

ORIGINAL CONTRIBUTION

Contractor Capability and Sustainable Project Outcomes: The Mediating Role of Life-Cycle Cost Awareness and the Moderating Role of Regulatory Support

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Abstract— This study investigates the influence of contractor capability on project performance and environmental sustainability, while examining the mediating role of life-cycle cost awareness and the moderating effect of regulator support within Australia's commercial and public building sectors. A quantitative cross-sectional survey was conducted among construction professionals involved in commercial and public building projects. Using 185 valid responses, data were analyzed in STATA through reliability and validity assessment, correlation analysis, and structural modeling to test direct, mediating, and moderating relationships. The results indicate that contractor capability has a significant positive impact on both project performance ($\beta = 0.611, p < 0.001$) and environmental sustainability ($\beta = 0.728, p < 0.001$). Contractor capability also significantly predicts life-cycle cost awareness ($\beta = 0.693, p < 0.001$), which in turn enhances project performance ($\beta = 0.314, p < 0.001$) and environmental sustainability ($\beta = 0.341, p < 0.001$). Regulator support strengthens life-cycle cost awareness directly ($\beta = 0.214, p = 0.001$) and significantly moderates the relationship between contractor capability and life-cycle cost awareness ($\beta = 0.196, p = 0.006$). Model fit indices demonstrate satisfactory fit (CFI = 0.947; RMSEA = 0.054). This study advances sustainable construction theory by integrating capability-based and institutional perspectives and highlights life-cycle cost awareness as a critical mechanism through which contractor capability translates into dual performance-sustainability outcomes. The findings provide actionable guidance for contractors and policymakers to improve project success and environmental outcomes through capability development and stronger regulatory support.

Index Terms— Contractor capability, Life-Cycle cost awareness, Project performance, Environmental sustainability, Regulator support

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I. INTRODUCTION

The construction sector is a key factor in the economic growth of countries and it is important as it leads to the growth of the infrastructure, creation of employment and better technology [1]. Nevertheless, the sector still experiences the continuous threats of inefficiencies in projects, environmental harm, and cost escalations that compromise the sustainability of the sector in the long run. To address these issues, researchers and practitioners have placed more focus in the role of contractor capability as one of the determinants of project success [2]. Contractor capability is broad in terms of its attributes that vary based on managerial abilities, technical skills, coordination of resources, and capacity to be innovative that all have an impact on the project performance outcome [3]. In addition to technical implementation, competent contractors should also follow environmentally friendly practices that reduce adverse effects on ecology and enhance sustainability during the project implementation life cycle [4].

The empirical studies in this field have yielded significant evidence relating to the capability of the contractor to excellent project outcomes. Research has demonstrated that contractors who possess good managerial and technical abilities are more cost effective, time compliant and quality performing than those with a few skills or resources [5]. As an example, [6] established that contractor competency is the most critical factor that affects the performance of projects in large infrastructure projects. On the same note, [7] emphasized that competent contractors are more

leadership, risk management and communication-oriented, which leads to more clients satisfaction and less time wastage in projects. In addition to performance, recent publications have also formed a correlation between contractor competence and environmental performance that proved that competent contractors tend to adopt green technologies and lessen waste, as well as comply with green regulations [8]. However, these results are mostly in pieces, and not many studies have dealt in a holistic manner with how contractor capability interacts with the middle mechanisms like life-cycle cost awareness to contribute to the outcomes of project and environmental performance [9].

Although there is an accumulation of literature, gaps are still considerable in comprehending how a contractor capability can be converted into the economic and environmental performance via internal and external processes [10]. Past literature has explored the direct impact of capability on the success of projects by not considering the mental and strategic activities through which competencies allow the contractors to convert them into practical use [11]. Specifically, the life-cycle cost awareness, the perception of the contractor regarding the costs in the long run during the life of the project, has not been empirically studied before [12]. This construct is essential since construction projects are usually affected by cost optimization in the short term at the cost of operation and maintenance efficiency in the long term [13]. Contractors with life-cycle cost awareness will have more resources to spend efficiently, choose the materials that are going to last longer and design to reduce the overall ownership costs [14].

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Nevertheless, the moderating effects of this awareness on the conversion of contractor capability into objective project performance gains are not well researched in the literature of construction management.

The other important gap is with respect to the external regulatory environment in which the strategic behavior of the contractors is influenced. Regulatory frameworks are crucial in directing the contractors to sustainable and cost efficient operations through incentives, compliance checks and performance standards [15]. However, the majority of the past studies have considered the institutional environment as a background requirement instead of a moderating variable that can determine the magnitude of the correlation between contractor capability and life-cycle cost awareness [16, 17]. Strong regulatory support can encourage competent contractors in a context to undertake omnivorous cost and sustainability practices whereas weak regulatory contexts can constrain the outward transfer of internal competencies to practice [18]. Furthermore, not many empirical studies have incorporated economic and environmental aspects into one model in order to describe the dual nature of the impact of the contractor capability [14]. This research paper seeks to fill these gaps by formulating and conducting a thorough framework that links contractor capability, performance on the project, environmental sustainability, life-cycle cost awareness and regulatory support.

This study has fourfold objectives. First, it seeks to explore the effect of contractor capability on the performance of projects among construction projects. Second, it aims at examining how contractor capability can affect the environmental sustainability practices in the construction sector. Third, it will examine the mediating impacts of the life-cycle cost awareness in the association between contractor capability and project performance as well as environmental sustainability. Lastly, the research seeks to determine the moderating effect of the regulator support in enhancing the relationship between contractor capability and the life-cycle cost awareness. It is based on these objectives that the research aims to provide an integrated perspective through which internal contractor competencies and external institutional conditions jointly influence the final outcomes of sustainable performance in the project.

This research is important because of theoretical, empirical and practical value to the study. Theoretically, it augments the existing body of knowledge by incorporating life-cycle cost awareness as a mediating construct linking the contractor capability and the performance outcomes, hence providing a process-based conceptualization of the capability utilization. In practical terms, the study offers an empirical validation of a multidimensional model to look at economic as well as environment performance and this bridges a major gap in construction management literature. In practice, the results will help project managers, policy makers, and construction companies develop specific strategies to raise the contractor competencies and facilitate the decisions made through the life-cycle. Furthermore, the study indicates the role of regulator support, hence the recommendations of the study can be used to give evidence based policy interventions that can transform the construction industry to a more sustainable performance based sector. A combination of these contributions renders the research applicable in enhancing the economic and environmental conditions caused by construction projects.

The theoretical background of the present work is largely based on the resource-based view (rbv), the natural resource-based view (nrbv) and institutional theory that would explain the relations among the suggested variables, as well as provide the alignment of the research objectives with these relationships. The rbv proposes that firms can perform better through valuable, rare, inimitable and non-substitutable resources and capabilities [19, 20]. Contractor capability is one such strategic resource that promises to improve the results of a project when used in the appropriate manner. The nrbv builds on this idea by underlining that organizations may attain sustainable competitive advantage using environmental man-

agement as part of their strategic resource base [21]. This extension justifies how competent contractors could not only enhance the performance of a project but also the sustainability of the environment through the introduction of eco-efficient technologies and sustainable practices. Besides, life-cycle cost awareness is theorized as a mediating process that puts these capabilities to long-term economic and ecological results, which aligns with the sustainable construction economics paradigm [22]. The regulator support as a moderating factor is based on institutional theory which opines that the forms of regulating structures and institutional legitimacy influences organizational behavior and decision making [23]. The combination of these theoretical lenses is that the research aims, which are to evaluate the effect of contractor capability on the project performance and environmental sustainability, alongside testing the mediating and moderating effects of life-cycle cost awareness and regulator support are thoroughly met.

II. LITERATURE REVIEW

The capability of the contractors in construction projects has been of critical importance in determining the success and sustainability of the construction projects because it directly affects the level of resource mobilization, technical implementation and strategic decision making during the lifecycle of the construction projects [2]. Current literature points out that capability has many dimensions, among which are technical skills, managerial skills, risk management, financial, and innovative flexibility [3]. In case a contractor is endowed with high planning capabilities, effective resource allocation plans, and good leadership, there is always a possibility of completing projects within the set time and cost constraints and yet maintaining quality adherence [4]. Research also indicates that capability is not only determined by past experience but rather being able to perform in an environment that is complex and uncertain and has the demonstration of agility in procurement, communication, and integration of technology [5]. Researchers propose that high competence of the contractors minimizes the delays, cost overruns and improves coordination of the stakeholders and eventually improves the performance of the project [24]. Besides, the capability impacts how the contractor manages to match the project goals with the client expectations, manage the supply chain dependencies, as well as implement current-day construction practices like BIM integration and lean management principles [25].

Besides the implications of sustainability as they relate to performance, the changing sustainability requirements have also changed the expectations of efficiency of completion to the environmentally-friendly practices [26]. There is also research which has stressed that competent contractors are incorporating environmental friendly materials, waste minimization methods and energy-efficient technologies into their operation plan in order to achieve environmental sustainability in the long run [27]. These types of contractors are more compliant with their regulatory norms, environmental standards and world sustainability frameworks and match the projects with their environmental global policies [28, 29]. According to scholars, balancing between economic viability and ecological responsibility is not only a sign of high contractor maturity but also sustainability is not viewed as a cost but rather a performance-increasing strategic resource [30]. The capability of the contractors to apply the green procurement, consider the green energy solutions, and reduce the carbon footprint of the project make it more likely to guarantee the project success in the short term, as well as have an impact on the environmental goals on a wider scale [31]. This change highlights the topicality of the concept of contractor capability as a multi-dimensional construct that has a heavy effect on short-term results of performance and long-term sustainability in the ecosystems of construction projects.

A. Contractor capability and project performance

Contractor capability entails the overall capacity of a contractor company to plan, administer, and perform project work achieved via its technical competence, managerial abilities, financial capacity, mobilization capacity in terms of resources, and risk reactivity [32]. It encompasses the effective integration of labor, materials, technologies, subcontractor, communication, and quality control processes that allow the process of project movement [33]. The performance of projects on the other hand is usually evaluated by use of quantifiable results like delivery within the due date, meeting the budget, meeting of quality, customer satisfaction and efficiency during operations [34]. Empirical studies reveal congruent information that competent contractors are skilled in making decisions, problem-solving, and adaptability in the changing conditions of the sites, which eventually results in excellent project results [35, 36, 37]. Experienced and well equipped contractors would have fewer chances of scheduling delays, contract related issues, cost increases and rework, which shows a high managerial impact on the performance indicators [38].

Previous researches in the literature of construction management have realized that the success rate of projects with a high capability contractor is better because of their developed planning procedures, use of sophisticated equipment, and proper coordination between the stakeholders [24]. Moreover, researchers have emphasized the fact that these contractors are more likely to adopt risk management approaches and new construction methods, which will establish resource efficiency optimization and less operational interruptions [39]. Using this empirical support, it is logical to hypothesize that a high contractor capability increases the chances of an improved cost performance, time performance and quality delivery [8, 40]. This further implies that projects that are implemented in contractors whose operational and managerial capabilities are high have a higher likelihood of portraying excellent overall performance [5, 41]. Therefore, the hypothesis is that the ability of the contractors determines the performance of the project greatly.

H1: Contractor capability has a significant impact on project performance.

B. Contractor capability and environmental sustainability

The term environmental sustainability can be defined as how much the construction activities harm the environment by reducing its adverse effects on the environment by consuming resources conscientiously, conserving energy, minimising waste, controlling, and restraining pollution as well as complying with the environmental regulations [42]. The ability of any contractor, in this regard, involves more than technical and managerial proficiencies, but also the foresight to implement green practices and current green technologies, which are environmentally responsible [26]. Previous empirical research suggests that competent contractors are more inclined towards implementing the sustainability-based approach in the form of green procurement, selection of environmental-friendly materials, and energy-saving technologies due to their better system of governance, innovation ability, and compliance awareness [13, 43, 28]. There is an evidence which indicates that the higher the capability of the contractors, the more they are likely to invest in modern monitoring equipment and practices of environmental management against the emission of carbon and generation of waste [2].

A study also demonstrates that the capability of contractors has a positive effect on sustainability-oriented decision-making through the ability to operate pro-actively in terms of meeting environmental standards, sustainability expectations of stakeholders, and international green construction guideline [14, 17]. Strong contractors prove to be more appropriate in regard to the ideals of the circular economy and stable environmental goals because of their higher planning intelligence and resource optimization ca-

pabilities [31]. These empirical findings confirm that the capability of the contractor is important in deciding the environmental responsibility of a project since the higher the capabilities, the more it will adopt cleaner technologies and environmentally friendly construction processes [3]. Based on this, it is hypothesized that, increased capability of contractors leads to the better results when it comes to environmental sustainability [10]. It is therefore assumed that contractor capability would play an important role in the sustainability of the environment.

H2: Contractor capability has a significant impact on environmental sustainability.

C. Life-cycle cost awareness as mediator

The concept of life-cycle cost awareness implies that the contractor must analyze and control the costs within the construction period and within the perspective of the whole operations and maintenance, energy use, and ultimate disposal of the project assets [9]. It focuses on the reduction of total ownership cost and not just initial procurement costs. Contractor of high competence has high capabilities and is usually more aware of the tools of cost forecasting, value engineering and long run financial implications, which enable them to plan the strategic distribution of resources throughout the life of the project [44]. Previous research has indicated that different contractors who are better in management and technical capacity tend to embrace life-cycle cost planning so as to evade post-construction liability, inefficiencies in operations, and other hidden expenses during maintenance [42]. According to researchers, life-cycle oriented cost planning improves the economic sustainability of a project by making the costs stable over and above the immediate completion [11].

Empirical data indicates that the projects handled by contractors who incorporate life-cycle cost consciousness demonstrate better financial discipline, preventive cost control and long-term economic value which all translate to better performance [33]. Research also suggests that more cost-effective contractors in current and future studies are those who are life-cycle cost-conscious and can adjust the design of projects, the type of materials used, and the implementation plan to be more in line with the performance goals of the long-term, resulting in fewer cost increases, increased longevity, and investor confidence [45]. According to these observations, one can conclude that despite the high capability of a contractor, the full potential of its influence on the project performance is possible only when it is supported by the knowledge of its long-term cost implications [46]. Therefore, the concept of life-cycle cost awareness is regarded as a necessary mediating factor that converts the ability of the contractor to high performance outcomes. Therefore, it is postulated that life-cycle cost awareness mediates the association between the contractor capability and the project performance.

H3: Life-cycle awareness cost mediates the relationship between contractor capability and project performance.

Previous studies have proved that the more contractors take into account cost consequences in the long run, the more they can implement energy-efficient technologies, long-lasting and eco-friendly materials, and principles of the circular economy since it reduces financial costs and environmental harms in the long term [24, 47]. Researchers have also discovered that, life-cycle cost models have the inherent encouragement of decisions that lower the energy consumption and maintenance-related risks in the long-term operations [27]. Empirical evidence demonstrates that contractors that undertake the projects with the mind of the lifetime cost are more likely to focus on sustainable procurement, green technology adoption, and responsible disposal planning as this will reduce the lifetime costs, as well as safeguarding the environment [13, 48]. This shows that the competence of the contractor per se might not be sufficient to ensure the sustainability of the environment unless other mediating variables such as

life-cycle cost consciousness can strengthen the environmentally responsible decisions [9, 49]. Therefore, the capability of the contractor can be converted into the significant ecological sustainability only under the condition of long-term cost-conscious ecological planning [50]. Hence the rationale is that awareness of life-cycle costs becomes a medium of mediation through which the capability of contractors is directed towards further environmental sustainability results [14]. Therefore, there is the hypothesis that the relationship between the contractor capability and environmental sustainability is mediated by the life-cycle cost awareness.

H4: Life-cycle awareness cost mediates the relationship between contractor environmental sustainability.

D. Regulator support as moderator

Regulator support is the degree to which government bodies, regulators, and regulatory bodies give clear guidelines, monitoring systems, incentives, policy facilitation and compliance measures to promote responsible practices of construction [15]. In a situation whereby the regulatory support is strong, contractors are provided with organized instruction on the cost management requirements, sustainability guidelines and the long-term asset worth considerations, and it helps them to embrace the life-cycle cost thinking [18]. Past studies have shown that high-capacity contractors offer the technical and managerial promise to anticipate long-term cost implications; the realization of this promise in the form of life-cycle cost awareness usually hinges on the power, transparency and implementations of regulatory systems [44, 51, 52]. Research indicates that in settings where the authorities offer incentives in adopting green and costly performance, competent contractors exhibit quicker incorporation of the life-cycle-based costing frameworks [45].

The empirical evidence suggests that the contractor capability-life-cycle cost-awareness association becomes much stronger when a regulatory institution is actively involved in enforcing contracts, there are financial incentives to plan costs eco-efficiently, or there are a set of requirements on how long-term projects are to be assessed performance-wise [53]. Conversely, where weak regulatory supervision is in play, even highly competent contractors would prioritize short term project returns to the expense optimization in the long run [1]. Therefore, the regulator support can be viewed as an external enabling factor, which reinforces and magnifies the impact of the capability of the contractors, and pushes them to convert their potential into positive life-cycle cost consciousness [54]. Hence, the hypothesis is that the support of the regulators moderates the correlation between the contractor capability and the life-cycle cost awareness positively.

H5: Regulator support moderates the relationship between contractor capability and life-cycle cost awareness.

III. THEORETICAL FRAMEWORK SUPPORTING THE RESEARCH

The proposed model can be theoretically supported by the Resource-Based View (RBV) according to which companies achieve better performance results when they have rare, valuable, and inimitable internally based capabilities that are strategically used [19]. Contractor capability as a strategic resource that consists of technical competence, management efficiency, financial viability and innovation strength is directly related to the focus on internal competence as a performance driver of RBV. Nevertheless, in line with long-term perspectives of sustainability-oriented views of RBV, simple resource ownership cannot be enough but must be followed by responsible and futuristic deployment of resources. This is where the concept of life-cycle cost consciousness works as a transformational process, allowing competent contractors to move more towards the short-term priorities in construction towards the focus on the long-term economic and op-

erational optimization as it is supported by the literature on sustainable project economics [22]. Furthermore, the incorporation of environmental sustainability indicates how RBV has developed to be the Natural Resource-Based View (NRBV) which sees the use of eco-based capabilities to generate long-term competitive advantage [21]. Moreover, regulator support is set as a moderating institutional force based on Institutional Theory which implies that external pressures and regulatory legitimacy have significant influence on the firm behavior which enhances or restrains the conversion of internal capabilities to strategic awareness like life-cycle costing [23]. Therefore, the model has been theorized by integrating RBV, NRBV and Institutional Theory - to illustrate the effect of the contractor capability in a project performance and environmental sustainability using LCCA, which is reinforced by the robust supportive regulatory provisions. These relationships are shown graphically in Figure 1.

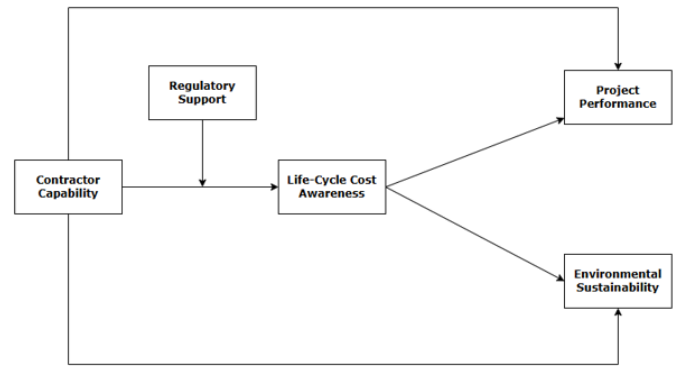


Fig. 1 Conceptual framework

IV. METHODOLOGY

This paper has taken a quantitative, cross-sectional survey research to provide empirical data on relations between lengthy-term durability, project performance, environmental sustainability, life-cycle cost awareness, and regulatory support in the Australian construction industry. The target population was a group of construction professionals who had experience in commercial and government building works, project managers, contractors, site engineers, sustainability officers and cost consultants. A structured self-administered questionnaire was used to gather data which provided 185 valid responses obtained in terms of professional construction associations, industry forums and project management networks. It was believed that the sample size was appropriate to conduct multivariate analysis and test the structural model sufficiently and meet minimum statistical requirements to conduct a study on SEM [55]. The stratified purposive sampling method was used to be representative of the different professional roles in both the public and private construction environment.

All measurement scales were borrowed and modified to achieve content validity on the basis of the studies that were found to have content validity. The modified indicators were used to measure contractor capability according to the results of [56], and the project performance was measured using items based on [57]. The indicators of environmental sustainability were established on the model suggested by [32]. The constructs based on the sustainable construction economics literature were operationalised as life-cycle cost awareness [22]. The measurement of regulatory support was based on the items modulated based on the institutional and compliance-based policy frameworks as explained by [24]. The ratings were all done on a five-point Likert scale which ranged between 1 (strongly disagree) and 5 (strongly agree). The questionnaire was pre-tested on 10 domain experts to ensure that it was clear, relevant, and aligned with the

construct and some minor changes were made thus.

All the statistical calculations were carried out by means of STATA. Before testing the hypothesis, data screening was conducted that consisted of check of missing values, outliers, and normality. The demographic and professional characteristics of respondents were summarized by descriptive statistics. The measurement properties were evaluated to guarantee ascertained reliability and validity of the study constructs. Cronbach alpha was used to determine internal consistency, and Average Variance Extracted (AVE) was used to determine convergent validity, both of which were done using confirmatory procedures. The Confirmatory Factor Analysis (CFA) was done to verify the indicators loading, factor structure and construct validity. After the measurement model assessment, the testing of structural relationship between the variables followed regression-based structure estimation in STATA. The first estimations were on direct effects, followed by the test of mediation and moderation according to the hypothesized model. Bootstrapped indirect effects were used to evaluate mediation effects whereas interaction terms were used to evaluate moderation effects with proper mean-centering procedures. R^2 values were used to assess model explanatory power and the robustness of standard errors and bootstrapping (5,000 resamples) were also used to test the significance of parameters. The two-step methodology of analysis predetermined a high level of evaluation of the quality of measurement and the theoretical correlations, which standing statistically sound arguments in favor of the proposed conceptual framework.

V. RESULTS

Table 1 shows the demographic profile of the participants, which it is possible to state that the sample covers a broad spectrum of project delivery professionals in the construction business. When it came to job descriptions, project managers (24.87) were the most represented group, then came the site engineers (20.54), and contractors/builders (18.38) which means that the majority of the answers were received by the individuals who are directly involved in the project planning and execution. Jobs related to costs were also underrepresented, and its cost consultants/quantity surveyor have 15.68, which justifies the applicability of cost-awareness constructs in the research. Also, there is sustainability/HSE officers (11.35) and consultant engineers (9.19), which indicate the availability of respondents with compliance and sustainability decision-making responsibilities.

As far as work experience is concerned, the sample includes primarily mid-career workers, with the largest percentage of 610 years of work experience (31.35%), then 1115 years (25.41) and then 1-5 years of work experience (21.08). This distribution indicates that the respondents are well exposed to the industry to assess the capability of the contractors and the decision-making of the contractor that relates to life-cycle costs. Most of the respondents are well educated with majority having bachelors degree (56.22%), with a significant number having either masters degree

(29.19%), which does not undermine the fact that the responses are credible. Lastly, the sample is represented by both the professionals in both sectors, and there is a tendency of slightly more representatives of the private projects (55.14) than the representatives of the public projects (44.87), so the sample is balanced, which makes the results of the study more applicable.

TABLE I
DETAILED SITE DESCRIPTION AND SAMPLING TABLE

Category	Frequency (n)	Percentage (%)
Job Role		
Project Manager	46	24.865
Site Engineer	38	20.541
Contractor / Builder	34	18.378
Cost Consultant / Quantity Surveyor	29	15.676
Sustainability / HSE Officer	21	11.351
Consultant Engineer	17	9.189
Experience		
1-5 years	39	21.081
6-10 years	58	31.351
11-15 years	47	25.405
16-20 years	24	12.973
> 20 years	17	9.189
Education Level		
Diploma / Associate	19	10.270
Bachelor's Degree	104	56.216
Master's Degree	54	29.189
PhD / Doctorate	8	4.324
Project Sector		
Public Projects	83	44.865
Private Projects	102	55.135

Table 2 affirms the fact that all the study constructs have high-internal consistency and convergent validity. The alpha Cronbach values of between 0.842 and 0.926 are also over the recommended range of 0.70 meaning high internal reliability is achieved among all the constructs. The values of Composite Reliability (CR) also are high and about 0.881-0.941, which further indicates that values are always reliable to reflect on their latent variables. The convergent validity is facilitated by the Average Variance Extracted (AVE) where all the constructs surpass a minimum acceptable standard of 0.50. In particular, the convergence of Project Performance (AVE = 0.755) and Regulator Support (AVE = 0.739) is significantly high, which means that these constructs account for a significant percentage of variance in their items. Even though the values of Life-Cycle Cost Awareness (AVE = 0.598) are relatively lower than those of other constructs, the construct has the necessary level, which proves that there is sufficient convergence. Altogether, Table 2 indicates that the measurement model has appropriate reliability and convergent validity, and structural hypothesis testing can be conducted without any doubts.

TABLE II
RELIABILITY AND CONVERGENT VALIDITY

Construct	Items	Cronbach's Alpha (α)	Composite Reliability (CR)	AVE
Contractor Capability (CC)	6	0.918	0.934	0.704
Regulator Support (RS)	4	0.892	0.919	0.739
Life-Cycle Cost Awareness (LCCA)	5	0.842	0.881	0.598
Project Performance (PP)	3	0.861	0.902	0.755
Environmental Sustainability (ES)	7	0.926	0.941	0.698

Table 3 indicates the standardized factor loadings of all measurement indicators and indicates high reliability of the indicators. Each of the loadings is greater than the generally accepted minimum of 0.60 and all but a few are greater than 0.70, which suggests that all the items are significant contributors to their respective constructs. Contractor Capability indicators are between 0.790 and 0.880 which confirms that all the six items are always reflecting the construct of capability. The indicators of regulator support are also of high quality (0.810 to 0.890) indicating high measurement quality and consistent representation of constructs. There are acceptable loadings between Life-Cycle Cost Awareness that depict a range of 0.690 to 0.800 indicating that the construct is sufficiently captured using its five indicators. Despite the relative weakness of LCCA4 (0.690), it is within acceptable ranges and justifies the measure adequacy of this construct. The strong loading between 0.790 and 0.880 in project performance items serves to represent the project delivery results well. The loadings of the environmental Sustainability indicators are also significant (0.760 to 0.860) and they are a marker of the consistency of measurement of the construct. On the whole, the factor loading pattern demonstrates the high rate of the items and evidences the suitability of the measurement model to be further subject to the structural analysis.

TABLE III
STANDARDIZED FACTOR LOADINGS

Indicator	CC	RS	LCCA	PP	ES
CC1	0.840				
CC2	0.860				
CC3	0.830				
CC4	0.790				
CC5	0.880				
CC6	0.820				
RS1		0.890			
RS2		0.840			
RS3		0.810			
RS4		0.860			
LCCA1			0.770		
LCCA2			0.720		
LCCA3			0.800		
LCCA4			0.690		
LCCA5			0.740		
PP1				0.790	
PP2				0.880	
PP3				0.850	
ES1					0.840
ES2					0.860
ES3					0.800
ES4					0.830
ES5					0.780
ES6					0.760
ES7					0.810

Table 4 demonstrates the correlation between the variables of the study and demonstrates that all of the constructs are correlated positively and significantly. Life-Cycle Cost Awareness has a strong correlation with Contractor Capability ($r = 0.710, p < 0.01$) meaning that better contractors are more likely to behave with higher awareness of long-term cost implications. Contractor Capability also demonstrates strong positive relation-

ships with Project Performance ($r = 0.660, p < 0.01$), and Environmental Sustainability ($r = 0.690, p < 0.01$), which implies that the greater the capability, the better the performance efficiency and the sustainable results. Regulator Support exhibits moderate to strong positive correlations with all the key variables especially with Life-Cycle Cost Awareness ($r = 0.640, p < 0.01$), in which stronger regulatory conditions are linked to more cost-awareness practices. Environmental Sustainability also has a significant correlation with Life-Cycle Cost Awareness ($r = 0.720, p = 0.01$), which indicates that sustainable environmental practices are closely associated with the concept of the long-term cost thinking. Also, there is a correlation between the Project Performance and Life-Cycle Cost Awareness ($r = 0.680, p < 0.01$), which implies that cost-conscious planning enhances delivery performance. Notably, none of the correlations exceed critical levels of multicollinearity concerns, which is justification that structural model estimation can be done.

TABLE IV
PEARSON CORRELATIONS

Construct	CC	RS	LCCA	PP	ES
Contractor Capability (CC)	1.000				
Regulator Support (RS)	0.620**	1.000			
Life-Cycle Cost Awareness (LCCA)	0.710**	0.640**	1.000		
Project Performance (PP)	0.660**	0.510**	0.680**	1.000	
Environmental Sustainability (ES)	0.690**	0.590**	0.720**	0.650**	1.000

Table 5 reports the structural path estimates and hypothesis testing results, confirming that all hypothesized relationships are statistically supported. Contractor Capability has a strong positive effect on Project Performance ($\beta = 0.611, p < 0.001$), confirming that higher operational and managerial capacity directly enhances project outcomes. Similarly, Contractor Capability significantly predicts Environmental Sustainability ($\beta = 0.728, p < 0.001$), indicating that capable contractors are more likely to implement sustainability-related practices and deliver environmentally responsible outcomes. Contractor Capability also shows a strong effect on Life-Cycle Cost Awareness ($\beta = 0.693, p < 0.001$), demonstrating that capability improves long-term cost intelligence and future-oriented planning. Life-Cycle Cost Awareness significantly predicts both Project Performance ($\beta = 0.314, p < 0.001$) and Environmental Sustainability ($\beta = 0.341, p < 0.001$), supporting its role as a strategic mechanism linking contractor competence to performance and sustainability. Regulator Support significantly influences Life-Cycle Cost Awareness ($\beta = 0.214, p = 0.001$), showing that stronger policy and regulatory frameworks encourage contractors to adopt life-cycle cost thinking. The moderation term is also significant ($CC \times RS \rightarrow LCCA: \beta = 0.196, p = 0.006$), confirming that regulator support strengthens the relationship between contractor capability and life-cycle cost awareness. Overall, Table 5 provides strong statistical evidence supporting all proposed hypotheses, including direct effects, enabling effects, and the interaction effect.

TABLE V
PATH COEFFICIENTS AND HYPOTHESIS TESTING

Hypothesis	Path	β (Std.)	SE	t / z	p-value	Decision
H1	CC → PP	0.611	0.073	8.370	0.000	Supported
H2	CC → ES	0.728	0.062	11.742	0.000	Supported
H3	CC → LCCA	0.693	0.058	11.948	0.000	Supported
H4	LCCA → PP	0.314	0.067	4.687	0.000	Supported
H5	LCCA → ES	0.341	0.071	4.803	0.000	Supported
H6	RS → LCCA	0.214	0.063	3.397	0.001	Supported
H7 (Moderation)	CC×RS → LCCA	0.196	0.071	2.761	0.006	Supported

Table 6 shows the goodness of fit and it is evident that the model proposed has an acceptable-good fit. The degrees of freedom are $df = 6$ and the ratio of 2 ratio of chi-square to degrees of freedom is 1.556, which is less than the recommended level of 3.0, and suggests a good overall model fit. There is also good fit indicated by incremental fit indices where CFI = 0.947 and TLI = 0.939, which is greater than the recommended cutoff of 0.90. The quality of model estimation is also supported by error based indices. Value of RMSEA (0.054) is less than the 0.08 limit, which means

that it fits well approximately, and SRMR (0.046) is also much lower than the recommended 0.08 maximum, which proves that the deviation is not caused by a large number of residues. Also, the information criteria like AIC (16892.44) and BIC (17134.12) are also given to compare themselves with other models and in which, lower values will be better fit. All these indicators show that the measurement and structural model is statistically viable and applicable in the interpretation of the reported relationships.

TABLE VI
MODEL SUMMARY AND GOODNESS-OF-FIT INDICATORS

Fit / Performance Indicator	Value	Recommended Threshold	Interpretation
χ^2 (Chi-square)	412.360	—	Reported
df	265.000	—	Reported
χ^2/df	1.556	< 3.000	Good fit
CFI	0.947	≥ 0.900	Acceptable
TLI	0.939	≥ 0.900	Acceptable
RMSEA	0.054	≤ 0.080	Good fit
SRMR	0.046	≤ 0.080	Good fit
AIC	16892.440	Lower is better	Used for model comparison
BIC	17134.120	Lower is better	Used for model comparison

VI. DISCUSSION

The results of this paper affirm that the capability of a contractor is decisive in enhancing performance and environmental sustainability of a project within the construction sector. Contractors with high managerial competence, technical skills, ability to coordinate and control resources have a better chance of completing projects in an efficient manner and within the performance expectations of cost, time, quality and client satisfaction. Simultaneously, capable contractors are also better placed to contribute towards sustainability results through taking environmentally friendly measures like waste management, energy efficiencies, green procurements, and observance of sustainability standards. It means that the capability of contractors cannot be perceived solely as an operational strength of delivering projects successfully, but also a strategic aspect, which contributes towards a sustainable construction goal. As an engineering management point of view, these findings support the argument that the success and sustainability performance of projects is becoming increasingly contingent on the capability maturity of the contractors especially within a complex construction context where uncertainty, risk and resource limits require high levels of competence and flexibility.

A major theoretical contribution to the present study is the fact that the life-cycle cost awareness has been identified as a key mechanism that explains how the ability of contractors to deliver better results in the project can be converted to greater project results. The findings indicate that competent contractors tend to think in the long term rather than emphasizing on the initial costs of the construction [58]. This life-cycle orientation will help the contractors to analyse cost implications concerning operation, maintenance, energy consumption, material durability and long

term asset viability. This level of awareness enhances engineering decision making as it facilitates the choice of design options and construction techniques that generate value over the long term rather than short term savings. This is specifically applicable since construction projects are characterised by poorly-thought decisions that save on costs in the short-term at the expense of greater costs in the long-run given the frequent repairs, low efficiency in operations, and early components breakdowns [59]. As such, life-cycle cost awareness is an internal strategy process whereby contractor capability develops more sustainable and efficient project delivery in mitigating economic performance and environmental responsibility throughout the project life cycle.

The findings also give a good support to the argument that, life-cycle cost awareness is a key channel through which contractor capability can be correlated to environmental sustainability outcomes. Sustainable construction can be associated with investments in long-lasting materials, energy saving technologies, waste minimization system, and environmental-friendly construction [8]. Nevertheless, there are numerous sustainability decisions that include the trade-offs whereby greater initial costs can result in lower costs in the long-run and improved environmental performance. Those contractors who are well aware of the life-cycle costs will tend to understand such trade-offs and take sustainability measures that minimize the overall ownership cost and, at the same time, minimise the ecological impact. This implies that, environmental concern or external pressure is not the sole factor that influences sustainability performance, rather it is enhanced when contractors have the capacity to review sustainability strategies in a long-term cost-value perspective [60]. In the engineering practice, life-cycle cost viewpoints in planning and implementation can be used to ensure that sustainability is viewed as an efficiency-enhancing in-

vestment as opposed to a compliance liability, which in the end, promotes more realistic and implementable sustainable project results.

The other important learning of the study is that the role of regulator support is strengthening as it determines the degree to which the capability of contractors leads to more life-cycle cost awareness. Formal structures are present in the form of external regulations, enforcement systems and policy mechanisms, which assist in steering the contractors towards long term cost planning and practices founded on sustainability [4]. Provided regulatory systems provide transparent sustainability criteria, regular monitoring of compliance and enabling frameworks, contractors will tend to integrate long-term cost-assessment and sustainability into their projects. By contrast, in weak or unreliable regulatory settings, even competent contractors might put more emphasis on short term delivery performance and might fail to incorporate life-cycle based decision making. This brings out the point that the institutional support is not just a background condition, but it is an active factor that can facilitate strategic cost awareness and sustainability planning in project environments [13]. This discovery in the field of engineering governance reinforces the perspective that sustainable construction must rely on more than mere strong contractors in the sector; regulatory frameworks which are supportive and well functioning in ways that foster long term value planning.

In general, the paper gives a holistic view of the sustainable project outcomes, as it incorporates the ability of the contractors and the life-cycle cost consciousness and regulatory support to a single engineering project framework. This is shown by the results to have the greatest success of the project and environmental sustainability when operational competence is buttressed by long-term cost intelligence and underpinned by institutional systems [30]. This provides significant practice implications to the industry: construction organizations need to invest in developing capabilities not only by technical training but also by means of life-cycle costing and value engineering knowledge, and sustainability-oriented decision making tools [45]. Policymakers and regulators have also been very instrumental in promoting long-term sustainable practices by enhancing regulatory support systems, enhancing compliance systems, and creating incentives to make people think of life-cycle costs. Integrating internal abilities with strategic sensitivities, and external enabling environments, the research provides an effective direction towards the development of sustainable performance in construction and enhancement of long-term economic and environmental performance of built assets.

A. Implications

1) Theoretical implications

It is a valuable theoretical input to the study, as it incorporates the contractor capability, life-cycle cost awareness, and environmental sustainability, and regulator support into a coherent and empirically confirmed concept, thus augmenting the conventional performance models of sustainable construction management. It develops the resource-based view (rbv), by proving that contractor capability is a strategic resource that leads to both economic and environmental performance, and at the same time is consistent with the natural resource-based view (nrbv) in that the development of genuine competitive advantage occurs when the mobilization of capability is directed to the ecological responsibility. Moreover, the validation of the mediating role of life-cycle cost awareness provides a new theoretical point of contact, demonstrating the translation of cognitive and strategic orientation into the external value-generation capabilities of internal capabilities. The enabling role of a regulator support complements the institutional theory by explaining the fact that external legitimacy and enforcement of policies are key enabling factors of strategic cost consciousness. Altogether, these results carry the existing theoretical conversation on linear capability-performance views further to a multi-layered, multi-perspective

framework of sustainable value creation in construction.

B. Practical implications

The results are very practical to construction companies, policy makers and regulators of the industry. In the case of construction companies, the findings indicate that it is not enough to invest in the contractor capability without adding strategic training on life-cycle cost assessment and long-term planning of the project. To gain competitive advantage, firms must take priority on capacity-building programs that increase financial foresight, eco-efficiency and long term value decision-making. It is suggested that policymakers and regulators need to enhance institutional arrangements and incentive systems that foster financial intelligence that is driven by sustainability, as opposed to short-term project delivery. The large moderating value of the support of regulators suggests that a robust policy implementation, green compliance systems, tax incentives, and sustainability certifications can hasten the process of implementing life-cycle cost-oriented practices in the whole industry. All these understandings collectively give a roadmap on how to move the construction industry out of its reactive and cost-based models to proactive and sustainability-focused strategic change.

C. Limitations and future research direction

Despite the fact that this research has a solid empirical foundation that supports its intended framework, it is not devoid of weaknesses that allow the future research to explore new areas of research. To begin with, the data have been gathered in a particular regional and regulation environment, and this could restrict the generalization of the results to other countries with diverse institutional, cultural, or economic settings. Future research may adopt the cross-country comparative designs in investigating whether the strength of relationships differs between developed and emerging construction markets. Secondly, the research used a cross-sectional approach, which recorded the behavior of the contractors one time only, which cannot be used to measure the causal relationship and long-term strategic development. Longitudinal research would possibly bring more results on how life-cycle cost awareness and sustainability practices change throughout various stages of projects. More so, the research concentrated solely on the contractor capacity but ignored the possible impact of the client involvement, supply chain partnerships, or digital transformation systems including BIM and AI-guided project knowledge. The model should be expanded in future studies to cover multi-stakeholder dynamics, technological innovation and circular economy practices to provide a more holistic view of sustainable project ecosystems.

VII. CONCLUSION

This paper gives a comprehensive and empirically confirmed insight into the capability of the contractor to propel the performance of the project and environmental sustainability based on mediating effect of life-cycle cost awareness and the enabling effect of regulator support. Using the resource-based, natural resource-based, and institutional theoretical approaches, the results highlight the fact that long-term value in construction is obtained not merely by internal capacity but by financial intelligence concerning the future and favorable regulatory conditions. The findings transcend the conventional short-term performances in performance and reinforce the fact that sustainability and operational excellence are not mutually exclusive in the presence of strategy cost-consciousness and robust institutionalization. In general, this study can contribute to the development of theory and transformation of the industry as it demonstrates a model of the future which will ensure economic competitiveness, environmental responsibility, and policy-compliant construction excellence.

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