants concerning the characteristics and nature of their relationships in the construction market. The study presented the findings as verbal accounts and narratives of lived experiences gathered through interviews. The study utilised thematic analysis of key informant interviews to extract impact mitigations and envisaged policy measures.

The positivist approach supported the research to achieve its objectives without the need to interfere with the study phenomena. In addition, it allowed the researchers to isolate the phenomena and ensured the repeatability of observations by manipulating variations within independent variables. The positivism philosophy was suitable for the study to allow for the generation of consistent and empirically established findings and to pursue an understanding and observation of a reality that consists of discrete occurrences by accepting that knowledge is derived from experience. The research denied any non-experienced theoretical notions through logical positivism, excluding value judgments for validity purposes. Consequently, through this philosophy, the study made the following assumptions (Kivunja & Kuyini, 2017):

i. Experience alone informed scientific knowledge.
ii. Direct application of methods of natural sciences to explain the social world.
iii. The subject matter of the study consisted of studying a reality external to itself.
iv. Expert normative statements had the status of knowledge.
v. Pursuance of technically practical knowledge.

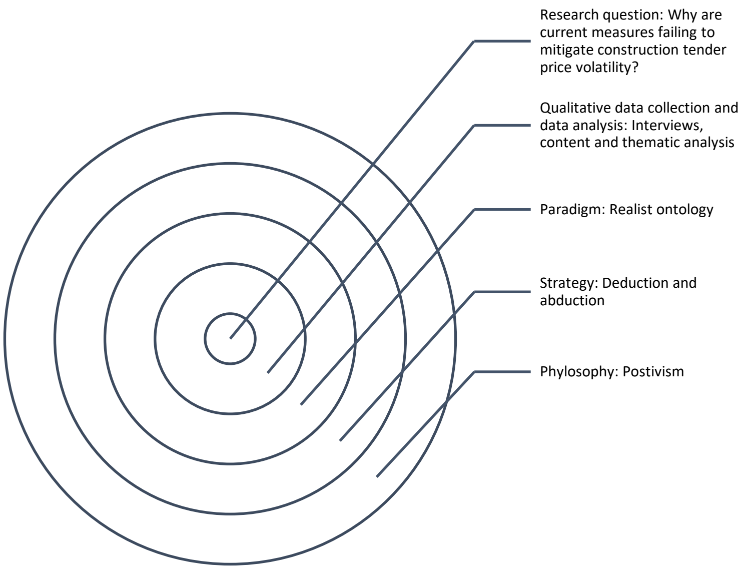

Figure 3: Research onion (Source: By the authors)

The study utilised a qualitative research design to answer the following research questions:

i. What strategies can the government use to address construction tender price inflation?
ii. How can we address construction tender price volatility in Zambia?

The study adopted qualitative research that followed an exploratory design to understand decisions and opportunities regarding construction tender price inflation. The technique allowed the study to focus the collection of data on a small number of respondents by asking questions through open-ended person-to-person interviews and observing the behaviour of respondents. This approach was essential in ensuring timely data collection and accuracy and gaining rich-preliminary insights.

Table 5: Participants for research interviews

S/N	Description	Age	Academic qualification/Highest level of education	Experience (years of practice)	Area of Practice/Expertise	Recommended by
1	Purposive Participant 1	47	Bachelor of Engineering (Civil and Environmental Engineering)	22	Civil engineering consultant	Researcher
2	Purposive Participant 2	40	MSc Project Management	18	Contractor	Researcher
3	Purposive Participant 3	65	MSc (Construction Management and Economics)	40	Quantity surveying and Construction management	Researcher
4	Purposive Participant 4	52	Bachelor of Engineering (Civil and Environmental Engineering)	27	Civil Servant/Public Infrastructure-Based Institution	Researcher
5	Purposive Participant 5	42	• MSc Business Management	17	Contractor	Researcher

			• Bachelor of Engineering (Civil Engineering)			
6	Purposive Participant 6	39	• MEng Construction Management • BSc Architecture	15	Architectural consultant	Researcher
7	Purposive Participant 7	51	• MSc Project Management • BSc Building Science	25	Quantity surveying consultant	Researcher
8	Purposive Participant 8	63	• MSc Architecture • PGDip. Project management and Building Law • BSc Architecture	30	Architectural consultant	Researcher
9	Purposive Participant 9	49	• MSc Logistics and supply chain management • BSc Procurement management • Dip. Chartered Institute of Purchasing and Supply	22	Civil Servant/Public Infrastructure-Based Institution	Researcher
10	Snowballing Participant 1	50	• Ph.D. (Transportation Economics) • MEng Civil (Pavement and Transportation) • BEng Civil and Environmental Engineering	24	Public project financing	Purposive Participant 1
11	Snowballing Participant 2	56	• MEng Civil (Pavement Design) • BEng Civil and Environmental Engineering	30	Civil engineering consultant	Snowballing Participant 1
12	Snowballing Participant 3	49	• MEng Construction Management • BEng Civil and Environmental Engineering	25	Civil engineering consultant	Snowballing Participant 2
13	Snowballing Participant 4	49	• MEng Project Management • BEng Civil and Environmental Engineering	22	Contractor	Snowballing Participant 3
14	Snowballing Participant 5	60	• MSc Construction Management • BSc Quantity Surveying	35	Quantity surveying consultant	Purposive Participant 7

4. FINDINGS

The study identifies four categories of pricing behaviours demonstrated by contractors during tendering, as shown in Table 6. These behaviours provide insights into construction tender-price inflation arising from industry and client-specific features. The pricing behaviours include resistance (PB1), reactive (PB2), anticipatory (PB3), and Consultant-based (PB4). Consultant-based (PB4) pricing was the least practised behaviour, whereas reactive (PB2) was the most established among all behaviours.

Table 6: Pricing behaviors

Bid pricing behaviour	Code	Features	Conditions for behaviour
Resistant	PB1	1. Ignoring nature and type of competition 2. Overlooking challenges 3. Contractor overconfidence	1. Single sourcing or direct bidding of contractors 2. Pre-bidding qualifications 3. Lack of competition 4. Lack of experience 5. Subcontracting
Reactive	PB2	1. Strategies regarding inflationary problems 2. Sensitivitystartegies to stakeholder interference 3. Prediction strategies against exchange rate fluctuation 4. Reaction strategies to external stimuli 5. Time strategies against delayed or non-payments 6. Strategies against client instability 7. Expectation strategies for profit erosion 8. Strategies for frontloading	1. The incompleteness of designs and tender documents 2. Poor or lack of information 3. Corruption 4. Project variations 5. Poor project management 6. Government financed projects 7. Profit maximisation
Anticipatory	PB3	1. Prediction strategies against exchange rate fluctuation 2. Client stability strategies 3. Strategies to gain competitive advantage 4. Innovation strategies	1. Donor funded projects 2. Incentives
Consultant-based	PB4	1. Stakeholder engagement strategies of competent pricing consultants 2. Policy strategies 3. Deliberate information-seeking systems 4. Strategies for reflecting market rates	1. Capacity building 2. Standardised specifications 3. Availability of historical data 4. Availability and uniformity of information

Source: Authors' compilation

Table 7 describes the characteristics of Zambia's construction tender pricing structure. Observation indicates that the pricing structure consists of five factors: client characteristics, aspects of local firms, foreign firms, the procurement process, and the project itself. The highest frequency or percentage designates the most significant description for each factor. For example, describing client characteristics of utmost consideration in the pricing structure is failing to make timely payments (CC1) and poor project management practices (CC2). Whereas other characteristic descriptions most relevant to pricing structure include:

i. Characteristics of local firms - Difficulties in accessing local financing (LF1)
ii. Characteristics of foreign firms - Receive foreign government assistance (FF1)
iii. Characteristics of the procurement process - Lack detection mechanism for the most economical price (PP1) and,
iv. Characteristics of construction projects - Heavily affected by macroeconomic factors (CP1)

Table 7: Description of the pricing structure of Zambia's construction industry

Industry characteristic	Interview quote describing the nature of the industry	Code	Frequency	Percentage	The local contractor pricing approach
1. Client characteristics	Fails to make timely payments	CC1	12	18	increase markup and frontload
	Embroiled with political interference	CC3	7	11	increase markup
	Poor project management practices	CC2	12	18	increase markup
	General preference for foreign firms	CC8	4	6	artificially lower price
	Low appetite for infrastructure projects	CC4	7	11	increase markup
	Prone to contract breaches	CC7	5	8	increase markup
	No incentives for local contractors	CC6	6	9	increase markup
	Corruption prone	CC5	7	11	increase markup
	Lack of sector regulation mechanism	CC9	4	6	increase markup
	Public projects lack economic benefits	CC10	2	3	increase markup and frontload
	Total		**66**	**100%**	
2. Characteristics of local firms	Lack government support	LF5	5	11	increase markup
	Heavily taxed	LF2	6	13	increase markup
	Ill-equipped to compete effectively	LF6	5	11	artificially lower price
	Poor development of cost estimates	LF4	4	9	increase markup or artificially lower price
	Lack appropriate capacity	LF3	6	13	artificially lower price
	Swamped by financial pressure	LF4	6	13	increase markup and frontload
	The proliferation of unqualified and non-technical players	LF7	4	9	increase markup
	Firms not growing to become competitive	LF8	4	9	increase markup and frontload
	Difficulties in accessing local financing	LF1	7	15	increase markup and frontload
	Total		**47**	**100%**	
3. Characteristics of foreign firms	Foreign government owned	FF3	7	19	artificially lower price
	Receive foreign government assistance	FF1	10	28	artificially lower price
	Have huge capital outlays	FF2	9	25	artificially lower price
	Have tax and material rebates from their home country	FF5	4	11	artificially lower price
	Higher efficiency than local contractors	FF6	6	17	artificially lower price
	Total		**36**	**100%**	
4. Characteristics of procurement processes	Lack of preferential systems for targeting local firms	PP2	7	16	artificially lower price
	Cannot detect collusion	PP8	3	7	increase markup and frontload

	Lack of detection mechanism for a most economical price	PP1	8	18	increase markup
	Not specialised in following construction principles	PP4	5	11	increase markup
	Procurement provisions do not suit the local market	PP3	7	16	increase markup and frontload
	Documents lack clarity and incomplete designs	PP5	5	11	increase markup
	Lengthy procurement processes	PP7	4	9	increase markup
	Not adequate for construction projects of complex technical nature	PP6	5	11	increase markup
	Total		**44**	**100%**	
5. Characteristics of construction projects	Heavily dependent on imports	CP8	4	7	increase markup
	Heavily affected by macroeconomic factors	CP1	11	19	increase markup
	Embroiled with external pricing pressure	CP7	5	9	increase markup
	High cost of inputs	CP2	8	14	increase markup
	High-risk allocation	CP3	7	12	increase markup and frontload
	Lack of adequate and practical price control mechanisms	CP5	6	11	increase markup
	No basis for pricing	CP9	3	5	Increase markup
	Reducing/reduced the number of projects	CP6	6	11	increase markup
	Stalled projects	CP4	7	12	increase markup
	Total		**57**	**100%**	

Source: Authors' compilation

Further, the study utilises a theoretical approach and a hierarchical analytical process to create thematic strategies reflecting relative significance and respondents' feelings. Table 7 shows the identified turnaround strategies and their respective groupings developed through synthesis criteria driven by importance considerations. The study scored one (1) every time a respondent mentioned a strategy as part of the turnaround framework. Emergent patterns for turnaround strategies include cost estimating and financing, mitigating external and internal interferences, providing incentives, providing training, and encouraging innovations. Others include revising legislation, contextualising procurement functions, improving project management practices, predicting market forces, and guaranteeing sustainability. Given these factors, Table 8 of the study identifies a possible range of nine both existent and non-existent strategies for mitigating construction tender-price inflation, including planning management practices, stakeholder management practices, capacity management practices, capacity building practices, legal-framework modernisation, procurement management practices, project management practices, management of macroeconomic indicators and sustainable-construction management practices. The study identifies nine key turnaround strategies for addressing construction tender-price inflation, grouped into six categories to include:

i. Planning management practices
ii. Stakeholder management practices
iii. Capacity management practices
iv. Capacity building practices

v. Legal-framework modernisation
vi. Procurement management practices
vii. Project management practices
viii. Management of macroeconomic indicators
ix. Sustainable-construction management practices

Table 8: Turnaround price management strategies

S/N	Participant ID	Pattern	Key Strategy	Sub-Strategy
1	PS1 PS2 PS3 PS4 SS2 PS6 SS3 PS7 SS4 PS8 SS5 PS9	Cost estimate and financing	Planning Management	• Government to plan and design execution of projects. • Develop funding projections and ensure readily available funds • Guarantee availability of project funding • Control interest, value-related, and time-related costs • Hire experienced consultants early enough in the project stages • Develop well-informed cost estimates • Avoid the "text-book" approach when developing price indices • Ensure timely payment to contractors • Prepare project plans with robust designs and costings • Ensure that control systems like the e-GP and materials price index are realistic • Develop models for rate build-up • Utilise various professionals to develop cost norms and value engineering • Produce indices timely
2	PS1 PS4 SS2 PS5 PS8 PS9	Interference	Stakeholder Management	• Government to depoliticise procurement and construction process • Mitigate against corruption • Stabilise the cost of materials, exchange rate, and inflation on the market • Stop harmful interference in project management processes • Manage the type and extent of stakeholder involvement
3	PS1 SS1 SS2 SS3 PS8 SS5	Incentives	Capacity management	• Develop preferential Treatment Methodologies • Pay contractors for greater output • Redress unfair competition practices • Package contracts into small lots • Earmark-specific work is to be for local contractors only • Review single-sourcing or direct-bidding rules • Introduce incentives in terms of taxes and statutory obligations • Redress entry barriers into the industry • Ensure that the shareholding of construction firms contains qualified allied professionals
4	SS1 SS2 PS6 SS3 PS8	Training and innovation	Capacity Building	• Ensure that people in the sector receive training • Support research and development • Develop an apprenticeship board

				• Utilise high-value projects to train personnel
5	SS1 PS7 PS9	Legislation	Legal-Framework Modernization	• Continuously review existing legislation • Fully legislate the 20% subcontracting policy into law • Timely produce regulations to guide the implementation of laws • Review procurement policy
6	PS2 PS3 SS3 PS7 PS8 PS9	Procurement function	Procurement Management	• Develop better mechanisms for pre-qualification criteria • Allow contractors to state the margin of profit on the project • Make procurement law more responsive to local needs • Subscribe procurement function to best and better practices • Cancel projects whose contractors manage without referencing their bidding documents • Ensure to award to the correct contractor • Establish a department or supreme organ to address all government procurement-related functions, including complaints, final-reporting, professional well-being of procurement officers, and appointment of officers
7	PS3 SS2 PS6 SS3 PS7 PS8	Project practices	Project Management	• Develop project management skills • Develop proper infrastructure governance mechanisms • Develop principles that reflect the value of time • Prevent deliberate government contract-breaches • Develop standards for infrastructure project implementation • Handle projects professionally • Ensure that project key personnel are professionals • Refer to the contents of the bidding document rather than concentrating on the general conditions of the contract alone
8	PS6 PS7	Market forces	Management of macroeconomic indicators	• Regulate the market in terms of the cost of materials • Stabilise inflation and exchange rate
9	PS5 PS7 SS4 PS8	Sustainability	Sustainable construction Management	• Develop standards for facilities management • Ensure global competition does not hinder the growth of local firms • Optimise bulk procurement of imported materials • Setup adequate and cost regulated material's producing plants • Redress incursion of no-professionals into the construction industry

Source: Authors' compilation

5. DISCUSSION

The study agrees with Joukar et al. (2017) regarding integrating strategies to manage tender price volatility in the construction sector. They found that risk management and incorporating price adjustment clauses were essential to mitigating tender price variability. The study further concurs with Weidman (2010) that price volatility harms the fundamental economic assumptions of a construction contract. The research by Tembo et al. (2023a) highlights the harmful impacts of tender price variability and inflation on the construction sector. They argue that tender price volatility causes an unpredictable business environment, reduces the number of public projects, reduces value for money, and compromises the quality of work. Like Joukar et al. (2017), the findings show the complexities of establishing adequate controls for managing construction tender pricing. Correspondingly, construction models present corrective, preventive, and organisational measures for cost control while lacking a predictive approach that can effectively begin to ensure advanced tender price control. The study agrees with Azizi and Aboelmagd (2019) that most research fails to establish a balance that improves profitability while reducing prices. Nový et al. (2016) argue that a precise determination of construction tender price is essential for project success. However, the process is tedious and insists on developing correct tools for pricing based on a specific situation.

The study further argues that attaining institutional goals is achievable by mitigating construction tender price inflation. Target goals in this implementation schedule include improving cost estimating and project financing, managing stakeholder interference, developing local-firm incentives, developing training programs and encouraging innovation, reviewing legislation, contextualising procurement function, improving project practices, stabilising market forces, and adopting sustainable construction practices. On the other hand, it shows that public institutions in developing countries like Zambia have failed to weave together pragmatic strategies for addressing public construction tender price inflation. The model proposes strategies and a guideline to assist the government in providing the needed support and contractors to develop consistent and logical tender prices. The model intends to prioritise tender price inflation management by enhancing strategies related to government and local contractor aspects.

The study also observes an application gap for construction regarding using price control incentive mechanisms. The findings further agree with Zhang and Jian-li (2016), who highlight the fundamental benefits of price-control incentives by developing an incentive-regulation model. The study findings show that governments can maximise social gains from an infrastructure project by deriving accurate technical parameters and optimising procurement. Figure 4 proposes the conceptual Negotiated Construction Approach (NCA) for public projects, summarising and weaving together identified strategies. The phasing of the vital system begins with the most critical:

i. Planning management (Engineering)– to be the first and most important strategy
ii. Capacity management – to be the second most important strategy
iii. Stakeholder management – to be the third most important strategy
iv. Procurement management– to be grouped as the fourth most crucial strategy
v. Project management – to be the fifth most important strategy
vi. Capacity building– to be grouped as the sixth most important strategy
vii. Modernising legal framework – to be the seventh most crucial strategy

A theoretical perspective of this study expands the current knowledge by providing valuable insights into the contractors' perception of the public construction sector, procurement methods, and client conditions. For instance, the study reveals that contractors increase price markups when there are difficulties in accessing local financing. It was also true when the client lacked a detection mechanism for the most economical price and was heavily affected by macroeconomic factors. Concerning the study area, the findings and corresponding conceptualised model apply to the wider developing world, especially Africa, whose infrastructure development is heavily public sector oriented. The conceptual negotiated construction approach focuses on developing life-cycle prices and costings for best-value-for-money in the public sector. However, the model requires further validation to ascertain its applications in country-specific settings. The model covers the gap between the planning and execution of public construction projects by consolidating procurement risk assessment and contracting strategy development. The benefits of the contracting model include ensuring the best value for money, avoiding unjustifiable and unnecessary procurement, better allocation of public resources, enhanced communication, development of a live process with feedback mechanisms, and an understanding of tender price-associated risks.

More specifically, this research explores sector tender-pricing problems worthy of widespread public and political attention to influence sector-based policy. Therefore, this study focuses on identifying specific parameters for constructing a model for addressing the current and imminent critical tender-pricing issues in the Zambian public construction industry. Additionally, the research provides comprehensive possible future direction with pragmatic perspectives toward resolving interminable sector challenges. Tembo et al. (2023a) argue that tender price variableness is a pervasive problem, especially in public construction projects, since several internal and external factors are responsible for the trend. On that premise, this research further models a process that assists a government in predicting tender price patterns in advance. The model helps the public sector plan for the construction workload, improving the construction market's stability.

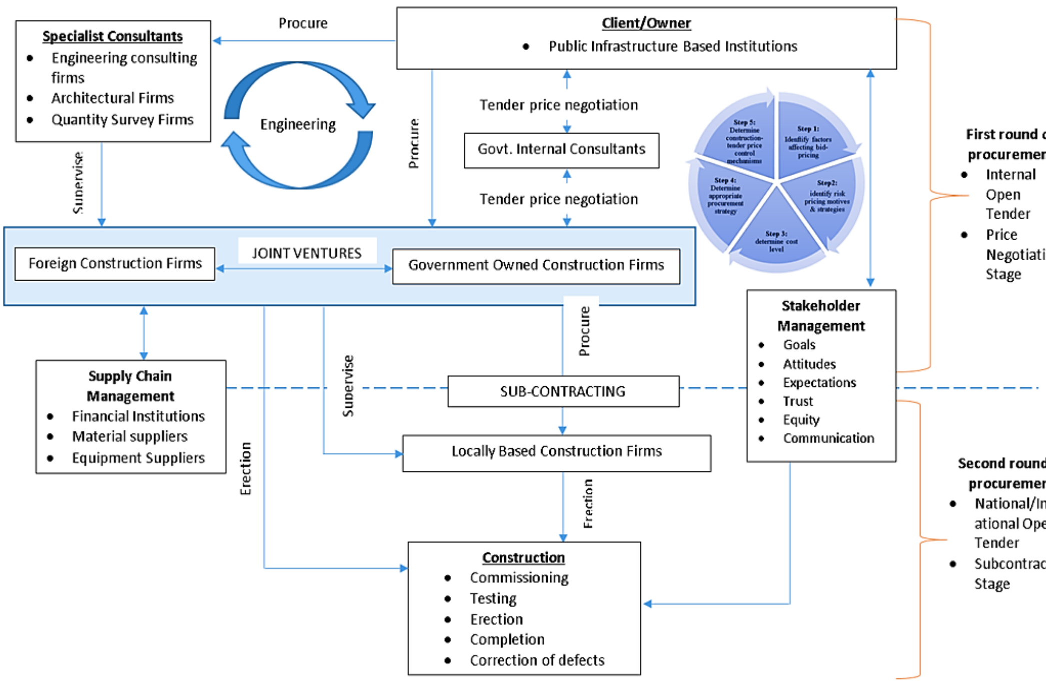

Figure 4: Conceptual negotiated construction approach for public projects (Wondimu et al., 2016; Walker and B. Lloyd-Walker, 2012; Finnie et al., 2018; Penn et al., 2017; Opoku and Ibrahim-Adam, 2018; Botha et al.,2020; Lefebvre and McAuley, 2019; Sanchez et al., 2015; Botha and Scheepbouwer, 2015)
(By the authors based on a literature review and research findings)

6. CONCLUSION

Contractors use price to mitigate procurement and client-related risks at the tendering stage. The trend requires developing and implementing procurement strategies that consider price control implications at the project tendering phase, leading to the development of contract delivery models that inadequately address the impact and potential value of pricing in construction projects. Therefore, strategies to overcome tender price volatility need a model that presents corrective, preventive, and organisational measures and a predictive approach to effectively ensure advanced tender price control. This study provides valuable knowledge and insights into the contractors' perception of the public construction sector, procurement methods, and client conditions. The study reveals that contractors increase price markups when there are difficulties in accessing local financing. It was also true when the client lacked a detection mechanism for the most economical price and was heavily affected by macroeconomic factors. The study further offers the conceptual negotiated construction approach that focuses on developing life-cycle costs and costings for the best value for money in the public sector. However, the model requires further validation to ascertain its applications in country-specific situations.

6.1 Practical implications

This study implies adding a novel contracting model to the ones shown in Table 3. The proposed contracting model specifies using a two-round procurement approach and establishing two classes of relationships between contractors and clients. The model also identifies the pre-conditions that contractors and clients must meet in the price negotiations and subcontracting stages. The model focuses on aligning the financial goals between the client and contractor through tender price negotiations. The model allows for the early elimination of adversarial relationships emanating from traditional contracting models. This contracting model is rooted in early price negotiation, thereby permitting exploring a concept of "preventative diplomacy" that is rarely applicable in construction.

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Assessing innovative tools and techniques for managing knowledge in construction firms in Nigeria

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ABSTRACT

The construction industry is plagued with projects that are often complex, involve numerous risks and require the input of several stakeholders. Therefore, there is a need to help organisations identify, assess, and manage these risks, reducing the likelihood of project delays, cost overruns, and other problems faced in the industry through effective Knowledge Management (KM). Previous studies on knowledge management and its practices in construction firms have dealt extensively with identifying these practices, how KM practices are carried out, and their importance to better construction performance and service. However, these studies have yet to recognise and discuss the innovative ways knowledge is managed. The practices of knowledge creation, acquisition, transfer, storage and use have seen recent developments in how they are being carried out, and this is primarily a result of the application of Information Technology (IT) to construction. The study sought to assess the innovations in KM practice in construction firms in Lagos state, Nigeria. The specific objectives were to assess innovative KM practices carried out by construction firms and examine the innovative tools and techniques for managing knowledge in construction firms. A quantitative research method was used in this study. The targeted population was construction professionals in construction firms. Data collection was through a structured questionnaire administered to the targeted population, and a response rate of 62% was achieved. The data was analysed using statistical tools. The study revealed that knowledge management is particularly important to the construction industry, and there is a need to improve and invest in knowledge management practices through adopting Information and Communication Technology (ICT) to improve project delivery and performance. The study recommended that construction firms be open to learning and adopting innovative ideas, tools and techniques to ensure that knowledge is properly managed.

Keywords: Construction firms, Innovations, Knowledge Management, Nigeria

1. INTRODUCTION

Construction firms must recover all relevant knowledge before the commencement of new projects to better estimate the time, costs, quality and sustainability of projects (Heisig et al., 2016). It is, therefore, critical for construction firms to transfer data and information from projects completed in the past, as this helps to ensure better project delivery as improvements are made on successes and corrections on mistakes. Tengan et al. (2014) noted that the construction industry is recognised as a knowledge centre. However, there have been issues with the comprehensive capture and management of project knowledge for growth and competitiveness.

The construction industry is plagued with complex projects that involve numerous risks and require the input of several stakeholders (Fischer & Kunz, 2017). Therefore, a need has been aroused to help organisations identify, assess, and manage these risks, reducing the likelihood of project delays, cost overruns, and other problems faced in the industry through effective Knowledge Management (KM). According to Elfar and Elsaid (2017), most organisations, including construction companies, have a competitive advantage depending on the knowledge available to them. Lee et al. (2016) noted that construction firms all over the world have identified the need to improve and implement best practices to improve their performance in order to improve the quality of project delivery, savings in cost and increase efficiency in service delivery. Therefore, good KM practice is critical for the success of construction projects. Innovation has become fundamental for all industries and countries due to its contribution to national economic growth, competitiveness, and higher living standards. This makes it a complex phenomenon with a wide range of inputs and outputs creating diverse impacts on performance at the company, sector and national level (Blayse & Manley, 2015). Paul et al. (2015) noted that innovations in knowledge management can be facilitated by providing employees with access to best practices, lessons learned, and other relevant knowledge. This can help construction firms identify new opportunities and improve their products and services. Technological tools play a critical role in ensuring innovations in KM practice, as new technologies and tools can facilitate knowledge sharing, collaboration and learning, leading to the development of new KM approaches (Alshamrani & Bahattab, 2018).

Al-Debei et al. (2015) noted that the construction industry is inherently complex, and effective knowledge management can be challenging due to fragmented information, diverse stakeholders and various disciplines involved. Therefore, innovations in KM, particularly in the area of Information and Communication Technology (ICT), have the potential to improve KM processes and outcomes in the construction industry. Previous studies carried out on knowledge management and its practices in construction firms have dealt extensively with identifying what these practices are, how KM practices are carried out and their importance to better construction performance and service. However, these studies have yet to recognise and discuss the new innovative ways that knowledge is being managed. The practices of knowledge creation, acquisition, transfer, storage and use have seen recent developments in how they are being carried out, and this is primarily a result of the application of Information Technology (IT) to construction. Therefore, this study will look into the innovative tools and techniques used to carry out KM practices in construction firms in Lagos state, Nigeria. Most of the ways of carrying out KM practices are either outdated or not as effective as they used to be due to the growing competition in the construction industry, and so innovative ways are being developed to stay competitive and meet the growing demands of clients.

Shujahat et al. (2019) affirmed that organisations with superior knowledge management practices are likely to achieve greater organisational performance. As a result, it is expected for construction firms to improve on their knowledge management practice to improve project performance and delivery. Several studies have been conducted on knowledge management in construction. Adegbembo et al. (2015) established that Quantity surveying firms were aware of the KM practice in construction; however, knowledge maintenance was lacking in most firms. The study recommended that QS firms should develop and implement a proper knowledge policy that will act as a guide for the organisations to direct their staff in managing knowledge and their application for effective practices. Oludolapo and Mohammed (2019) explored the barriers, benefits and capabilities of knowledge management for construction professionals. The study recommended that construction firms should pay keen attention to time management and the development of appropriate methodology that will foster KM implementation, and professional bodies should collaborate with government parastatal and construction firms to train professionals on KM. However, no such study focuses on the innovations and innovative tools and techniques in knowledge management. The study sought to assess the innovations in KM practice. The specific objectives were to assess innovative KM practices carried out by construction firms and examine the innovative tools and techniques for managing knowledge in construction firms.

2. CONCEPT OF KNOWLEDGE MANAGEMENT PRACTICE IN CONSTRUCTION

In the Construction industry, it is critical to transfer data and information from projects completed in the past; this helps to ensure better project delivery as improvements are made on successes and corrections on mistakes. Construction firms must recover all relevant knowledge before the commencement of new projects to better estimate the time, costs, quality and sustainability of projects (Heisig et al., 2016). Using this framework, construction firms are expected to reduce time, costs, delays and increase quality, efficiency and sustainability. Handzic and Durmic (2015) noted that construction organisations have utilised the project management tools in project planning and execution to achieve project management performance outcomes in terms of time, cost and quality. It was concluded that the construction industry uses a considerable number of knowledge workers and implementing KM for project planning and execution is the key to sustaining the growth of construction organisations and industry, particularly when KM implementation is linked to project performance outcomes. Research studies have shown that, while the construction industry is recognised as a knowledge centre, there have been issues with the comprehensive capture and management of project knowledge for growth and competitiveness (Tengan et al., 2014). It was concluded that to effectively incorporate KM, the organisational framework of construction policies must be considered. By comprehensively identifying and integrating the resources and expertise of project team members, knowledge management will greatly improve the institution's overall resolution capacity. Geisler and Wickramasinghe (2015) shared their dissatisfaction with the industry's challenges, which include a lack of KM system, a lack of managerial guidance and a misperception of KM practices.

Knowledge management is defined as the explicit and effective management of important knowledge and its related practices of identification and exploitation (Ngah, 2016). Alaarj (2016) identified that effective knowledge resources make up knowledge capability among organisations with the help of knowledge sharing, knowledge creation, innovativeness, and knowledge absorption. Therefore, when these resources merge, it determines the KM practices, which ultimately turn into a relationship with organisational performance. KM is a systematic, organised and continuous process whose objectives are to increase competitiveness, promote organisational learning and preserve knowledge (Kim, 2014; Liu et al., 2019). It is applied throughout the organisation, adapting to policies and always requiring monitoring and evaluation. Good knowledge management becomes a competitive strategy because it works on learning from previous lessons, avoiding mistakes and repeating successes (Dong & Ni, 2018). Akhavan (2016) stated that knowledge management practices such as knowledge sharing, knowledge acquisition, and knowledge application contribute to innovation, which helps to improve organisational performance. KM practices in construction firms involve the systematic identification, acquisition, organisation, sharing, and application of knowledge to improve project performance, enhance organisational learning, and foster innovation within the construction industry. These practices aim to capture both tacit and explicit knowledge and facilitate its effective utilisation throughout the organisation.

2.1 Innovations in knowledge management practice in construction firms

Innovation not only represents the creation of new things, but, it can also be considered within the adoption, adaptation and modification of processes as well as the management and organisation of work (Pellicer et al., 2015). Lindgren et al. (2018) considered it an advanced activity, in both the scientific and technical aspects, that requires more complex communication processes. Small companies in the construction sector have the characteristic of being more disposed to innovation; this is because of their proximity to suppliers, which are sources of knowledge that can be captured, as identified by Hartono et al. (2019). Also, they can more easily strengthen their organisational learning without the need for excessively institutionalised management, as a precursor of innovation processes (Wen & Qiang, 2016; Ni et al., 2018). Innovation being an advanced activity implies being holistic, continuous and systematic, which means, integrating both process and people, thus eradicating the isolated perception of it (Sujan et al., 2020).

The present-day society relies on Information and Communication Technology (ICT) tools to manage intangible and tangible knowledge; this implies that ICT has the capacity to support KM through its multiple technologies, which combine microelectronics, computer hardware and software, telecommunications, and optoelectronics, such as microprocessors, semiconductors and fibre optics, which enable the processing and the storage of large amounts of information, as well as its rapid dissemination through computer networks (Ngenge, 2013). It was concluded that knowledge needs to be managed because it is at risk of becoming extinct if appropriate measures are not taken to preserve and manage it. ICT plays a significant role in creating knowledge as well as its management. In this regard, ICT systems provide useful tools for creating and capturing knowledge as well as its application (Sarlak, 2018). Forati (2018) discussed that ICT comes with a variety of capabilities, such as archiving, transferring and sharing of information. In addition, these tenets enable efficient and effective classification of information and its dissemination. Lopez et al. (2015) identified that ICT assists individuals and organisations with information. However, the relevance and usefulness of that said information need to be first confirmed and determined by the people. ICT assist in knowledge creation and in other KM practices. Consequently, the proper ICT infrastructure is required as a precursor to successful KM (Afrazeh, 2017). In this regard, strategic use of ICT becomes a necessity to keep abreast of globalisation and the rapid changes in the workplace. Therefore, organisations should strive to establish knowledge management systems that utilise ICT systems to enhance the creation, acquisition, transfer, storage and application of information/knowledge. The innovations in knowledge management practices are discussed below.

2.1.1 *Knowledge creation*

Knowledge creation consists of the generation of new knowledge or replacing content that already exists with new explicit or tacit forms of knowledge (Swartbooi, 2010). Although paper-based knowledge is still relevant, it was concluded that cognitive workload and memory measures are replaced by the use of a computer and electronic-aided tools. Lamproulis (2017) noted that technology plays a significant role in enhancing the creation of knowledge in organisations. Thus, the adoption of ICT enhances the efforts of staff to increase the speed and efficiency of work.

2.1.2 *Knowledge acquisition*

An organisation's ability to acquire, synthesise, manipulate and exploit knowledge has been considered paramount to efficiently working on projects and improving organisational performance (Anumba, 2011). According to Vanyzk (2014), the traditional knowledge acquisition process involves observing the person solving real problems, through discussions, identifying the kinds of data, knowledge and procedures required to solve different types of problems, through building scenarios with the expert that can be associated with different problem types, have the expert solve a series of problems verbally and ask the rationale behind each step. Blick and Grit (2019) identified in their research on innovative processes of knowledge acquisition that knowledge can be acquired with the aid of ICT tools such as online Libraries, digitalised past project reports and project review meetings.

2.1.3 *Knowledge transfer*

According to Alashwal and Abdul-Rahman (2014a), knowledge transfer is the flow of knowledge from a source to a receiver for assimilation and reuse based on previous experience. Innovation in knowledge sharing/transfer is encouraged through tape/voice recording, videos and film reels, as identified by Kremer et al. (2019). Knowledge can be transferred as well through collaborations within the organisation and with other organisations (Adams et al., 2017).

2.1.4 *Knowledge storage*

Knowledge that has been created should be captured and stored in formats that allow reuse because organisations may create knowledge, generate ideas and learn from experiences, but this knowledge is bound to be forgotten and lost if not captured and stored (Swartbooi, 2010). Shen (2016) also identified other innovative systems for storing knowledge, such as Document management systems that are used to store and manage a wide range of knowledge assets, including project plans, technical documents, and best practices; Cloud-based storage systems used to store and assess data and can be accessed from any device with an internet connection; Big data, for analysing large sets of data. With this, organisations can gain insights and identify patterns and trends that can inform decision-making and improve performance.

2.1.5 *Knowledge use/application*

According to Ni et al. (2018), the application of knowledge is the direct aim of KM, which leads to improvement in working efficiency and the enhancement of work results. With knowledge application, an organisation is able to become more innovative, which leads to the creation of more new knowledge, which enables the continuation of the KM process. The innovative ways of applying knowledge are seen in the use of current ICT tools such as GIS, robotics, BIM, Project Management software, knowledge portals and other ICT performance tools as identified by Forati (2018).

2.2 Innovative tools and technique for managing knowledge in construction firms

Innovative Management Tools and Techniques (IMTTs) have a wider and more accurate consideration and have been defined as a range of tools, techniques, and methodologies that help companies adapt to circumstances and meet market challenges in a systematic way (Hidalgo & Albors, 2008). IMTTs result from a new way of thinking and are49related to the capacity of firms to apply their knowledge to improve their businesses internally and their relationship with external actors (Albors, 2015). Al-Khaldi and Koushki (2019) noted that intranet infrastructure facilitates the sharing of knowledge and information among employees, leading to improved project performance and reduced errors. Intranet infrastructure also provides a platform for collaboration, which enhances teamwork and promotes innovation. Additionally, intranet infrastructure allows employees to access information and knowledge anytime, anywhere, thereby improving decision-making processes and reducing project delays. Intranet infrastructure provides basic functionality for communication through means such as email and teleconferencing and also enables storage, sharing, searching and retrieval of knowledge, documents and data (Zanjani & Moghaddam, 2016). Intranet infrastructure has been recognised as a powerful tool for knowledge management innovation in the construction industry.

Bock et al. (2018) noted that Artificial intelligence (AI) technologies can analyse large volumes of data to identify patterns and predict construction projects. AI-powered virtual assistants can help construction workers access critical information in real-time; including safety procedures, project schedules, and building codes (Gheisari & Memarian, 2019). Intelligent Agents are software programs or codes that accept input in the form of a user profile indicating the information that is deemed significant in a particular job or in a specific working environment and produce the information in an easy-to-understand manner (Petter, 2015). It was further noted that, intelligent agents are rarely stand-alone programs; rather, they are embedded in other applications programs such as E-mails, Decision support systems, Groupware systems, Simulation systems, Taxonomy based systems, word processors, or scheduling programs. Project management software, which is used to plan, organise, and control construction projects, can support the application of knowledge in the construction industry by providing access to project-related information and knowledge assets (Shen et al., 2015). This can help project teams make informed decisions and manage projects more effectively.

Mobile devices have become a popular tool for knowledge management due to their portability, ease of use, and versatility. According to a study published in the International Journal of Information Management, the use of mobile devices for knowledge management is on the rise, with more and more individuals and organisations using these devices to capture, store, and share information (Ji & Lin, 2019). Mueller and Oppenheimer (2017) identified that one way that mobile devices can be used for knowledge management is through note-taking apps. These apps allow users to quickly capture ideas, insights, and information on the go. Research has shown that using a mobile device for note-taking can improve the quality of the notes taken and lead to better retention of the information. Mobile devices can also be used for task management. There are many task management apps available for both Android and iOS devices, such as Trello and Todoist, which allow users to keep track of tasks, assign deadlines, and prioritise their work (Deng et al., 2019). Another way that mobile devices can be used for knowledge management is through communication apps. Apps such as Slack and Microsoft Teams allow users to communicate with colleagues, share information, and collaborate on projects (Lee & Kim, 2019). This has helped to improve teamwork and collaboration.

3. METHODOLOGY

The study sought to assess the innovations in KM practice in construction firms in Lagos state and the innovative tools and techniques for managing knowledge in these firms. To achieve this aim, a quantitative research method was adopted. In line with the quantitative method, a survey research approach would be used for this study because it is suitable for obtaining answers from a broad population and also, it is good for gathering data from a relatively large number of respondents within a limited period.

The target population of the study comprised construction professionals from registered quantity surveying firms, architectural firms and other construction firms in Lagos state, Nigeria. The choice of Lagos is due to its high population of construction firms situated there, which enabled the obtaining of reliable and relevant data. The accessible population for the study was from the list of registered quantity surveying firms from the Nigeria Institute of Quantity Surveyors (NIQS), which indicated that 57 quantity surveying firms were registered in Lagos in the year 2022. According to FineLib.com (Nigeria Directory and Search Engine), in correlation with the Architects Registration Council of Nigeria (ARCON) and Council for the Regulation of Engineering in Nigeria (COREN), the number of registered architectural and construction firms in Lagos state in the year 2022 is indicated at 336 and 195 respectively.

3.1 Sample and sampling techniques

Convenience sampling method was used to obtain the necessary data. The reason for choosing this method is in line with the affirmation of Abrams (2010) that described the convenience sampling as a method of sampling in which respondents are picked based on convenience considering the accessibility, availability, proximity and other relevant conditions by the researcher. A total of 179 questionnaires were administered, out of which 111 responses were obtained, representing a response rate of approximately 62%. This response rate is considered acceptable since the average and the acceptable response rate is 60% ± 20% (Fincham, 2008).

3.2 Data collection and analysis

This study used a structured, close-ended questionnaire as an instrument for collecting primary data. The questionnaires were self-administered to the various construction professionals who are concerned through direct contact with them. This was done in order to ensure relevant information is provided on the objectives of this research. Frequency and percentage were used to analyse the background information of the respondents. The background information included information such as "highest academic qualification of the respondents", "years of working experience", and other relevant information necessary to underpin the suitability of the respondents to give valid information to achieve the aim of this study. Construction professionals were requested to respond to items on innovations in knowledge management in construction and the innovative tools and techniques for managing knowledge in construction firms on a 5-point Likert scale, assessing level of awareness and level of use.

The data was analysed with the aid of Statistical Package for the Social Sciences (SPSS) software. The data was analysed by means of Mean Score (M.S), Standard deviation (S.D), Kruskal-Wallis test and Paired sample T-test. The mean score and standard deviation helped present the data in a meaningful and understandable way, thereby simplifying the interpretation. Kruskal-Wallis test, a non-parametric test used in testing the significant difference in the perception of three or more categories of respondents, was employed in assessing the relationship in the view of the three categories of the respondents as to the level of awareness and use of innovations in knowledge management practices in construction firms. The T-test helped to determine whether the mean difference between two sets of observations is a null hypothesis or an alternate hypothesis. The null hypothesis assumes that the mean difference between the paired samples is zero, and the alternate hypothesis assumes that the true mean difference between the paired samples is not equal to zero. Significance is determined by looking at the p-value; a low p-value indicates decreased support for the null hypothesis, taking the confidence level to be 95%, and the precision level is 0.05.

4. RESULTS

4.1 Demographics of the respondents

Table 1 shows the background information of the respondents. The distribution of respondents according to the type of profession of the respondent revealed that 49.5% of the respondents were Architect, Engineers were 29.7%, and Quantity surveyors were 20.7%. The distribution of respondents according to their professional qualification revealed that many of the respondents (49.5%) were ARCON/MNIA, (20.7%) MNIQS/QSRBN while (29.7 %.) were COREN/NCE. The distribution of respondents according to academic qualification revealed that 49% of the respondents were B.Sc/B.Tech, 39% were M.Sc/M.Tech, while 4% were HND and 8% of the respondents were PhD. All of the respondents (100%) had completed tertiary education. Additionally, the distribution of respondents according to professional experience, the results revealed that 34.2% were between 11-15 years of experience, 22.5% were between 16-20years of experience, 18.9% were between 6-10 years of experience, 13.5% were between 1-5 years of experience and 10.8% were above 21 years of professional experience.

Table 1: Summary of the characteristics of the respondents

Factor	Variable	Frequency	Percentage
Respondents Profession	Architect	55.0	49.5
	Quantity Surveyor	23.0	20.7
	Engineer	33.0	29.7
	Total	**111.0**	**100.0**
Years of working experience	Less than 5 years	15.0	13.5
	6 to 10 years	21.0	18.9
	11 to 15 years	38.0	34.2
	16 to 20 years	25.0	22.5
	Above 21 years	12.0	10.8
	Total	**111.0**	**100.0**
Academic Qualification of respondents	M. Tech/Msc	54.0	49.0
	B.Tech /Bsc	43.0	39.0
	PhD	9.0	8.0
	Hnd	5.0	4.0
	Total	**111.0**	**100.0**
Professional Qualification of the respondent	ARCON/MNIA	55.0	49.5
	MNIQS/QSRBN	23.0	20.7
	COREN/NCE	33.0	29.7
	Total	**111.0**	**100.0**

4.2 Innovations in knowledge management practice in construction firms

In Table 2, the mean item score was used in ranking the level of awareness of innovations in knowledge management practices in the construction industry. The Kruskal-Wallis test, a non-parametric test used in testing the significant difference in the perception of three or more categories of respondents, was employed in assessing the relationship in the view of the three categories of the respondents as to the level of awareness of innovations in knowledge management practices in construction firms. The result is presented in Table 2.

Following a similar approach to Ahadzie et al. (2008), for each of the identified processes, a benchmark of 3.5 was fixed. This implies that a level of awareness of innovations in knowledge management practices in the construction industry is being used if it has a mean of 3.5 and above, while it is not when its mean value is less than 3.5.

From the Table, it is evident that Architect identify nine (9) out of the fifteen (15) as their common awareness of innovations in knowledge management practices in the construction industry, Quantity surveyors identified twelve (12) as their common awareness of innovations in knowledge management practices in the construction industry, and Engineers identified eleven (11) as their common awareness of innovations in knowledge management practices in the construction industry due to their mean item score is high than 3.5.

The respondents were made aware of the following: Structural Design Software with a mean of 4.15, 2D/3D AutoCAD Packages with a mean of 4.77, Electronic Mails with a mean of 4.01, Word Editor Packages with a mean 4.46, Spreadsheet Package with mean 4.68, Internet (websites and social platforms) with mean of 4.57, Collaborations with other Organisations with mean of 3.53, Digitalized Past Project Reports with mean of 3.78, Tape/Voice Recordings with mean of 4.14, Cloud Computing Technique with mean of 3.99 and Augmented Reality with mean 4.21.

Kruskal-Wallis test showed that only seven (7) out of the identified levels of awareness of innovations in knowledge management practices in the construction industry are very popular in construction project performance and have a significant p-value of below 0.05. These are Structural Design Software with a significant p-value of 0.012, Word Editor Packages with a significant p-value of 0.000, Database Systems with a significant p-value of 0.001, Internet (websites and social platforms) with a significant p-value of 0.026, Digitalised Past Project Reports with a significant p-value of 0.000, tape/voice recordings with a significant p-value of 0.025 and Big Data with a significant p-value of 0.001.

Table 2: Level of awareness of the innovations in knowledge management practices in construction firms

	ARC		QS		ENG		Overall		Kruskal-Wallis	
Variables	**MIS**	**RK**	**MIS**	**RK**	**MIS**	**RK**	**MIS**	**RK**	**Chi**	**Sig.**
Structural Design Softwares	3.98	9	4.13	6	4.45	3	4.15	6	8.785	0.012*
2D/3D AutoCAD Packages	4.75	2	4.70	1	4.85	1	4.77	1	1.998	0.368
Electronic Mails	4.05	8	4.17	5	3.82	9	4.01	8	3.380	0.185
Word Editor Packages	4.73	3	4.00	7	4.33	5	4.46	4	18.226	0.000*
Spreadsheet Package	4.76	1	4.57	2	4.61	2	4.68	2	3.917	0.141
Database Systems	3.38	11	3.83	9	3.15	13	3.41	12	13.246	0.001*
Internet (websites and social platforms)	4.71	4	4.43	3	4.42	4	4.57	3	7.322	0.026*
Collaborations with other Organisations	3.40	10	3.57	11	3.73	10	3.53	11	2.871	0.238
Online Libraries	3.13	13	3.43	12	3.15	13	3.20	13	2.551	0.279
Digitalised Past Project Reports	3.33	12	4.22	4	4.09	8	3.78	10	23.417	0.000*
Tape/Voice Recordings	4.27	5	3.74	10	4.18	7	4.14	7	7.405	0.025*
Video and Film Reels	2.80	14	3.04	13	2.64	14	2.80	15	2.845	0.241
Cloud Computing Technique	4.16	7	3.91	8	3.76	11	3.99	9	5.686	0.058
Application of BIM, Robotics and Augmented Reality	4.22	6	4.13	6	4.24	6	4.21	5	0.237	0.888
Big Data	2.55	15	2.96	14	3.27	12	2.85	14	13.268	0.001*

*Significant at the 0.05 level (2-tailed)

In Table 3, the mean item score was used in ranking the level of uses of innovations in knowledge management practices in the construction industry. Kruskal-Wallis test, a non-parametric test used in testing the significant difference in the perception of three or more categories of respondents, was employed in assessing the relationship in the view of the three categories of the respondents as to level of uses of innovations in knowledge management practices in construction firms. The result is presented in Table 3.

Following a similar approach to Ahadzie et al. (2008), for each of the identified processes, a benchmark of 3.5 was fixed. This implies that a level of use of innovations in knowledge management practices in the construction industry is being used if it has a mean of 3.5 and above, while it is not when its mean value is less than 3.5.

From the table, it is evident that Architects identified twelve (12) out of the fifteen (15) as their common use of innovations in knowledge management practices in the construction industry, Quantity surveyors identified ten (10) as their common use of innovations in knowledge management practices in the construction industry, and Engineers identified twelve (12) as their common use innovations in knowledge management practices in the construction industry due to their mean item score is high than 3.5.

The respondents made use of Structural Design Software with a mean of 4.47, 2D/3D AutoCAD Packages with a mean of 4.61, Electronic Mails with a mean 4.08, Word Editor Packages with mean 4.27, Spreadsheet Package with mean 4.53, Database Systems with mean of 4.57, Internet (websites and social platforms) with mean of 4.84, Collaborations with other Organisations with mean of 4.28, Tape/Voice Recordings with mean of 4.11and Cloud Computing Technique with mean of 4.06.

Kruskal-Wallis test showed that only four (4) out of the fifteen (15) identified innovations in knowledge management practices in the construction industry are used in construction projects and have a significant p-value of below 0.05. These are Electronic Mail with a significant p-value of 0.026, Word Editor Packages with a significant p-value of 0.011, Online Libraries with a significant p-value of 0.046 and Application of BIM, Robotics and Augmented Reality with a significant p-value of 0.000.

Table 3: Level of use of the innovations in knowledge management practices in construction firms

	ARC		QS		ENG		Overall		Kruskal-Wallis	
Variables	**MIS**	**RK**	**MIS**	**RK**	**MIS**	**RK**	**MIS**	**RK**	**Chi**	**Sig.**
Structural Design Software	4.36	5	4.70	2	4.48	3	4.47	5	4.081	0.130
2D/3D AutoCAD Packages	4.64	2	4.61	4	4.58	2	4.61	2	0.052	0.974
Electronic Mails	3.89	10	4.09	8	4.39	5	4.08	9	7.279	0.026*
Word Editor Packages	4.11	7	4.65	3	4.27	6	4.27	7	8.961	0.011*
Spreadsheet Package	4.62	3	4.48	5	4.42	4	4.53	4	3.729	0.155
Database Systems	4.55	4	4.61	4	4.58	2	4.57	3	0.165	0.921
Internet (websites and social platforms)	4.84	1	4.78	1	4.88	1	4.84	1	0.916	0.632
Collaborations with other Organisations	4.16	6	4.26	7	4.48	3	4.28	6	5.120	0.077
Online Libraries	3.55	12	3.00	12	3.24	12	3.34	12	6.174	0.046*
Digitalised Past Project Reports	3.60	11	3.48	9	3.27	11	3.48	11	2.969	0.227
Tape/Voice Recordings	3.98	9	4.35	6	4.15	7	4.11	8	3.358	0.187
Video and Film Reels	3.11	13	2.96	13	3.52	10	3.20	13	5.646	0.059
Cloud Computing Technique	4.05	8	4.35	6	3.88	9	4.06	10	4.581	0.101
Application of BIM, Robotics and Augmented Reality	3.00	15	3.39	10	3.91	8	3.35	14	15.739	0.000*
Big Data	3.09	14	3.22	11	2.70	13	3.00	15	4.070	0.131

*Significant at the 0.05 level (2-tailed)

4.3 Innovative tools and techniques used in knowledge management in construction

Table 4 shows how a paired sampled t-test was used to analyse innovative techniques and tools for managing knowledge in construction, which shows the paired difference between the two variables to be compared. The paired samples t-test determines whether the mean difference between two sets of observations is a null or alternate hypothesis. The null hypothesis assumes that the mean difference between the paired samples is zero, and the alternative hypothesis assumes that the true mean difference between the paired samples is not equal to zero. Significance is determined by looking at the p-value; a low p-value indicates decreased support for the null hypothesis, taking the confidence level to be 95%, the precision level is 0.05

From the Table below Sig. (2-tailed) is also known to be p-value; when the p-value (sig 2-tailed) is greater than 0.05, that means there is no statistically significant difference between the two samples, but if the p-value (sig 2-tailed) is less or equal to 0.05, there's a statistically significant difference between the two samples. From the Table below, in the case of having 0.460 as the p-value (Sig. 2-tailed) of Decision Support Systems, this shows there is no statistically significant difference between the two samples because the p-value (Sig. 2-tailed) 0.460 is greater than 0.05. In the case of Intranet Infrastructure, in which 0.030 is the p-value (Sig. 2-tailed), there is a statically significant difference between the two samples because the p-value is lesser than the precision value, which is 0.05. These shows Intranet Infrastructure, Groupware Systems, Document Management Systems, Simulation Systems, Ontology/Taxonomy Based Systems, Knowledge Repository System and Wikis are significant among the Innovative Techniques and Tools for Managing Knowledge in Construction project.

Table 4: Innovative techniques and tools for managing knowledge in construction

Variables	Mean diff.	SD	*t*-value	Sig. (2 tailed)
Intranet Infrastructure - Intranet Infrastructure	0.171	0.819	2.202	0.030*
Groupware Systems - Groupware Systems	0.315	0.894	3.715	0.000*
Document Management Systems - Document Management Systems	0.396	1.003	4.166	0.000*
Decision Support Systems - Decision Support Systems	-0.081	1.153	-0.741	0.460
Artificial Intelligence Technologies - Artificial Intelligence Technologies	-0.027	0.899	-0.317	0.752
Simulation Systems - Simulation Systems	-0.315	1.458	-2.278	0.025*
Workgroup Support Systems - Workgroup Support Systems	-0.072	0.997	-0.761	0.448
Ontology/Taxonomy Based Systems – Ontology	0.207	0.926	2.359	0.020*
Knowledge Repository System - Knowledge Repository System	0.892	1.289	7.291	0.000*
Wikis – Wikis	-0.703	1.225	-6.041	0.000*
Social Media - social media	-0.144	1.249	-1.216	0.227
Mobile Devices - Mobile Devices	-0.234	1.314	-1.878	0.063
Electronic Networking - Electronic Networking	0.153	1.130	1.428	0.156
Knowledge Map - Knowledge Map	0.027	1.411	0.202	0.840
Bank of Ideas - Bank of Ideas	0.207	1.389	1.572	0.119
Weblogs – Weblogs	0.108	1.545	0.737	0.463
K-logs - K-logs	-0.216	1.467	-1.553	0.123

*Significant at the 0.05 level (2-tailed)

5. DISCUSSION OF THE FINDINGS

5.1 Innovations in knowledge management practice in construction firms

The objective here was to assess the innovative KM practices carried out by construction firms. From the findings as presented in Table 4.2, Structural Design Software, Word Editor Packages, Database Systems, Internet (websites and social platforms), Digitalized Past Project Reports, Tape/Voice Recordings, and Big Data were the innovative knowledge management practices that are most aware in construction firms. Also from Table 4.3, Electronic Mails, Word Editor Packages, Online Libraries and Applications of BIM, Robotics and Augmented were the major used Knowledge Management Practices in construction firms. This is in agreement with the findings of Lopez et al. (2015) and Afrazeh (2017). It was identified in their research that ICT has become a necessity in ensuring proper knowledge management practice by construction firms. Afrazeh (2017) concluded that to keep abreast of globalisation and the rapid changes in the world today, organisations should strive to establish knowledge management systems that utilise ICT systems to enhance the creation, acquisition, transfer, storage and application of information/knowledge.

5.2 Innovative tools and techniques used in knowledge management practices in construction firms

The objective here is to examine the Innovative tools and techniques for managing knowledge in construction firms. Table 4.4 shows that Intranet Infrastructure, Groupware Systems, Document Management Systems, Simulation Systems, Ontology/Taxonomy Systems, Knowledge Repository Systems and Wikis are significant among the Innovative Techniques and Tools for Managing Knowledge in Construction projects. This is in agreement with the findings of Albors (2015). It was concluded that, for construction companies to meet market growing needs and ensure better project delivery, construction firms must adopt IT tools, techniques and methodologies. IT-based systems such as groupware systems, document management systems, knowledge repository systems and taxonomy-based systems that are relevant in storing information are particularly important in improving the KM process of construction firms, as this helps to record successful ideas, procedures and techniques. It also records failures in procedures, which will be discussed to ensure that such failures are not repeated.

6. CONCLUSION

This paper has assessed the innovations in knowledge management in construction firms in Lagos state, Nigeria. Furthermore, it assessed the drivers of innovations in knowledge management in construction firms, the challenges facing innovations in knowledge management in construction and the innovative tools and techniques used in knowledge management practices as identified and evaluated from Lagos state. Through a comprehensive review of pertinent literature, fifteen (15) variables were identified for innovative knowledge management practices, and seventeen (17) innovative tools and techniques used in knowledge management practice in construction firms were identified. Results showed that respondents viewed the innovative KM practices on the level of awareness and use and the innovative tools and techniques used in KM practice on the level of awareness and use. Based on the findings, it can be concluded that;

i. The innovative knowledge management practice in construction firms is centred on the development, use and exploitation of the rapidly evolving Information and Communication Technology (ICT). This indicates that the more technology advances in the world, the construction industry will incorporate these technological changes into its activities in order to meet world standards, thereby increasing awareness and use of ICT in construction management.
ii. ICT tools, platforms, gadgets and devices are vital in managing knowledge in construction firms. The development of intranet infrastructures in construction firms will continue to improve the innovative practice of knowledge management in the industry.

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Project performance affecting claim events under the JBCC Principal Building Agreement in South Africa

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ABSTRACT
The Joint Building Contracts Committee Principal Building Agreement is the leading construction contract in South Africa, and it is common for claims to arise during projects where this agreement is used. This research aimed to investigate the claim events that most severely impact project performance under the agreement in the South African construction industry. The study employed a quantitative research approach and distributed an online structured questionnaire that was completed by 380 respondents, which included principal agent practitioners and contractors in South Africa. The collected data was analysed using descriptive statistics. The results revealed that the most impactful claim events are contract instructions, additional work, and adverse weather. On the other hand, the least impactful claim events are the exercise of statutory power, opening and testing of work, materials and goods, and the insolvency of a nominated subcontractor. This study addresses the knowledge gap around the types of claims that most severely impact project performance under the Joint Building Contracts Committee Principal Building Agreement in South Africa. It provides especially principal agents with a good base level understanding of the critical claims under this agreement, assisting them to prevent and effectively manage such claims to mitigate potential damages for all parties involved. Although this study focused on South Africa, the findings may also be applicable to users of the agreement in other contextual settings especially neighbouring countries.

Keywords: Construction claims; JBCC Principal Building Agreement; South Africa

1. INTRODUCTION
In the rapidly evolving context of developing economies, construction undertakings have a crucial function in propelling the advancement of infrastructure and economic prosperity. The success of the various construction undertakings largely hinges on the effective handling of contracts, a task that frequently encounters many hurdles especially in less developed nations. Efficient contract management is vital to ensuring projects are completed promptly, expenses are managed, quality is ensured, and risks are minimised (Charrett, 2018).

Considering the above, the CIDB (2019) highlights that the four main suites of construction contracts used in South Africa are: The Joint Building Contracts Committee (JBCC), General Conditions of Contract for Construction Works (GCC), FIDIC (International Federation of Consulting Engineers), and New Engineering Contract (NEC). The GCC, FIDIC, and NEC are forms of contract that can be used on all types of engineering and building works, while the JBCC is confined to only building works (CIDB, 2019). The JBCC, FIDIC, and NEC series of documents also contain short contract versions for minor construction works. The four series of documents jointly cover the generally encountered contracting strategies that are presently practised internationally (CIDB, 2019). Within this context, the JBCC Principal Building Agreement is widely recognised as the leading construction contract in the South African building industry (De Klerk, 2021).

According to Mukuka et al. (2015) and Prinsloo (2018; 2019), it is uncommon for construction projects to proceed without numerous claims for additional time and costs, often leading to disputes in the industry. However, there is a lack of understanding among project participants regarding the critical claim events under the JBCC Principal Building Agreement. Furthermore, empirical studies on claims in the South African construction industry remain limited, and there is a scarcity of available literature specifically addressing the topic within the JBCC Principal Building Agreement (Le Roux, 2014; Maritz and Prinsloo, 2016). Thus, the purpose of the study presented in this paper is to identify the significant claim events under the JBCC Principal Building Agreement, with a view to minimising claims and disputes from arising.

2. CLAIMS AND CLAIM EVENTS UNDER THE JBCC PRINCIPAL BUILDING AGREEMENT

This section offers a broad introduction to claims, followed by an emphasis on the specific claim events pertaining to the JBCC Principal Building Agreement. This contextual information is essential for understanding the focus of the study.

2.1 Claims

According to Rai et al. (2021), a claim refers to the action taken by a party which feels aggrieved in order to seek redress for a deviation from the agreed-upon contractual obligations. For Hewitt (2011), a claim is the assertion of a party's rights based on the terms of the contract, specifically in the construction industry, where it entails the right to additional time or payment to complete the work. Similarly, McManus Jr. and Blank (2016) describe a construction claim as a request for an extension of time or additional payment resulting from a change or event that has impacted the schedule or content of the work, leading to extra costs for which compensation is sought. Various authors in the literature identify the common sources of construction claims as follows:

- Issuing variations and instructions;
- Delayed provision of construction information;
- Delayed selection of subcontractors and suppliers;
- Modifying information and material specifications;
- Instructing the suspension of the works;
- Impact of adverse weather conditions;
- Changing access and egress routes on the construction site;
- Differing site conditions from those specified in the contract, such as unexpected physical obstacles or man-made obstructions;
- Increased work quantities beyond what was initially stated in the contract;
- Inaccurate descriptions of items in the bills of quantities;
- Amending laws of the country where the project is located; and
- Instructing the acceleration of the works to make up for lost time (Fertitta et al., 2016); Nagata et al., 2018; Burr, 2018; Prinsloo, 2020; Putlitz, 2021).

Wilson (2021) underscored that the probability of claims increases with the size and complexity of a project. Similarly, Hall (2020) and Clark (2021) emphasised that contractual conditions outline the specific circumstances under which a contractor can seek additional payment or an extension of time from the employer.

2.2 Claim events under the JBCC Principal Building Agreement

Several studies have been conducted on the JBCC Principal Building Agreement, examining various aspects such as the management of clients' strategic objectives (Richards and Bowen, 2007), the effectiveness of payment and construction guarantees (Maritz, 2008), the agreement's efficacy for contractors (Cumberlege et al., 2008), contractors' perception and evaluation of risks (Othman and Harinarain, 2009; Othman and Harinarain, 2011a; Othman and Harinarain, 2011b), the compliance of edition 6.1 with statutory requirements (Maritz and Putlitz, 2014), and the facilitation of project management through the agreement (Du Plessis and Oosthuizen, 2018; Du Plessis, 2019). However, only three studies were found that specifically focused on claims, with two exploring the methods used by professionals to analyse claims and one considering the frequency of claim events (Le Roux, 2014; Maritz and Prinsloo, 2016; Deacon and Kajimo-Shakantu, 2023). Given the limited current knowledge of claims under the JBCC Principal Building Agreement, this study aims to address this gap by conducting an opinion survey among South African construction professionals and contractors to determine the most impactful claim events under the JBCC Principal Building Agreement.

The most recent edition of the JBCC Principal Building Agreement, which is edition 6.2, published in 2018, provides detailed provisions regarding the circumstances that allow a contractor to request a revision of the practical completion date and an adjustment of the contract value, as outlined in clause 23 (JBCC, 2018). The specific claim events associated with the JBCC Principal Building Agreement are presented in Table 1. Clause 23.1 of the agreement grants the contractor the entitlement to only a time extension for the events listed, while the events listed in clauses 23.2 and 23.3 provide the contractor with both an extension of time and additional payment.

Table 1: Claim events under the JBCC Principal Building Agreement

No.	JBCC PBA Clause	Event	Description
1	23.1.1	Adverse weather	If delay is caused by climatic conditions that inhibit progress towards practical completion.
2	23.1.2	Inability to obtain materials and goods	If delay is caused by the contractor's inability to obtain the materials and goods at such time as it would be possible for him to complete the works by the due date, and he has taken reasonable steps to avoid or reduce such delay.
3	23.1.3	Making good physical loss and repairing damage to the works	If delay is caused by the contractor making good any physical loss and repair damage to the works during the construction period that is not due to his or the employer's fault.
4	23.1.4	Late supply of a prime cost amount item	If the contractor complies with instructions and is delayed by the supplier of a prime cost amount item.
5	23.1.5	Exercise of statutory power	If the execution of the works is delayed by the exercise of statutory power by a body of state or public or local authority, through no fault of the contractor.
6	23.1.6	Force majeure	If delay is caused by the occurrence of a supervening circumstance that is unforeseeable and beyond the control of the contractor as per the JBCC definition of Force Majeure.
7	23.2.1	Delayed possession of the site	If delay is caused by the failure of the employer to give possession of the site on the agreed date as contained within the contract provisions.

8	23.2.2	Making good physical loss and repairing damage to the works	If the contractor complies with instructions to make good physical loss or damage to the works for which he is not at risk (in terms of clause 8.5).
9	23.2.3	Contract instructions	If the principal agent is late to issue an instruction, or fails to issue an instruction, provided that the contractor has in writing requested such instruction.
10	23.2.4	Opening and testing of work and materials and goods	If delay is caused by an instruction to open work for inspection that has been covered up and/or provide samples of work, materials, and goods to be tested, and the work, materials and goods are found to conform to the contract.
11	23.2.5	Late or incorrect issue of construction information	If delay is caused by the late or incorrect issue of construction information by the principal agent.
12	23.2.6	Late supply of free issue materials and goods	If delay is caused by the late supply of materials and goods that are issued by the employer.
13	23.2.7	Late appointment of a subcontractor	If delay is caused by the late instruction to appoint a nominated or selected subcontractor, provided that the contractor has taken reasonable steps to avoid or reduce such delay.
14	23.2.8	Late acceptance by the principal agent and/or agents of a design undertaken by a selected subcontractor	If delay is caused by the late acceptance of a selected subcontractor's design by the principal agent, provided that the contractor ensured that the subcontractor timeously prepared the subcontract documentation.
15	23.2.9	Act or omission by a nominated subcontractor or a direct contractor	If delay is caused by any default on the part of a nominated subcontractor or disruption by a direct contractor.
16	23.2.10	Insolvency of a nominated subcontractor	If delay is caused by the insolvency of a nominated subcontractor.
17	23.2.11	Suspension or termination by a subcontractor due to a default by the employer, the principal agent and/or agents	If delay is caused by the contractor's suspension of the works due to the failure of the principal agent to issue payment certificates within the provision of the contract or the failure of the employer to provide a payment guarantee.
18	23.2.12	Execution of additional work	If certain work is under measured in the bills of quantities or the principal agent issues an instruction for the execution of additional work.
19	23.2.13	Suspension of the works	If delay is caused by the contractor's suspension of the works due to the listed events in clauses 28.1.1 to 28.1.5.
20	23.3	Any cause beyond the contractor's reasonable control	If delay is caused by any other cause, not applicable to clauses 23.1 and 23.2, and which is beyond the contractor's reasonable control and could not have been anticipated.

Source: JBCC (2018)

3. METHODOLOGY

The study employed a quantitative research approach, which is characterised as an objective and systematic approach that involves the collection of numerical data (Abbott and McKinney, 2013; Farrell et al., 2017). To capture quantitative data in an observational context, the survey methodology was adopted, as it is widely recognised as a standard approach for recording such data (Zikmund et al., 2013). Surveys involve gathering information about various aspects of human behaviour from individuals or groups through questions that inquire about experiences, opinions, attitudes, and characteristics, with the responses subsequently being tabulated (Leedy and Ormrod, 2016). The purpose of conducting surveys is to gain insights about a population by evaluating a sample of that population (Maree and Pietersen, 2019a). The primary advantage of quantitative research is the ability to draw conclusions for a larger population using a smaller group thereof (Creswell and Creswell, 2018). Surveys can be conducted using two main instruments: interviews and questionnaires (Mukherjee, 2019). In this study, a structured questionnaire comprising standardised questions in a specific order was employed (Cheung, 2014). This approach is effective for assessing the preferences and emotions of participants, as well as for efficiently quantifying data (Naoum, 2019). The survey aimed to gather information on the personal experiences of principal-agent practitioners and contractors regarding the claim events under the JBCC Principal Building Agreement that have the most impact on project performance.

3.1 Population, sampling method, and response rate

The study specifically targeted professionals working as principal agents in the construction industry and contractors registered with the Construction Industry Development Board (CIDB) to participate. In the role of the principal agent, individuals are appointed by the employer to act with full authority and responsibility in accordance with the terms of a construction contract, as highlighted by Richards (2017), Le Roux (2018), Putlitz (2018), and the South African Council for the Project and Construction Management Professions (SACPCMP) (2019). Consequently, the study selected construction project managers, architects, and quantity surveyors, as they typically fulfil the principal agent role in the building industry (Ramsden, 2018; Hauptfleisch, 2019), where the JBCC Principal Building Agreement is predominantly utilised. Additionally, contractors were included in the study because they are the parties that enter into construction contracts with employers to carry out the building works (Hauptfleisch and Siglé, 2018).

Ethics approval was sought and granted by the university ethics committee to conduct this study. Furthermore, permission was requested from and granted by the relevant professional bodies, namely, the South African Council for the Project and Construction Management Professions (SACPCMP), the South African Council for the Architectural Profession (SACAP), and the South African Council for the Quantity Surveying Profession (SACQSP), to conduct the survey among their registered professional members. Additionally, consent was obtained from the Construction Industry Development Board (CIDB) to survey their registered contractors.

The size of the population for the study was determined based on the total number of professionally registered members from the SACPCMP, SACAP, and SACQSP, as well as the number of contractors registered with the CIDB under grades 2 to 9 (Gray, 2021). The CIDB excluded their contractors registered under grade 1 from participating in the survey, while only the professional construction project manager (Pr. CPM) members of the SACPCMP were selected, considering the specific target population. Table 2 indicates the final population size based on the 2020/2021 annual reports of the respective organisations. The population size encompassed both individuals and organisations and was considered comprehensive as it included all the relevant professionals and contractors accessible in South Africa.

Table 2: Sampling framework

Organisation	Profession	No. of Members	Percentage of Population
CIDB	Builder/contractor	15 806	65.44%
SACAP	Pr. Architect	4 261	17.64%
SACQSP	Pr. Quantity Surveyor	2 409	9.97%
SACPCMP	Pr. Construction Project Manager	1 679	6.95%
Total		**24 155**	**100%**

The sampling methodology employed in this study aimed to achieve a non-biased and representative sample, which would enable reliable and valid findings. Given that the researchers had access to all individuals in the population through their respective organisations, voluntary response sampling was chosen for the study (Taherdoost, 2016). One important feature of this technique is that it provides an equal opportunity for every member of the population to be included in the sample based on their willingness to participate (Maree and Pietersen, 2019b).

A total of 380 participants responded to the survey. According to Krejcie and Morgan (1970), a sample size of 377 is considered valid for a general research population ranging between 20,000 and 25,000 when a confidence level of 95% is used. Additionally, using an online sample size calculator with a confidence level of 95%, the sample size for the target population size was calculated as 378 (Creative Research Systems, 2022). A sample size of 380 out of a population of 24,155 is therefore justified as an acceptable response rate in representing the interests, opinions, and views of the population (Holtom et al., 2022). Refer to Table 3 for the breakdown of the specific sample size of each sub-group.

Notwithstanding, it should be noted that the response rate may have been influenced by professionals and contractors who deemed the study irrelevant to them. This could include professionals who do not act in the capacity of the principal agent, as well as professionals and contractors working in the engineering sector of the construction industry who do not utilise the JBCC Principal Building Agreement. Additionally, the questionnaire may not have reached all intended recipients due to email spam filters being strict with the keyword 'survey' (Lindemann, 2021).

3.2 Data collection

As indicated, the study received ethical approval from the University of the Free State and the industry councils involved before embarking on data collection. To collect data, a questionnaire was developed and shared using an online tool called Google Forms. The researchers received support from the SACPCMP, SACAP, and SACQSP, who assisted in distributing the questionnaire link to their members. In the case of the CIDB, the researchers were provided with a list of contractors and their contact information. Subsequently, an email containing the questionnaire link was sent to the contractors, inviting them to participate in the study.

The online survey included three sections and primarily comprised closed-type questions due to their ease of answering and time-saving nature, making them convenient for respondents (Maree and Pietersen, 2019a). In the first section, the purpose of the study was stated, along with assurance of respondent's anonymity and contact information for survey inquiries. Participants were then required to provide their consent to proceed to the next section. The second section collected general information on the participants, including their profession or CIDB-grading, years of experience in the construction industry, sector of operation, and frequency of using the JBCC Principal Building Agreement. The third section focused on the effect of the various claim events under the JBCC Principal Building Agreement. Participants were asked to rate the impact of claims for the 20 events identified through the literature review using a five-point Likert scale, where 1 indicated 'not significant' and 5 indicated 'very significant'. The Likert scale numbers overall implied the following:

- Negligible consequence that can be handled through routine procedures.
- Low consequence that could threaten a project element, but normal monitoring and control procedures are sufficient.

- Moderate consequence that could necessitate project adjustments and thus requires monitoring of contributing factors and reassessment of project milestones.
- Significant consequence that threatens project objectives and therefore requires close management to avoid substantial cost increase, time delay, or reduction in technical performance.
- Extreme consequence that could stop project objectives by causing unacceptable schedule slippage cost overrun, or project failure.

3.3 Data analysis and interpretation of the findings

The data analysis for the study involved using R software version 4.1.1. Descriptive statistics were employed to determine the effect of the different claim events, following the guidelines provided by Bhattacharyya and Johnson (2019) and Maree and Pietersen (2019c). The analysis included calculating the distributions, means, and deviations in order to assess the severity of the various events.

The questionnaire scale was evaluated for its reliability using Cronbach's alpha (Cα) test. This test is commonly employed to assess the internal consistency of questionnaire scales. Cronbach's alpha value ranges between 0 and 1, where a higher value indicates greater internal consistency, while a lower value suggests less consistency. A minimum acceptable level of 0.6 is typically considered, while a value of 0.7 or higher is preferred (Field, 2017). To calculate Cronbach's alpha, the responses of each respondent regarding the effect of claims items were summed, and the total was divided by the number of items in the scale. The results revealed that the alpha coefficient was 0.96, indicating excellent internal consistency of the scale. The high alpha value, surpassing the preferred threshold of 0.7, confirms the reliability and trustworthiness of the questionnaire.

4. RESULTS

4.1 Characteristics of respondents

Table 3 presents the profile of the respondents, outlining their characteristics. The results show that the respondents were divided fairly evenly between building contractors and professional consultants. Additionally, the majority of the respondents were employed in the private sector and had accumulated over 10 years of experience in the construction industry. Moreover, most respondents primarily reported working on projects within the private sector, with a smaller percentage having experience in public sector projects.

Table 3: Characteristics of respondents (n = 380)

No.	Characteristic	Frequency	Percentage
1	**Profession**		
	Builder / Contractor	209	55.00%
	Pr. Architect	108	28.42%
	Pr. Construction Project Manager	46	12.11%
	Pr. Quantity Surveyor	17	4.47%
2	**Place of employment**		
	Public sector (i.e., government)	46	12%
	Private consulting firm	114	30%
	Private construction firm (i.e., contractor)	216	57%
	Academia	4	1%
3	**Years worked in the construction industry**		
	0 to 5 years	46	12%
	6 to 10 years	91	24%
	11 to 15 years	80	21%
	16 to 20 years	57	15%
	21 years or more	106	28%

4	**Types of building projects worked on (multiple choice)**		
	Private residential	213	56%
	Private commercial	213	56%
	Private industrial	99	26%
	Public health: government hospitals, clinics, etc.	30	8%
	Public works: government schools, libraries, infrastructure, etc.	27	7%
	Public human settlements: government low-cost housing	15	4%

4.2 Effect of claims

Table 4 indicates the severity of the recognised claim events under the JBCC Principal Building Agreement.

Table 4: Impact of claims

Impact of Claims										
JBCC PBA Clause	**Description**	**n**	**Mean**	**SD**	**Min.**	**Q1**	**Med.**	**Q3**	**Max.**	**Rank**
23.2.3	Contract instructions	380	3.13	1.33	1	2.00	3.0	4	5	1
23.2.12	Execution of additional work	380	3.10	1.36	1	2.00	3.0	4	5	2
23.1.1	Adverse weather	380	3.01	1.36	1	2.00	3.0	4	5	3
23.2.5	Late or incorrect issue of construction information	380	2.95	1.35	1	2.00	3.0	4	5	4
23.1.2	Inability to obtain materials and goods	380	2.92	1.33	1	2.00	3.0	4	5	5
23.3	Any cause beyond the contractor's reasonable control	380	2.89	1.37	1	2.00	3.0	4	5	6
23.2.13	Suspension of the works	380	2.88	1.43	1	2.00	3.0	4	5	7
23.2.1	Delayed possession of the site	380	2.73	1.39	1	2.00	2.0	4	5	8
23.2.7	Late appointment of a subcontractor	380	2.71	1.30	1	2.00	3.0	4	5	9
23.1.6	Force majeure	380	2.68	1.36	1	1.00	3.0	4	5	10
23.1.3	Making good physical loss and repairing damage to the works	380	2.61	1.22	1	2.00	2.5	4	5	11
23.2.8	Late acceptance by the principal agent and/or agents of a design undertaken by a selected subcontractor	380	2.61	1.33	1	1.00	2.0	4	5	12
23.1.4	Late supply of a prime cost amount item	380	2.59	1.22	1	2.00	2.0	4	5	13
23.2.11	Suspension or termination by a subcontractor due to a default by the employer, the principal agent and/or agents	380	2.58	1.37	1	1.00	2.0	4	5	14
23.2.6	Late supply of free issue materials and goods	380	2.57	1.33	1	1.00	2.0	4	5	15
23.2.9	Act or omission by a nominated subcontractor or a direct contractor	380	2.54	1.21	1	2.00	2.0	3	5	16
23.2.2	Making good physical loss and repairing damage to the works	380	2.54	1.25	1	1.00	2.0	3	5	17
23.2.10	Insolvency of a nominated subcontractor	380	2.52	1.38	1	1.00	2.0	4	5	18

23.2.4	Opening and testing of work and materials and goods	380	2.51	1.19	1	2.00	2.0	3	5	19
23.1.5	Exercise of statutory power	380	2.51	1.23	1	1.75	2.0	3	5	20

Note: SD = Standard deviation; Med. = Median

5. DISCUSSION OF THE FINDINGS

The respondents in this study were fairly divided, with 55% working as building contractors and 45% as professional consultants, including architects, construction project managers, and quantity surveyors (refer to Table 3). The respondents' level of knowledge was considered satisfactory, as 88% of them had work experience of 6 years or more in the construction industry. This aligns with the perspective of Olanrewaju and Anavhe (2014), who emphasised the importance of having a minimum of 5 years' work experience in construction before dealing with claims.

Table 3 illustrates that the respondents have diverse experience across various project types, although a significant portion of their work has been in the private sector. This can be attributed to the declining public sector expenditure on construction since 2016, which has led to the private sector emerging as the dominant investor in the South African construction industry, surpassing government and public entities (PWC, 2016; Ogbeifun et al., 2019; Watermeyer and Phillips, 2020; Olarewaju and Ibrahim, 2020; Stats SA, 2021; Mahlaka, 2022). The COVID-19 pandemic and subsequent national lockdown further exacerbated this imbalance by causing delays in the approval and implementation of public sector infrastructure projects (Arndt et al., 2020; National Treasury, 2021; Musonda and Rakolote, 2022; Chigara and Moyo, 2022). Additionally, contractors and consultants are increasingly hesitant to undertake public sector projects due to significant payment delays, with 60% of payments being overdue (Maritz and Robertson, 2012; CIDB, 2022).

According to Sullivan and Artino Jr. (2013), mean scores ranging from 2.5 to 3, which correspond to 50% to 60%, generally indicate moderate support for a cause. They also note that mean scores of 3 or higher, equivalent to 60% or more, suggest strong support for a cause. Regarding the importance of claims, three events were deemed significant in the present study as their mean scores exceeded 3. The remaining 17 events were considered ordinary since their mean scores ranged from 2.5 to 3. No event was considered insignificant, as none had a mean score of below 2.5. As a result, it can be concluded that 15% of the claim events are significant and 85% are ordinary in terms of their impact on project performance. The significant claim events will be further examined.

The most significant claim event identified was contract instructions (clause 23.2.3) (Mean = 3.13; SD = 1.33), which specifically addresses notifications related to contractual obligations, such as changes in specifications or when contract administrators fail to fulfil their contractual duties. However, it is important to note that this clause does not encompass alterations to the scope of work, which is addressed under clause 23.2.12 (execution of additional work) (Segal, 2018). This finding supports the studies conducted by Oyegoke and Al Kiyumi (2017), Assaf et al. (2019), Shaikh et al. (2019) and Guévremont and Hammad (2021) respectively, who similarly identified major changes in requirements and delayed responses from the owner's representatives as causes that result in major claims. It should further be emphasised that a contractor cannot make a claim if an instruction requires compliance with contractual obligations while the contractor is in default, such as subpar workmanship or failure to meet specifications (Iyer et al., 2008).

The second most significant claim event is the execution of additional work (clause 23.2.12) (Mean = 3.10; SD = 1.36). As mentioned earlier, this clause specifically covers contract instructions for the execution of additional work and encompasses two aspects: variations to the scope of work and instances where items in the bills of quantities (BOQ) are undermeasured (Segal, 2018). The JBCC Principal Building Agreement recognises that contractors heavily rely on the BOQ to develop their construction program. Therefore, the agreement allows contractors to adjust their program when extra work is ordered or when items are found to be unmeasured, providing them with sufficient time to complete the additional work. Considering this, the emergence of claims is an unavoidable outcome when modifications occur in the scope of work, as these changes were not pre-emptively accounted for in the contract documentation (Apte and Pathak, 2016). However, as Le Roux (2014) and Prinsloo (2016) point out, sometimes claims in the South African building industry often lead to disputes due to employers either rejecting claims entirely or offering lesser amounts than what contractors believe they are entitled to.

The above findings support the studies conducted by Assaf and Al-Hejji (2006), Doloi et al. (2012), Das and Emuze (2018) and Elhag et al. (2020), which show that contract instructions for the execution of additional work, which was not initially included in the contract, have a significant impact on the time and cost performance of projects. Furthermore, the present study's finding is consistent with the conclusions drawn by Yousefi et al. (2016), Khabisi et al. (2016), Famiyeh et al. (2017), and Ansah and Sorooshian (2018), that contract instructions related to undermeasured quantities in the BOQ also have a severe impact on projects.

It is important to highlight that both the aforementioned claim events are associated with contract instructions, which affect projects by necessitating additional planning, coordination, resource allocation, and adjustments to project schedules and budgets (Gunduz and Elsherbeny, 2020; Reyneke and Simelane, 2022). Considering this, both events are also covered by clause 23.2 of the JBCC Principal Building Agreement, which means that they have implications for both time and cost. Consequently, these claim events naturally have a significant impact on project performance. The JBCC Principal Building Agreement, under subclause 17.5, is further clear in stating that a contract instruction must be provided in written form. There is a commonly raised question about whether an entry in the site instruction book or the minutes of a site meeting fulfils the requirement for a contract instruction to be in writing. However, it is not advisable for both the principal agent and contractor to consider such practices as satisfactory. It is important that a contract instruction is appropriately identified and dated, and that the contractor or an authorised site representative acknowledges its receipt by signing it (JBCC, 2019).

The third most significant claim event was found to be adverse weather (clause 23.1.1) (Mean = 3.01; SD = 1.36). The most common form of adverse weather is rain, and the JBCC Principal Building Agreement acknowledges that rain-related delays have a dual impact by recognising the resulting circumstances (Segal, 2018). Typically, rain prevents contractors from working during its occurrence and also leaves the construction site muddy and waterlogged, requiring work to halt until it dries out. Other examples of adverse weather conditions include strong winds, which affect work at elevated heights, and extremely cold weather, which hampers the handling and setting of concrete. This finding resonates with the deductions made by Motlhatlhedi and Nel (2019) and Karim and Amin (2021), that progress towards practical completion is severely impeded by the occurrence of unfavourable weather conditions.

6. CONCLUSION

The primary contribution of this study is to highlight the significant claim events within the JBCC Principal Building Agreement, as perceived by the main stakeholders, namely principal agents and contractors. The most prominent claim events in terms of severity, along with their corresponding contract clauses, were contract instructions (clause 23.2.3), execution of additional work (clause 23.2.12), and adverse weather conditions (clause 23.1.1). On the other hand, the least critical claim events were the exercise of statutory power (clause 23.1.5), opening and testing of work, materials, and goods (clause 23.2.4), and the insolvency of a nominated subcontractor (clause 23.2.10). The claim events all impact negatively on the time and cost performance of projects, with varying levels of severity. The study concludes that while it is neither realistic nor feasible to prevent all claims, understanding the nature of claims could minimise their occurrences and/or plan for how to deal with the consequences of their severity better. In addition, this can also provide some lessons learnt for the benefit of contractual parties in future construction projects.

The study contributes to the theoretical understanding of construction claims by highlighting significant claim events within the JBCC Principal Building Agreement. This enhances the knowledge about the types of events that tend to lead to claims in construction projects. Moreover, the results of the study can directly impact the practical handling of claims under the JBCC Principal Building Agreement. By understanding the types of events that commonly lead to claims, stakeholders can be better prepared to address them effectively. By emphasising the importance of paying attention to the identified claim events to prevent or minimise future claims, the study has practical implications for project planning, risk management, and the development of strategies to mitigate potential issues.

Drawing from the findings of this study, the following recommendations are suggested to mitigate unwarranted claims with severe effects. To prevent or minimise changes requested by the employer during the project execution, it is advisable for employers to allocate additional time to the design stages. By thoroughly reviewing and fine-tuning the design before approving the detailed design, employers can ensure that they achieve the desired outcome and avoid the need for significant modifications later on. Further, recognising the absence of a flawless compilation of construction information, it is crucial for professional teams under the leadership of the principal consultant to diligently examine tender documents. This meticulous review aims to identify and rectify any errors or inaccuracies present in bills of quantities, drawings, specifications, and schedules.

At the beginning of a contract, it is further essential for the principal agent and contractor to affirm the procedure outlined in the contract for managing changes and variations, whereby mutual agreement should be reached regarding the requesting, issuing, and documenting of contract instructions. However, if changes become necessary, they should be handled promptly. Upon realising the need for a change request, it is important that the principal agent analyses its impact on time and cost, with the schedule and budget accordingly revised upon its approval. It is further advised that a contract instruction should be prepared in the office using a standard office template, which receives greater attention and scrutiny compared to one issued hastily at the site.

Lastly, principal agents should also conduct a comprehensive examination of contract programmes to prevent impractical schedules that cannot be feasibly accomplished. It is crucial to incorporate contingency plans for unfavourable weather conditions, including precipitation, wind speeds, humidity, and temperature, within the schedule. Historical weather data sources should be utilised to estimate the average number of workdays lost in the past due to adverse weather, assuming that similar weather patterns will recur in the future.

The paper ends with a note on the limitations of the present study. It must be noted that the study is limited to the JBCC Principal Building Agreement and does not consider other types of construction contracts, which restricts the generalizability of the findings to the building sector of the construction industry. The focus of the study on South Africa also limits the applicability of the study's findings to other countries, such as Botswana and Swaziland, which have their own unique contexts in terms of industry practices, regulations, and market conditions. The study also identifies critical claim events but does not delve into the quantification of their impact on project performance. This lack of impact assessment restricts a comprehensive understanding of how these claim events influence project outcomes, which could be important for project planning and risk management.

To build on the valuable insights provided by this study, a follow-up study should be conducted to quantify the impact of the claim events on project performance in terms of time and cost. In addition, further investigations could be carried out to examine the severity of claims under the JBCC Principal Building Agreement in other countries especially in the Southern African region. Another area for further research identified is an investigation into the claim events within the JBCC Principal Building Agreement that commonly give rise to disputes.

7. DATA AVAILABILITY STATEMENT

All data that support the findings of this study are available from the corresponding author upon reasonable request.

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9. DISCLOSURE OF INTEREST

Both the authors declare that they have no conflicts of interest.

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Assessing knowledge management and time performance of building construction projects in Ghana

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ABSTRACT

The construction industry, given its nature of frequent disbanding and exit of professionals and workforce after a project is completed, cannot downplay the importance of managing knowledge and the need to manage the knowledge of construction professionals and the workforce at the corporate and project levels. This study sought to assess project knowledge management and time performance of building construction projects in Ghana. The objectives of the study were to determine whether project knowledge managed on past projects is applied on current projects, to determine the impact of project knowledge management on project time performance, and to determine the critical factors governing the application of knowledge management in enhancing project time performance. The study adopted a cross-sectional survey research design with construction professionals employed by 19 D1K1 construction companies within the Greater Accra Region of Ghana as the population. A purposive sampling method was adopted for the study, with a questionnaire as the data collection instrument. The questionnaire was administered by Google Forms, and a response rate of 69% was achieved. The study found that Ghanaian building construction firms apply knowledge gained from previous projects to current projects during construction, and the application of this knowledge managed on current projects during construction explains a 30% improvement in project time performance. Also, the findings of the study suggest improved project supervision and site management, a fully utilised construction team, and proper planning of works, among others, are critical factors that govern the application of project knowledge management for improving project time performance. These factors should be documented and applied as lessons learned on future projects to rid projects of delays and time overruns. The study would enable construction project managers to understand the extent of importance the application of project knowledge management is to a project's time performance. It will also inform construction project managers about the critical factors that the application of project knowledge management improves to enhance project time performance.

Keywords: Construction projects, Ghana, Project Knowledge Management, Time performance

1. INTRODUCTION

A project's performance is usually equated to success, and knowledge is known as a push factor for a project to achieve success (Bakar et al., 2016). Among various resources available to a company, knowledge is the most valuable because it embodies best practices, routines, lessons learned, problem-solving methods, and creative processes that are often difficult to replicate (Shonubi et al., 2021). Most organisations, including construction companies, according to Elfar and Elsaid (2017) have a competitive advantage depending on the knowledge available to them. Studies conducted on the frequency and effects of flaws and errors in the Swedish construction process indicate that these flaws and errors account for some 6% of the total production costs and that about 10% of working time is spent on correcting errors and reworking what has been done or planned (Dosumu et al., 2017). A portion of the errors, according to Dosumu and Aigbavboa (2017), are caused by deficiencies in design work. The deficiencies include shortcomings in the knowledge available to those engaged in the construction, and a considerable proportion of the errors are also traceable to difficulties caused by vagueness or imprecision in the instructions that the design team provides of which the same problems befall the construction team (Eja and Ramegowda, 2020).

To minimise these errors, those in charge of work at the site and others engaged in the practicalities of a construction project need adequate knowledge to carry out their work properly; moreover, they need to continuously update their working knowledge to keep abreast of the latest technologies (Shamsudeen and Biodun, 2016). As a result, the industry needs to make conscious efforts to manage knowledge in the lifecycle of construction projects. Several studies (Idrees et al., 2023; Othman and ElKady, 2023; Samuel and Justina, 2023; Agyemang, 2018; Agyekum and Smith, 2017) have been conducted on knowledge management in construction. Idrees et al. (2023) conducted a study on the impact of knowledge management capabilities on organisational performance in construction firms and the mediating role of innovation. It was established that KM dimensions, knowledge acquisition, application and protection positively and significantly influence organisational performance; however, knowledge conversion is insignificant. The same study also found that innovation positively and substantially mediates the relationship between knowledge acquisition, application, protection, organisational performance and the insignificant terms of knowledge conversion. According to Othman and ElKady (2023), lack of organisational culture and low involvement of top management were identified as the highest barriers to implementing KM in architectural design firms in developing countries and also highlighted the fragmented nature of the architectural design process, which leads to the loss of valuable information and makes the process of capturing and sharing knowledge a hard task. Having conducted a study on the implementation of effective knowledge management practices for improving productivity of Nigerian Construction Small and Medium-Scale Enterprises. According to Samuel and Justina (2023), there is a high level of agreement and convergence of opinion on the effect of knowledge management on productivity. It was also concluded that knowledge management implementation improved the productivity of construction SMEs. Agyemang (2018), established that Ghanaian construction firms practice the management of knowledge. Agyekum and Smith (2017) explored the challenges to the adoption of knowledge management in civil engineering construction firms in Ghana. However, no such study focuses on assessing project knowledge management and project time performance of building construction projects. This study sought to assess project knowledge management and project time performance of Ghanaian building construction projects. The specific objectives were to determine whether project knowledge managed on previous projects is applied to current or future projects, determine the influence of the application of knowledge managed on future projects' time performance, establish critical factors that govern the application of knowledge management for enhancing time performance of projects.

2. CONCEPT OF KNOWLEDGE MANAGEMENT

During the execution of a construction project, construction professionals and the workforce tap into both codified knowledge (explicit knowledge) as well as a greater proportion of tacit knowledge. According to Bolisani and Bratianu (2018), knowledge is described as a state or fact of knowing, with knowing being a condition of understanding gained through experience or study, the sum or range of what has been perceived, discovered, or learned. This state or fact of knowing is either codified -explicit or as well tied in the experiences and intuition, tacit, of construction professionals. Explicit knowledge, according to Gutiérrez (2012), is generally accepted knowledge that can be expressed in formal and systematic language and shared in the form of data, scientific formulae, specifications, manuals, and such like, and can be processed, transmitted and stored relatively easily. Explicit knowledge in construction embodies working drawings, specifications, etc, while tacit knowledge constitutes the lessons learned from practice and experience gained from such practice over time. According to Igbinovia and Ikenwe (2018), knowledge is defined as the process of consciously coordinating the explicit and tacit knowledge of an organisation through systematically and organizationally specified processes to enhance organisational performance and create value. These specified processes include knowledge creation, knowledge capture, knowledge sharing, and knowledge application.

2.1 Creating, capturing, sharing, and applying construction project knowledge

Creating construction project knowledge requires the existence of a person or group of people who come up with new ideas, new concepts, innovative products or processes, and can be achieved through research, innovation projects, experiments, and observations (Sondari et al., 2016).

By far, the works of Nonaka (1991, 1994), Nonaka and Konno (1998), Nonaka and Takeuchi (1995), Nonaka, Toyama and Konno (2000), Nonaka and Toyama (2003), and Nonaka, Toyama and Hirata (2008), progressively developed, refined and proposed the dynamic model of knowledge creation as a coherent and comprehensive model based on the experience of the Japanese companies (Bratianu, 2015) and it is the most discussed model in the knowledge management literature. This knowledge creation model specifies four knowledge creation modes as the processes of interplay between tacit and explicit knowledge that led to the creation of new knowledge: socialisation (tacit to tacit), externalisation (tacit to explicit), combination (explicit to explicit), and internalisation (explicit to tacit) (Hoegl, 2019). This conceptualisation is often referred to by the acronym SECI.

According to Plyasunov and Saint-petersburg (2017), capturing knowledge prevents the loss of critical knowledge due to retirement, downsizing, and outsourcing and discards the experts and professionals at the expiration of the project. Aggestam et al. (2010) expressed further that failure to capture the knowledge and experiences throughout the life cycle of a construction project is a great loss to the construction organisation and also represents unnecessary wastage of assets. Therefore, there is a need to develop an appropriate strategy for capturing construction project knowledge by using technology, techniques, concepts, and tools. Once project knowledge has been captured and codified, knowledge needs to be shared and disseminated throughout the organisation (Mohajan, 2019) and intended for use. The organisational capabilities, knowledge, and resources are developed and improved through the process of executing projects and sharing the lessons that were learned and developed through the project's execution to avoid repeating the same mistakes in the projects that follow (Ahmad and Karim, 2019). These lessons learned can be applied to subsequent projects to improve organisational capabilities and, more importantly, project performance once this knowledge is shared (Rusuli and Tasmin, 2010).

KM typically addresses one of two general objectives: knowledge reuse to promote efficiency and innovation to introduce more effective ways of doing things (Igbinovia and Ikenwe, 2018). Although the three presented processes are equally important, much premium is placed on the application of managed project knowledge on subsequent projects since management without application to ascertain the verdict on a subsequent project's performance, in this study, time performance is void.

2.2 Construction project time performance

The common assessment of the success of construction projects is that they are delivered on time, to budget, to technical specifications, and meet client satisfaction (Anoop et al., 2016). The cost, quality, and client satisfaction performance indicators of construction projects are all a function of the project's time set for completion. A successful project is a project which has accomplished its technical performance, maintained its schedule, and remained within budgetary costs (Rahman et al., 2012). These accomplishments can be made when much attention is given to the time spent executing projects. Poor performance of time can lead to a significant amount of time overrun, increase project cost, and eventually affect project quality (Othman et al., 2018). As a result, construction time is a fundamental and important parameter for measuring the success of any construction project (Harjinder et al., 2017). To avoid spending productive construction time re-inventing the wheel on an aspect of a project to cause needless extension of project duration, a rigorous application of previous project knowledge on ongoing or future projects comes in handy to save the situation.

2.3 Knowledge management and time performance

With construction project performance anchored on the projects ability to meet time schedules (Gledson, 2017), the need to meet these time schedules in a project's construction is primarily hinged on the efficiency in planning the project at the various project levels (Gledson et al., 2018). This, according to Makore and Eresia-Eke (2021), requires some amount of past experiences that have been deliberately gathered and kept intended for future use. Several other factors that cause delays in project execution and, as a result, cause time overrun, such as delays in obtaining permission from authorities, poor supervision and site management, unrealistic time schedules, unforeseen ground conditions and lack of skilled professionals (Sharma and Gupta, 2021), would have their effects minimised, if not completely avoided, when knowledge gathered on previous projects is tapped during the execution of a current project (Alhammadi et al., 2022). Knowledge as a prime asset of an organisation has an influence on the performance of the organisation (Sallam et al., 2018). According to Bayari et al. (2022), the management of knowledge affects organisational performance dimensions positively. This influence on performance includes performance on time, cost, quality, and client satisfaction, among others (Abuaddous et al., 2018). The management of knowledge not only affects organisational performance it affects the performance of individual projects' time performance as well. The management of project knowledge helps improve project time performance by informing the project team to plan work properly, monitor work closely, communicate effectively, and hire skilled workers (Al-Nabae and Sammani, 2021).

With about 10% of working time spent on correcting errors and reworking what has been done or planned (Dosumu et al., 2017), the management of previous experiences on projects goes a long way towards improving project time performance (Sallam et al., 2018: Salama et al., 2016). According to Al-qarioti (2015), projects that draw on previous project knowledge are able to perform better in meeting timelines by saving sometimes between a period of 2 to 5 months of the time scheduled for project completion.

2.4 Factors governing the application of knowledge management in enhancing time performance of construction projects

The significance of time performance in construction projects cannot be underestimated due to its effect on the cost and also a key parameter in measuring the success of construction projects (Rauzana, 2021). A project's time performance would be greatly improved if all factors that cause delay at all stages of a project's life cycle are eliminated or their effects reduced to the minimum. A major construction project setback time overrun is caused by several factors during the construction of a project (Othman et al., 2018). Adeyemi and Masalila, (2016), categorised factors that cause delays thereby affecting project time performance into client related factors: Finance of and payments for completed work, owner interference, slow decision making, unrealistic contract duration and requirements imposed; contractor related factors: subcontractors, site management, construction methods, improper planning, mistakes during construction stage, inadequate contractor experience; consultant related factors: contract management, preparation and approval of drawings, quality assurance/control, waiting time for approval of tests and inspection; material related factors: quality of material, shortage in material; labour and equipment related factors: labor supply, labor productivity, equipment availability and failure; contract related factors: change orders, mistakes and discrepancies in contract document; contractor relationships related factors: major disputes and negotiations, inappropriate overall organisational structure linking to the project, lack of communication between the parties; and external related factors: weather condition, regulatory changes, problem with neighbours, unforeseen site conditions and project occurrences. Jagboro (2015) identified building regulations bureaucracy in government agencies, delay in obtaining permits and approvals from the government, project location, lack of experience in similar project, the complexity of the project, poor site safety, lack of communication between project members, suspension of work by owner, contractors financial difficulty, inadequate tender pricing, poor site management, inappropriate construction methods, frequent change of sub-contractors, the poor performance of contractors, more than an estimated waste of materials in the site, rework of bad quality performance, improper planning and scheduling resulting in a poor judgment of time and resources, lack of sub – contractor's skill, inadequate control over sub – contractor's, uncertainties related to sub – contractor's technical qualification, among others, as factors that cause time overrun in construction projects. The presence of these factors adversely affects the project schedule (Bekr, 2017). However, project time performance is enhanced when the factors that cause time overrun on a project are noted in the manner, they present themselves during the execution of projects and experiences drawn are brought to bear during the construction of a current or future project (Sallam et al., 2018).

3. METHODOLOGY

The study sought to determine the influence of project knowledge management practices on project time performance of building construction projects in Ghana. To achieve this aim, a quantitative research method was adopted. In line with the quantitative method, this study aligns with a deductive reasoning approach (Burney and Saleem, 2008). The study adopted a cross-sectional survey research strategy and a descriptive design to be able to find answers to the objectives stated. Two null hypotheses were developed based on the objectives stated. The null hypotheses in relation to the stated objectives are:

H0: Project knowledge managed on previous projects is not applied to future projects in the Ghanaian construction industry and

H0: Project knowledge management applied on a future project has no impact on the future project's time performance.

The target population of the study comprised construction professionals (construction managers, architects, quantity surveyors, structural engineers, mechanical engineers, and safety engineers) employed by D1K1 construction firms within the Greater Accra Region (the captital city of Ghana). D1K1 construction firms are first-class construction firms that have the capacity (financial and others) to execute any project (Ofori-Kuragu et al., 2017). The Greater Accra region was chosen as a study area because this region has the highest concentration of D1K1 companies. The classification of companies according to the Ministry of Water Resources Works and Housing indicates that these companies represent the highest class and have no limit to the size of the project they can undertake. According to the

Ministry of Water Resources, Works and Housing, D1K1 construction firms who are in good standing operating nationwide are 52 (Ministry of Water Resources, Works and Housing, 2019). Out of this, 19 of them are currently operating in the Greater Accra region, representing 36.5%, 10 in the Ashanti region, 4 in the Eastern region, 4 in the Central region, 3 in the Volta region, 3 in the Upper East region, 2 in Upper West region, 2 in Brong Ahafo, 3 in Northern region, and 2 in Western region (Ministry of Water Resources, Works and Housing, 2019). It is estimated that each firm averagely has three of the construction professionals targeted for this study, viz, construction managers, architects, quantity surveyors, structural engineers, mechanical engineers, and safety engineers.

3.1 Sample and sampling techniques

Two main types of sampling – probability and non-probability – are used in research: probability and non-probability sampling (Bhardwaj, 2019). Probability sampling is a sampling which permits every single subject from the population to have an equal chance of presence in the sample, while in nonprobability sampling, subjects in a population do not have the same chance of being in the sample (Bhardwaj, 2019). The respondents for the study were selected using a non-probability (i.e., purposive) sampling technique by requesting the D1K1 construction firms to ask their professionals who have been employed in their respective professional areas for at least three years to respond to the research instrument. The three–year threshold was set with the assumption that professionals employed in their various professional capacities may have had enough experience in the project knowledge management subject matter. A total of 131 questionnaires were administered, out of which 91 responses were obtained, representing a response rate of approximately 69%. This response rate is considered acceptable since the average and the acceptable response rate is 60% ± 20% (Fincham, 2008).

3.2 Data collection and analysis

This study used a structured close-ended questionnaire as an instrument for collecting primary data. A questionnaire is a systematically prepared document with a set of questions deliberately designed to elicit responses from respondents or research informants to collect data (Kabir, 2016). This choice of data collection instrument was informed by the widely geographically dispersed population. This instrument helped in reaching a greater geographically dispersed building construction professionals' population in the Greater Accra Region at a lesser time and cost. The researcher could only reach a large number of geographically dispersed construction professionals within a limited period and at a comparatively less cost through Google Forms. Google form was the means through which the questionnaire was administered. Construction professionals were requested to respond to items on project knowledge management in the Ghanaian building construction industry, on a 5-point Likert scale: 5 – strongly agree, 4 – agree, 3 – neither agree nor disagree, 2 – disagree, and 1 – strongly disagree.

The data were analysed with the aid of Statistical Package for the Social Sciences (SPSS) software. The data was analysed by means of both descriptive (Mean Score (M.S) and standard deviation) and inferential (t-test and linear regression) statistics. The mean score and standard deviation helped to present the data in a meaningful and understandable way, thereby simplifying the interpretation of the data. The t-test helped to compare a hypothesised mean with the sample mean to determine whether the difference is statistically significant while the multiple regression helped in determining the effects of knowledge management practice on project time performance.

4. RESULTS

4.1 Demographics

Gender of Respondents

The gender of the respondents is depicted in Table 1. According to the questionnaire responses, 77 of the respondents were males, accounting for 84.6% of the total, while 14 of the remaining respondents were females, accounting for 15.4%.

Professional Status of Respondents

Table 1 indicates the professional status of respondents in each category. In this study, architects accounted for 22.4% of legitimate responses, while structural engineers accounted for 11.8%. 10.6%, 23.5%, 12.9%, and 18.8% of responders were service engineers, quantity surveyors, and mechanical engineers, respectively.

Table 1: Demographics of respondents

Variable	Frequency	Per cent
Gender		
Male	77	84.6
Female	14	15.4
Total	91	100
Educational qualification		
PhD	1	1.10
Master's degree	39	42.86
First degree	44	48.35
Diploma	7	7.69
Total	91	100
Work experience		
3 – 6 years 7 – 10 years 11 – 14 years	16 25 26	17.58 27.47 28.57
Above 15 years	24	26.37
Total	91	100.00
Professionals		
Architect	18	19.80
Quantity Surveyor	14	15.40
Structural Engineer	5	5.40
Mechanical Engineer	3	3.30
Electrical Engineer	20	22.00
Building Manager	30	33.00
Safety Engineer	1	1.1
Total	91	100.0

Respondents Work Experience

The number of years' respondents have worked in the construction business is shown in Table 1. Respondents who had worked from 3 to 6 years in the construction industry were 17.58% according to the study. Respondents with working experience ranging from 7 to 10 years recorded 24.47%, 11 to 14 years recorded 28.57%, and above 15 years obtained 26.37%. The distribution of years of experience tells that the various experiences of various professionals could be tapped to help in the conclusions drawn in this study.

4.2 Application of project knowledge management to current projects

From Table 2, the mean response is 3.86, which approximates 4.00. This corresponds to 'agree' on the five-point Likert scale used for this study. A degree of variability as low as 0.38 signifies these responses are closely clustered around the mean.

Table 2: Descriptive statistics for project knowledge application

Variable	N	Mean	Std. Deviation	Std. Error
Application of previous project knowledge on other projects	91	3.86	0.382	0.040

The null hypothesis on whether project knowledge managed from a past project is applied during the execution of an ongoing project was tested using one-sample t-test and the results are summarised in Table 3. Restated; H0: Project knowledge managed from a past project is not applied to future projects.

Table 3: Output of one sample t-test for project knowledge application

	Test Value = 3					
	t	Df	Sig. (2-tailed)	MD	95% CI of the Difference	
					Lower	Upper
Application of previous project knowledge on other projects	46.36	90	0.000	1.8	1.78	1.94

Df – Degree of freedom, MD-Mean Difference, CI - Confidence Interval

From Tables 2 and 3, there is a statistically significant difference (M = 3.86, SD = 0.38), t (90) = 46.36, p = 0.000. This implies that project knowledge managed from a past project is applied to future projects, and as a result, the null hypothesis is rejected.

4.3 Influence of project knowledge management on project time performance

The null hypothesis on the influence of project knowledge management on project time performance is:

H0: Project knowledge management of Ghanaian building construction projects has no significant influence on project time performance.

This hypothesis sought to determine whether project knowledge management has any influence on project time performance. The null hypothesis stated that project knowledge management does not influence project time performance. The regression model estimated in Table 4 reveals that the project knowledge management is statistically significant at β = 0.167, t = 3.180, p = 0.002s. The results of the regression analysis show that the adjusted coefficient of multiple determination, 0.301, implies that project knowledge management explains 30.1% of a project's performance in time. Again, the regression model is statistically significant at F (4, 86) = 4.847 and the resulting probability = 0.001. From the foregoing statistics, at a 95% level of confidence, project knowledge management has an impact on the project's time performance. Thus, the null hypothesis stating that project knowledge management has no impact on project time performance is rejected, and the alternate hypothesis that states that project knowledge management has a significant impact on project time performance is accepted.

Table 4: Results of influence of project knowledge management on project time performance.

	Unstandardised Coefficients		Standardised Coefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	0.489	0.291		1.681	0.096
Project knowledge management	0.167	0.052	.358	3.180	0.002

R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
0.577[a]	0.332	0.301	0.224	1.754

	Sum of Squares	Df	Mean Square	F	Sig.
Regression	1.342	4	.336	4.847	.001b
Residual	5.954	86	.069		
Total	5.954	86			

a. Predictors: (Constants) Project Knowledge Management b. Dependent Variable: Project Time Performance

4.3 Critical factors governing the application of knowledge management in enhancing project time performance

The study assessed factors governing the application of managed project knowledge that enhances or improves a current project's time performance. Several factors were suggested for respondents to express the extent to which they agree with them as helping improve project time performance. Table 5 provides descriptive results of the critical factors governing project knowledge management for enhancing project time performance. This is followed by Table 6, which presents one sample t-test for critical factors governing project knowledge management for enhancing project time performance.

Table 5: Descriptive statistics of factors governing the application of knowledge management in enhancing project time performance.

	N	Mean	SD	St. Error
Improved project supervision and site management	91	4.86	0.436	0.046
Proper planning of works	91	4.90	0.396	0.042
Committed leadership and management	91	4.81	0.492	0.052
Proper planning for tools and equipment	91	4.85	0.470	0.049
Send clear and complete messages to workers to ensure effective communication	91	4.87	0.427	0.045
Hire skilled workers to achieve good progress, avoid double-handling	91	4.91	0.384	0.040
Focus on the quality, cost and delivery of the project	91	4.88	0.443	0.046
Training and development of all participants to support the delivery process	91	4.82	0.462	0.048
Reduced staff absenteeism	91	4.73	0.651	0.068
Fully utilise the construction team	91	4.81	0.492	0.052
Use new construction technologies (IBS-Industrialize Building System)	91	4.79	0.506	0.053
Focus on the client's need	91	4.82	0.485	0.051
Adoption of tools and techniques, i.e., Value Management, Lean Thinking, etc.	91	4.86	0.436	0.046
Measure performance against other projects	91	4.84	0.543	0.057
Helps in getting over design changes in record time	91	4.77	0.579	0.061
Helps in evaluating project duration accurately	91	4.81	0.595	0.062
Informs the need to appoint competent subcontractors and suppliers	91	4.79	0.606	0.064

Informs the recruitment of the needed quality and quantity of labour	91	4.84	0.478	0.050
Helps in the swift resolution of conflicts between project parties	91	4.80	0.477	0.050
Helps in better assessment of weather conditions	91	4.77	0.579	0.061
Helps in assessing ground conditions	91	4.82	0.485	0.051
Informs the usage of appropriate construction methods	91	4.86	0.461	0.048
Helps avoid needless rework caused by mistakes	91	4.86	0.436	0.046
Helps properly programme and schedule works to minimise staff idle time	91	4.85	0.445	0.047
Improves problem-solving and decision-making	91	4.88	0.417	0.044
Minimises construction site labour unrest (boycotts, strikes, etc.)	91	4.78	0.574	0.060
Helps to minimise litigation	91	4.74	0.647	0.068
Helps facilitate prompt payments by clients	91	4.77	0.579	0.061
Helps improve documentation and procedure	91	4.85	0.445	0.047
Helps in material ordering and scheduling	91	4.85	0.445	0.047
Fast tracks contract design and specification interpretation disagreements	91	4.85	0.470	0.049
Informs proper plant and equipment management to avoid needless breakdown	91	4.86	0.436	0.046
Aggregate scores	**91**	**4.82**	**0.50**	

All respondents for the study, as depicted in Table 5, strongly agreed that the application of knowledge managed from a previous project on current or future projects helps improve these factors and, consequently, project time performance. Table 6 further shows that there is a significant difference in the mean scores. This significant difference in means of the responses to the critical factors to the test value of 3 implies that the responses of the professionals strongly agreeing to the factors are not by chance.

The aggregate mean score for the ways by which project knowledge applications improve project time performance is 4.82, approximating 5. A mean score of 5 on the five-point Likert scale used for this study represents strongly agree. This suggests that the professionals agree strongly that knowledge of the project, when applied, helps improve project time performance by way of the factors as presented in Table 5. A standard deviation of 0.07 represents very less variability in responses and also suggests that the responses are clustered close to the mean.

Table 6: Output of one sample t-test for factors governing the application of knowledge management in enhancing project time performance

	Test Value = 3					
	t	**df**	**Sig. (2-tailed)**	**MD**	**95% CI of the Difference**	
					Lower	**Upper**
Improved project supervision and site management	62.45	90	0.000	2.85	2.77	2.95
Proper planning of works	69.89	90	0.000	2.90	2.82	2.98
Committed leadership and management	54.49	90	0.000	2.81	2.71	2.92
Proper planning for tools and equipment	57.81	90	0.000	2.84	2.75	2.94
Ensure effective communication	64.06	90	0.000	2.86	2.78	2.96
Hire skilled workers to achieve good progress, avoid double-handling	72.27	90	0.000	2.91	2.83	2.99
Focus on the quality and cost of the project	61.98	90	0.000	2.87	2.79	2.97
Training and development of all participant	58.34	90	0.000	2.82	2.73	2.92

Reduced workforce absenteeism	39.94	90	0.000	2.72	2.59	2.86
Fully utilise the construction team	54.49	90	0.000	2.81	2.71	2.92
Use new construction technologies (IBS)	52.63	90	0.000	2.79	2.69	2.90
Focus on the client's need	55.52	90	0.000	2.82	2.72	2.93
Adoption of tools and techniques, i.e., Value Management, Lean Thinking,	62.45	90	0.000	2.85	2.77	2.95
Measure performance against other projects	49.81	90	0.000	2.83	2.72	2.95
Helps in getting over design changes on time	45.63	90	0.000	2.76	2.65	2.89
Helps in evaluating project duration	45.13	90	0.000	2.81	2.69	2.94
Informs the need to appoint competent subcontractors and suppliers	43.95	90	0.000	2.79	2.67	2.92
Helps in swift resolution of conflicts	56.09	90	0.000	2.80	2.70	2.90
Helps in better assessment of weather	45.63	90	0.000	2.76	2.65	2.89
Helps in assessing ground conditions	55.52	90	0.000	2.82	2.72	2.93
Informs the usage of appropriate construction methods	59.09	90	0.000	2.85	2.76	2.95
Helps avoid needless rework	62.45	90	0.000	2.85	2.77	2.95
Helps properly schedule works to minimise idle time	60.97	90	0.000	2.84	2.75	2.94
Improves problems solving and decision making	65.82	90	0.000	2.87	2.79	2.97
Minimises construction site labour unrests	46.24	90	0.000	2.78	2.66	2.90
Helps to minimise litigations	40.34	90	0.000	2.73	2.60	2.87
Helps facilitates prompt payments	45.63	90	0.000	2.76	2.65	2.89
Helps improve documentation and procedure	60.97	90	0.000	2.84	2.75	2.94
Helps in material ordering and scheduling	60.97	90	0.000	2.84	2.75	2.94
Fast tracks contract design and specification disagreements	57.81	90	0.000	2.84	2.75	2.94
Informs proper plant and equipment management to avoid needless breakdown	62.45	90	0.000	2.85	2.77	2.95

5. DISCUSSION OF THE FINDINGS

5.1 Application of project knowledge management to current projects

The current study established that building project knowledge, when managed, is indeed applied during the execution of a current project. The findings of this study accord with that of Ranf and Herman (2018). Ranf and Herman (2018) found that project managers apply managed knowledge on previous projects in the project management activities of a current project. Falqi (2017) and Anumba et al. (2005a) are also of a similar view that the application of knowledge or experiences drawn from a previous project on a current ongoing project is a regular practice by construction professionals and workforce, although no two projects are the same. This suggests that during the construction of a current building project, ideas and experiences drawn and carried by professionals and workforce and managed are brought to bear.

5.2 Influence of project knowledge management on project time performance

The results of the multiple regression from Table 3 show that project knowledge management explains some 30 per cent of a project's time performance. This implies that the conscious application of previously managed knowledge to current or ongoing projects has some positive influence on an ongoing or a current project's time performance. Drawing on previous experiences consciously managed helps to mitigate the extent of delays caused by decision making, construction site labour unrests (boycotts, strikes, etc., litigations arising during project delivery and actions that could bring about litigation, payments by clients, documentation, and procedure, material ordering and scheduling, design and specification interpretation disagreements, plant and equipment management this study finds. Managing and applying project knowledge on future projects helps improve project supervision and site management; pull together committed leadership and management; inform the need to hire skilled workers to achieve good progress, avoid poor quality of work, more rectification and double handling; helps in getting over design changes in record time Guribie and Tengan (2019), training and development of all participant to support project delivery process; proper planning for tools and equipment; measure performance against other projects; focus on the quality, cost and delivery of the project; reduce staff absenteeism; helps in evaluating project duration accurately; informs the need of appointing and aids in appointing competent subcontractors and suppliers; send clear and complete message to operatives to ensure effective communication; proper planning of works; informs the recruitment of the needed quality and quantity of skilled and unskilled labor; helps in swift resolution of conflicts between project parties, helps avoid needless rework caused by mistakes; minimises construction site labor unrests (boycotts, strikes); helps to minimise litigations arising during project delivery and actions that could bring about litigation, helps in material ordering and scheduling; fast-track contract design and specification interpretation disagreements; informs proper plant and equipment management to avoid needless breakdown, helps in better assessment of weather conditions; informs the usage of appropriate construction methods; helps properly program and schedule works to minimise staff idle time; improves problems solving and decision making; fully utilise the construction team; use new construction technologies (IBS-Industrialize Building System); focus on client's need; Provide knowledge/training to unskilled workers based on their scope of work, helps facilitates prompt payments by clients; helps improve documentation and procedure (Oluikpe et al., 2011). These factors cause delays in projects. The lessons learned and the experiences drawn on previous projects avoid the impact of these critical factors on project duration. When knowledge of the previous project is managed and applied to future projects, reworks and 're-inventing the wheel' waste time avoided, and projects tend to save considerable time.

5.3 Critical factors governing the application of knowledge management in enhancing project time performance

The building construction professionals affirmed strongly that upon the application of project knowledge management, some critical factors are impacted which, consequently, enhance project time performance, viz: project supervision and site management, planning of works, committed leadership and management, planning for tools and equipment, send clear and complete message to worker to ensure effective communication, hire skilled workers to achieve good progress, avoid double handling, focus on the quality, cost and delivery of the project, training and development of all participant to support delivery process, staff absenteeism, construction team utilisation, usage of modern construction technologies, focus on client's need, adoption of tools and techniques i.e., Value Management, Lean Thinking, etc., measurement of performance against other projects, getting over design changes in record time, accurate evaluation of project duration, appointment of competent subcontractors and suppliers, recruitment of the needed quality and quantity of labor, resolution of conflicts between project parties, assessment of weather conditions, ground conditions assessment, usage of appropriate construction methods, rework caused by mistakes, works programming and scheduling to minimise staff idle time, problems solving and decision making, minimisation of litigations, payments by clients, material ordering and scheduling, contract design and specification interpretation disagreements, plant and equipment management. These causes of project time overrun established by (Soomro et al., 2019) are said to be positively impacted when project knowledge of a previous project is managed and drawn on during the execution of a future project (Grabar and Grd, 2014) and as a result helps improve the time project's time performance (Alyoubi et al., 2018).

6. CONCLUSION

The management of knowledge of the workforce in organisations has become an organisational pre-requisite since labour turnover is on the increase. The construction industry, characterised by disbanding a project team and a greater number of workers going their way after a project is completed, loses valuable experience that is carried away in the heads of professionals and the workforce as teams disband after a project is completed. This loss can be avoided by managing the knowledge carried by this project workforce. This study sought to establish whether project knowledge managed on the previous project is applied to future projects in the Ghanaian construction industry, determine whether the application of such knowledge has an impact on future project time performance, and establish the factors by which the application of project knowledge managed helps improve to improve the time performance of a future project.

The study concludes that the Ghanaian construction industry taps from the depth of knowledge managed from previous projects and applies this knowledge during the construction of a future project. This application, according to this study, consequently influences project performance positively by saving the project about 30% of the total project duration. Since project time performance is improved on the application of previously managed knowledge to current projects, this study recommends that building construction project teams must pay attention to factors that cause time overrun during the construction of a project, attempt to note these factors as they occur and the manner which these occur, document lessons learned and apply these lessons learned to future projects to rid projects of delays. A limitation of this study is that the findings of this study are based on the opinions of the professionals that were studied. A study on the whole construction project workforce could have given a deeper understanding. Further research is recommended to be conducted on other construction workers.

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