

Research Paper

Analyzing Determinants of Construction Project Resilience and Success in Ethiopia: a Structural Equation Modelling Approach (PLS-SEM)

KEBEDE BEKELE DESTA¹, LUNGA MSENGANA²

¹University of South Africa. Republic of South Africa. kbdmst@gmail.com(corresponding author)

²University of South Africa. PMP Certified. Republic of South Africa. Lunga12@gmail.com

Abstract. The purpose of this study is to investigate the factors that contribute to the success and resilience of construction projects in Ethiopia's construction industry. A major gap exists in the current literature regarding the empirical validation of the relationships between resilience and success in the Ethiopian construction industry. Data collection was conducted via an online survey between March 8th and May 13th, 2024. PLS-SEM analysis was performed on the survey responses. Results indicate that resilience significantly impacts a project's success. The following are resilience-enabling factors that increase a project's resilience and enhance overall project performance. These are: resilient leadership (taking risks; learning from subordinates; being flexible during decision making); organisational structures (having few direct reports; narrow span of control; job rotation); and project team culture (assign right people for right jobs; recognition or rewarding the team members; team passions for contribution for project success; team trusts); external environment factors (mitigating high inflation effect; managing unstable economy; using appropriate legal enforcement); and risk management practices (communicating frequently; understanding/knowing how to implement risk management practices; integrating risk management practices into routine activities; having enough budget/finance). Success indicators for construction projects include quality, cost, time, safety and customer satisfaction. Therefore, developing resilience-enhancing strategies could greatly increase the effectiveness of construction project performance. The contribution of this study includes empirical evidence from the Ethiopian context, as well as practical recommendations for policymakers and project managers to create customised resilience strategies. The limitations of this study include reliance on self-reported data and convenience sampling in collecting survey responses. Overall, the study emphasizes the importance of resilience in overcoming the challenges of the construction industry in Ethiopia.

Keywords: Construction, Resilience, Ethiopia, PLS-SEM, Project Success.

Introduction

The Ethiopian construction industry is growing. The political and socio-economic factors that affect its performance are similar to those affecting most of the construction sectors; they can contribute to delays in projects and cost overruns. Funding, policy, and corruption are some of the political factors that are influenced by, and in turn influence, socio-economic factors such as a stable economy, funding for construction, availability of skilled workers, and market demand[1]. In light of this fast growth and

a significant number of issues in the Ethiopian construction industry, there is a need for a study of how to improve resilience and then achieve success in construction projects.

The consequences of not addressing what makes projects resilient and successful within the construction industry can be catastrophic [2]. Project delays can become much more severe due to a lack of resilience, which might result in huge financial losses as well as missing opportunities for stages of development [3]. Moreover, if one fails to understand what it takes for a project to be resilient, infrastructure undertakings may have cost overruns, be of low quality, or even fail to meet societal needs. This is very important given Ethiopia's fast rate of urbanisation (4), which increases the complexity and vulnerability of construction projects. Challenges, if not addressed, could hinder progress towards sustainable development goals (SDGs), hamper social and economic advancements, and perpetuate poverty cycles alongside inequality [5].

Generally speaking, the Ethiopian construction industry deals with many socio-economic-political-environmental matters that require resilience if projects are to be completed successfully [1]. For instance, the different actors in Ethiopia have to anticipate these challenges so as to deliver the quality infrastructure needed by the increasing population of the country. It is therefore imperative to assess factors that contribute to both project resilience and success in the context of such rapidly evolving environments.

This research has greater implications beyond academics. It involves multiple stakeholders in Ethiopia's construction industry, giving attention to adopting resilient practices as a whole. Several players within the sector should contribute to the resilience and success of the construction sector. For instance, it is crucial for construction practitioners to comprehend the characteristics of a resilient project and the strategies for achieving success [6]. Additionally, policymakers could use these findings as a guide for creating an enabling environment for sustainable construction during infrastructure development.

In Ethiopia, there is a limited understanding of how resilience affects the outcomes of construction projects. In this research, the authors examine the specific relationship between success and resilience within the Ethiopian construction context. This entails identifying critical characteristics of projects and their impact on success within an Ethiopian setting. Thus, enhancing performance at the project level as well as within the sector makes it more justified that such project resilience research should be carried out.

This research may be useful to African professionals involved with construction, particularly those based in Ethiopia, since there may be benefits gained from it. Some measures could be provided for promoting resilience so that more constructions succeed in Ethiopia. The paper examines leadership, team culture, organisational structure, risk management, and external environmental factors that contribute to resilient project delivery systems while ensuring successful outcomes within specified time frames. Taking this broader approach into account, the management of uncertainty can enhance the success of projects by meeting stakeholders' expectations satisfactorily.

The method applied in this research is quantitative, which aims at finding out what makes the Ethiopian construction sector resilient and successful. In line with the method, the PLS-SEM statistical modelling tool is applied in this research. Additionally, the research provides useful suggestions and insights for policymakers, practitioners & researchers in the Ethiopian construction industry who may want to

know more about resilience within this sector. It also adds to the current knowledge base (such as PMI PMBok, IPMA, and APM PMBok) to better understand resilience in Africa, with a focus on Ethiopia. These findings highlight opportunities for broader stakeholder benefit through resilience research specific to Ethiopia.

The novelty of this study lies in its ability to examine the impact that resilience has on project success within Ethiopia's construction industry. The study will therefore fill the gap of knowledge that exists around this topic in the Ethiopian setting. The study provides real-world and practical information about the most important variables that affect resilience (leadership, team culture, organisational structure, risk management, and external environmental factors) and, as such, will be beneficial to practitioners and policymakers. In addition to providing insights into resilience in an Ethiopian context, this study will provide information that will support sustainable development and improved project outcomes in Africa.

1. Literature review

1.1. Resilience and resilience factors

Resilience is defined as the ability of a system to anticipate, absorb, adapt to, and recover from unexpected challenges [[7], [8]]. Definitions in the literature address core themes, including stability, risk reduction, and the ability to adapt [9]. Although there is considerable consensus on the concept of resilience, empirical research on its implementation remains limited. Project resilience should be considered not as something static but as a dynamic capability [10], [11].

Project dynamic resilience involves continuous adaptation and reorganization in response to emergent, unpredictable changes or challenges, while highlighting the importance of ongoing learning and transformation resulting from the complexity and change associated with a project [99].

Leadership and project team culture have been suggested repeatedly in the literature to act as important enablers of project resilience. Leadership styles (shared, transformational, and responsible) play a strong role in team adaptability and crisis response and overall project success [13], [14]. These styles promote team collaboration, shared decision-making power among team members, and embracing diversity. However, limited empirical research has examined how specific leadership and team culture resilience strategies operate in the context of Ethiopian construction projects [67]. A gap remains in understanding how leadership and team culture can be used to develop resilient projects under unique socio-cultural and political conditions.

Leadership Agility represents an essential skill for leaders to operate in today's rapidly changing, increasingly complex work environment[100]. Agile Leaders will show agility in their own development, in creating change in their organization, in leading their team, and in having key conversations. When a leader develops mastery in these four areas, it can lead to both the resiliency and effectiveness of the leader and the organization within which they operate, particularly in volatile, uncertain, complex, and ambiguous (VUCA) environments[100].

Organisational structure is critical to resilience because it defines communication flows, accountability, and decision-making [15]. Where lines of authority are not clearly defined – and job uncertainty can be

typical in an obsolete hierarchical structure – there is inadequate organisational flexibility [16]. Ethiopia lacks extensive studies that investigate the various types of organisational structure as they affect project resilience [67]. Since the nature of such construction is undergoing change, investigation into the formal and flexible structures of projects becomes eminently necessary for instituting adaptive management models capable of heightened responsiveness to crises and external shocks.

External environmental factors, such as political stability, economic conditions, and socio-cultural factors, are understood to be critical in defining the resilience of a project. In Africa, there is a knowledge gap of how external shock interacts with internal organisational processes [17] [18]. Morgunova and Bolkina (2021) also note a lack of consideration as to how these two can interact [19]. Political and market instability in Ethiopia represents the biggest challenge to organisations, and therefore it would be useful to study the extent to which external factors influence organisations' resilience strategies [67].

External shocks (political instability, economy, or regulation) are examined through a resilience theory lens that looks at how firms recognise, respond to, and recover from unexpected external disruptions [96]. In construction projects, external shocks are inherently unpredictable but can critically impair project continuation [97]. A firm's capacity to manage an external shock effectively is based on its organisational resilience, which in turn is based on its organisational agility and strategic flexibility, with the latter allowing the firm to quickly reorganise its resources to prevent a loss of operational stability [98].

Risk management is fundamental to establishing project resilience [10], [20]. While the literature indisputably endorses risk management as a fundamental aspect of project resilience, studies conducted in Ethiopia reveal low levels of risk management implementation [21], [22]. The literature lacks substantial guidance on how to effectively incorporate systemic and disruptive risks into resilience frameworks for construction projects in Ethiopia [67].

1.2. Research gaps

Existing literature has identified several gaps in knowledge about project resilience in the Ethiopian construction industry [67], including an absence of empirical data from other parts of East Africa. Of particular note is the very limited number of studies that have focused on Ethiopia, which creates barriers to the development of project-level resilience practices tailored to the needs of the Ethiopian construction environment. While many studies address the topic of resilience, none have examined its application at the construction project level. As a result, there exists a gap in the body of knowledge related to the practical applications of project-level resilience in construction. In addition, little research has been conducted into how leadership styles, cultural influences, and contextual factors affect the ability of organisations to be resilient. Such an absence represents a limitation to the applicability of resilience frameworks to local contexts. There is also a dearth of valid measurement tools and indicators to measure the level of resilience within projects, as well as limited research on enabling factors such as technology, collaboration, and supply chain management to enable projects in Ethiopia to become more resilient based on their geographic and socio-economic environments. To fill gaps in the knowledge base on project resilience, it is necessary to develop contextually based practices that increase the likelihood of successful outcomes for construction projects and improve their sustainability. In the case of Ethiopia,

further empirical research and practical frameworks are needed to enhance understanding of resilience [12].

1.3. Research conceptual framework

This research emphasises project resilience in the Ethiopian construction industry to establish a conceptual framework for it. The development of this framework was based on a literature review, which revealed findings and areas where further research is needed. Therefore, this framework aims at investigating elements of projects' resiliency following the research questions. It also identifies the variables that promote the best response to project resilience and their benefits for successful project outcomes. This approach leads to the identification of the Ethiopian construction projects' knowledge gap and the resilient enablers.

The study has identified the five determinants (independent variables) that are considered to be influential in contributing to project success (the dependent variable), as well as to project resilience, as shown in Figure 1. Project team culture, leadership, organisational structure, external environment and risk management are the independent variables in the conceptual framework, while quality, cost, time, safety, and customer satisfaction are the related benchmarks for project success. A short description of each variable is provided below.

- a. The independent variables in this study include: The *project team culture* is one of the factors that could support a resilient project. Project team culture is heavily influenced by the organisational culture. An organisation has a higher level of flexibility in order to adapt to the changing needs of a situation when it has an adaptable *organisational structure* [68]. To successfully navigate the uncertainty of a situation, organisations must have effective *risk management*, including identifying and tracking risks and developing strategic plans [63]. Strong *leadership* is critical for successful projects during periods of uncertainty and is supported by top management's commitment [[69]; [63]; [70]]. By being aware of the *external environment* factors of the organisation, managers will be better equipped to provide the necessary measures to ensure the stability of the project under the influence of uncertainty [70].
- b. The dependent variable is the project success indicator, which includes five items: quality (the standard of work), cost (conformity to budget), time (completion on schedule), safety (health standards), and customer satisfaction (approval by stakeholders).
- c. Project resilience as a construct is the ability of a construction project to be able to anticipate, react to, and recover from disturbances. while project success is meeting the established goals of a project in those key areas.

In general, the conceptual framework would enable the researcher to identify and reveal the important aspects of project resilience applicable to the Ethiopian construction industry and to suggest the best applicable resilience enablers and practices, especially for the Ethiopian construction industry.

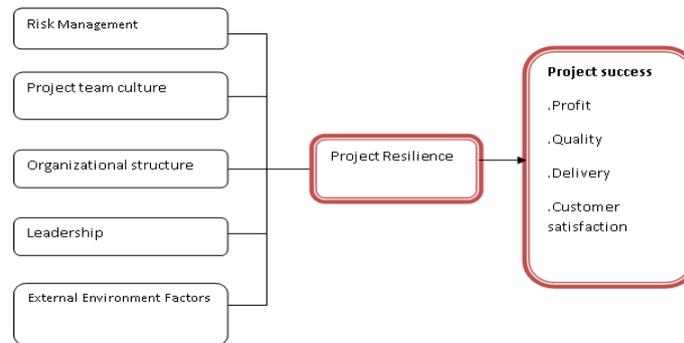


Figure 1. Conceptual research framework (Reprinted from [77])

2. Materials and Methods

The main objective of this research was to investigate the relationship between project resilience and project success using positivism as a theoretical framework.

To test the proposed hypothesis, the deductive method of research was adopted, where a hypothesis is formulated, and a research design is developed to prove or disprove it. The research design employed for this research was a survey strategy, which allows the collection of quantitative data about project resilience and its relationship with project success. A confirmatory research design was used based on deductive reasoning. It is important to sample for an accurate representation of a large population.

2.1. Research Design

This study is based upon a deductive research approach, which involves developing a hypothesis and creating a research plan to test the hypothesis. In this research, a survey-based strategy was chosen to collect the quantitative data that would help to determine how resilient a project is and whether or not that project has been successful. A confirmatory research design was chosen along with a deductive reasoning approach. To understand what is happening across a large population, proper sampling is required to be able to obtain a representative population. This study was comprised of professionals in the construction sector of Ethiopia, including employees of consulting firms, construction companies, and clients. The data for this study were collected through a questionnaire, which included a 4-point Likert scale. The data collected from the 192 participants in the study were analysed using quantitative analysis and nonparametric statistics. Using Partial Least Squares Structural Equation Modelling (PLS-SEM), the relationship between the observable and latent constructs was identified during the study. The main goal for the study was to develop and evaluate both formative and reflective measurement models. For PLS-SEM analysis, the data were analysed using SPSS and SmartPLS4.

2.2. Original research theoretical framework

The theoretical framework details below describe possible indicators for each of the resilient factors, based on the conceptual framework described in section 2.3. The factors shown below (Fig. 2) are relevant to the Ethiopian construction sector. The interpretation of the codes used in the theoretical model (Fig. 2) is shown in Table 1.

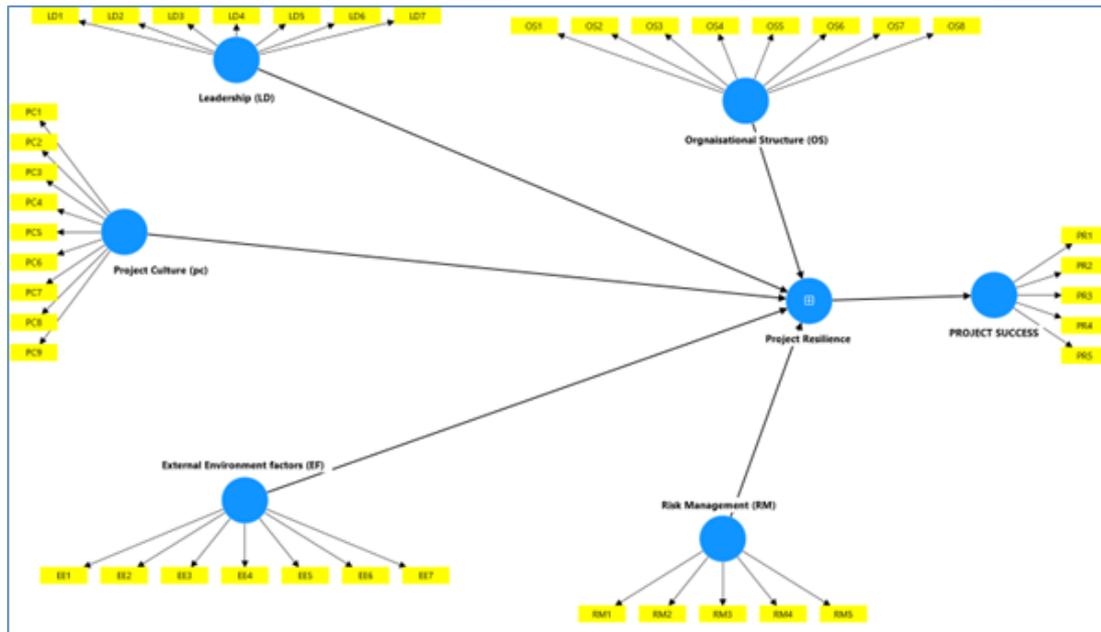


Figure 2. Original theoretical framework

Construct	Indicator Code	Description
Leadership	LD1	Flexibility during management decisions
	LD2	Learning from subordinates
	LD3	Willingness to share knowledge
	LD4	Willingness to share part of his responsibility
	LD5	Self-confidence in his knowledge
	LD6	Risk-taking during management decisions
	LD7	Team members are empowered by team leaders
Project team culture	PC1	Being aware of changes to projects
	PC2	Proper communication on the scope of work
	PC3	Teams Trust
	PC4	Team's passion for meaningful contribution
	PC5	Defined roles and responsibilities
	PC6	Team members support each other
	PC7	Team recognition schemes
	PC8	The right team member for the right job
	PC9	Provide training regularly
Organisational structure	OS1	Being assigned to manage one process of the project activity
	OS2	Having the right to establish their own reward and incentive system
	OS3	Job rotation
	OS4	Close supervision
	OS5	Few number of direct reports
	OS6	Members' participation during leaders decision making
	OS7	Use of fewer standard operating procedures
	OS8	Responding quickly to changing circumstance
External Environment	EE1	Presence of favourable government regulations
	EE2	Presence of anti-corruption and anti-bribery policies
	EE3	Low inflation rate
	EE4	A stable economic environment of the country favours performance
	EE5	Absence of breach of contract by the project parties
	EE6	Complying with rules and regulations
	EE7	Enforcing proper legal certainty

Risk management	RM1	Awareness on project related risk management issues
	RM2	Project risk management communication or knowledge
	RM3	Skill or knowledge in risk management
	RM4	Risk management integration with routine operation
	RM5	Allocation of budget for risk management
Project success factors	PR1	Quality
	PR2	Cost
	PR3	Time
	PR4	Safety
	PR5	Satisfaction

Table 1. Codes interpretations for theoretical framework

2.3. Sample size

PLS-SEM is commonly used to analyse path models containing latent constructs, particularly when dealing with small samples, and offers a range of advantages for sampling [[71]; [34]; [44]]. Four possible sample-size estimation procedures were examined: (a) The "rule-of-thumb" approach recommends that there be no less than ten times the largest number of arrows leading to each variable; here, the number of proposed samples is 70. (b) R^2 analysis indicated that a sample of 51 would have been sufficient if the R^2 had been 0.25 [35]; [72]. (c) Daniel Soper's A-priori calculator calculated a minimum of 131 samples necessary for the model's complexity [73]. (d) The inverse square root procedure recommended a sample size of 155 for a path coefficient of 0.20 at 95% confidence [74]; [75]. Therefore, the researcher chose a sample size of 156 to ensure reliability and to distribute this evenly among construction professionals [35]; [72].

2.4. Target Population and sample distribution

2.4.1. Target Population

The target population comprised Ethiopian construction professionals (clients, consultants, and contractors) involved in project management. The professionals included architects, engineers, surveyors, project managers, etc., who had the necessary training and/or certifications on construction.

Client representatives were those professionals working for project owners or sponsors (e.g., design engineers, architects, and project heads). *Contractor representatives* included project engineers, managers, quantity surveyors, and safety and quality engineers. *Consultant representatives* included design engineers, resident engineers, contract administrators, and quality managers. *Government representatives* included engineers and architects working on government-funded public projects.

Although there were difficulties in obtaining detailed information about specific projects due to political and security conditions, the survey did provide a comprehensive picture of the construction sector and the professional knowledge of these respondents. A total of 192 responses to the online survey were collected between March 8 and May 13, 2024.

2.4.2. Sample distribution

Since there was no empirical evidence on the effect level of the target group on whether a construction project will be successful or unsuccessful, the researchers applied a logical approach to divide the effect levels of the target groups equally and distribute them across the sample sizes for each target group.

Thus, to provide all participants with an opportunity to contribute equally to the results, the 156 sample size was divided into three equal parts (33.3% of the total sample size) (see Table 2).

Target population (professionals)	Number of samples
Client representatives (private and government)	52
Consultant	52
Construction contractor	52

Table 2. Target Population Sample Size (Source: Own)

2.5. Data collection methods

Primary data collection was carried out using an electronic questionnaire format and sending it to participants using Google Forms. As such, the survey instrument contained several related variables that include project team culture, leadership, organisational structure, risk management, and external environment, and the survey instrument also used a 4-point Likert scale for each variable. The survey instrument and the questions were validated and reliability tested before they were deployed in the field. In addition, the survey instrument was disseminated via multiple electronic internet-based communication systems (WhatsApp, email, and Telegram) to maximise response rates from participants.

2.6. Analytical tool-PLS-SEM

Al-Adwan et al. (2021) [71] stated that partial least squares structural equation modelling (PLS-SEM) has emerged as one of the most commonly utilised techniques for modelling latent variables and their connections. It enables researchers to estimate latent variable path models and their relationships. Russo & Stol (2021) [34] added that, in addition to modelling the relations among latent variables and their interactions, PLS-SEM is frequently employed to model the relations between latent variables. Russo & Stol (2021) [34] also confirmed that PLS-SEM is a suitable analytical tool for the estimation and assessment of complex theoretical models when only a small amount of data is available. Such analyses can be completed under the conditions of less stringent data requirements, such as small sample sizes and non-normal data distributions. As a result, they have served as useful tools for investigating the associations among constructs. According to a study by Sarstedt et al. (2022) [76], 82.01% of all the studies mentioned PLS-SEM as an appropriate methodology to utilise for this type of analysis. The top five factors for utilising PLS-SEM were sample size (small sample sizes = 47.7%), non-normality of the data (31.8%), theory development/exploratory studies (30.54%), complexity of models (29.29%), predictive research goals (25.52%), and formative measures (23.43%). All of these are pertinent to the current research objectives. The Smart PLS v.4.0 software was used to perform a PLS-SEM analysis to assess the relationships between the measurement and structural models.

Smart PLS4 provided the capability to analyse PLS-SEM; specifically, to assess both measurement models and the structural relationships between the latent constructs.

Through the use of PLS-SEM, the relationship between observed variables and unobserved latent variables could be investigated. Specifically, the goal of this research was to evaluate formative and reflective measurement models. SPSS and Smart PLS 4 were used for PLS-SEM analysis.

3. Data analysis

3.1. Pretesting the Questionnaire

Cronbach's alpha was used to check the reliability of the tool. To make sure there is internal consistency, the alpha value should be at least 0.7[23]. The Cronbach's alpha for this questionnaire was 0.95, which means that the items were very reliable and consistent with each other.

3.2. Data collection

An online survey via Google Forms was conducted from March 8th to May 13th, 2024. There were 41 questions in the main survey section.

The link was sent to potential respondents from various platforms, including Telegram, WhatsApp, and email, with the hope that they would distribute the hyperlink to other professionals known to them so as to bolster the comprehensiveness of the dataset. A hard copy of the questionnaire was also printed and distributed to participants who found some difficulty completing the online form due to unpredictable internet connectivity. Because responses were entered directly into Google Forms, the exact number of links provided to other professionals is unknown. In total, 203 participants were reached, of whom 11 declined the online questionnaire; thus, the total number of responses is 192, which were used for data measures.

3.3. Demographics of the respondents

The first part of the questionnaire was the Demographics Section. It included information on the organisation type that the respondents worked for; the job role (or function) that respondents performed at their organisations; the respondents' highest degree of qualification; if respondents knew what project resilience is; respondents' exposure to applying the project resilience concept in construction projects; the number of years that respondents had been employed professionally; and the number of years that respondents worked for their companies. The next sections will provide an overview of the demographics of the respondents:

Years of Professional Experience: Of all respondents, 8.50% reported 5 or fewer years of professional experience; 24.90% reported 6–10 years of professional experience. Likewise, 27.00% of respondents reported 11–15 years of professional experience; 25.90%, 16–20 years; and 13.70%, more than 20 years. Therefore, the respondents' years of experience support their ability to answer the survey questions presented in the subsequent questionnaire data analysis. Additionally, 66.70% of respondents stated that they have over 11 years of construction experience; therefore, their answers are based on this.

Years of experience of the respondents' organisations: Years of experience of the respondents' organisation: 27.50% of respondents' organisations have 21 years or more experience. 17.50% of respondents' organisations have 16–20 years of experience. The next 21.20% of respondents' organisations have 11–15 years of experience. Therefore, the total percentage of years of experience for the remaining 27.50% and 6.30% of the respondents is 6–10 years and less than five years, respectively. Also, the majority of the respondents' organisations (66.2%) have more than 11 years' experience in the construction sector. Therefore, the construction company's work experience corresponds to the 66.7% of respondents who have more than 11 years' professional experience.

Fields related to construction where respondents worked: Areas of the construction industry where respondents have worked.

Accordingly, 59.30% of respondents were working in the construction company; 21.70% were working in the area of consulting firms; 12.70% were working in the client area; and 6.30% of respondents were working in government agencies. These associations give evidence that respondents have been working in the construction sector.

Education levels of the respondents: The respondents' education levels include 59.80% Master's degree, 38.60% Bachelor's degree in Science, and 1.60% PhD. Thus, the study participants had the appropriate education to respond to the research questionnaire.

Positions of the respondents: The results indicate that 24.42% of the respondents were directly engaged in managing projects; 3% of respondents were consultants; 8.14% of respondents were contract managers; 18.20% of respondents were department managers; 5.23% of respondents were architects; and 3.49% of respondents were in planning and monitoring. Furthermore, 94.73% of the respondents were engineers.

Awareness and use of the project resilience concept by respondents: 59.60% of respondents indicated that they were aware of the concept of project resilience, and 25.90% of respondents indicated that they had applied it in their respective areas of expertise. Thus, the fact that resilience experts completed the survey supports its reliability.

3.4. Data Preprocessing

The Google Forms survey required completion of each question before proceeding, ensuring no missing data. Mean and median values were close across most categories, indicating high data consistency and a uniform distribution.

Table 3 provides statistical information about many of our variables in terms of the mean, median, minimum and maximum that were recorded as well as standard deviation. The mean and median are both measures of central tendency based on different methods of calculation. Codes for Table 3 can be found in Table 1.

	Mean	Median	Observed min	Observed max	Standard deviation
EE1	2.54	2	1	4	0.603
EE2	2.46	2	1	4	0.676
EE3	2.974	3	1	4	0.726
EE4	2.672	3	1	4	0.964
EE5	2.307	2	1	4	0.725
EE6	2.484	2	1	4	0.790
EE7	2.516	3	1	4	0.770
LD1	2.708	3	1	4	0.660
LD2	2.604	3	1	4	0.684
LD3	2.745	3	1	4	0.631
LD4	2.932	3	1	4	0.764
LD5	2.698	3	1	4	0.623
LD6	2.745	3	1	4	0.655
LD7	2.677	3	1	4	0.854
OS1	2.271	2	1	4	0.721
OS2	2.318	2	1	4	0.713
OS3	2.635	3	1	4	0.671
OS4	2.75	3	1	4	0.661
OS5	2.656	3	1	4	0.583
OS6	2.714	3	1	4	0.658
OS7	2.663	3	1	4	0.616
OS8	2.544	2	1	4	0.594
PC1	2.906	3	2	4	0.622
PC2	2.417	2	1	4	0.850
PC3	2.943	3	1	4	0.830
PC4	3.198	3	1	4	0.861
PC5	2.865	3	1	4	0.831
PC6	2.953	3	1	4	0.792
PC7	2.984	3	1	4	0.893
PC8	2.974	3	1	4	0.753
PC9	2.49	3	1	4	0.661
PR1	3.469	4	1	4	0.637
PR2	2.901	3	2	4	0.674
PR3	2.682	3	1	4	0.962
PR4	3.099	3	1	4	0.820
PR5	3.411	4	2	4	0.663
RM1	2.414	2	1	4	0.735
RM2	2.776	3	1	4	0.840
RM3	2.917	3	1	4	0.766
RM4	2.833	3	1	4	0.799
RM5	2.766	3	1	4	0.843

Table 3. Descriptive statistics

Z-score analysis was used to detect outliers, with a cutoff of ± 3.29 [24]. Any responses exceeding this threshold [25] were removed; one outlier ($Z = 3.8676$) was omitted from the analysis.

With respect to the normality test of kurtosis and skewness, all construction values should fall between -3 and +3 for normality [26]. Most skewness values (-0.937 to 0.126) and kurtosis values (-1.794 to 0.364) indicated a normal distribution. Cramér-von Mises P-values below 0.05 indicated that none of the variables were perfectly normally distributed [27].

3.5. Assessment of the measurement model

PLS-SEM applies a measurement model to test validity, reliability, and the nature of relationships between constructs. Measurement variables can be of two types: reflective variables, interchangeable ones that strongly correlate with each other, and formative variables, which do not relate to one another and cannot be substituted for each other [28]. More current literature in PLS-SEM employs more advanced holistic component modelling in which higher-order constructs are invoked [29]; [30]; [31].

For reflective constructs, internal consistency and validity are first tested normally by Cronbach's alpha and composite reliability [32]; [33]. Convergent and discriminant validities are crucial.

A. Convergent validity

Indicators must accurately reflect their construct for convergent validity [26]. Outer loadings should be at least 0.70 [34], but values between 0.4 and 0.7 can be kept as long as removing them does not raise AVE [35] [36]. Indicators with values less than $\lambda = 0.4$ are not included [28]. In this research, 37 of the 41 indicators had loadings between 0.4 and 0.861. Indicators with loadings below 0.4 (PC1, EE1, EE2, OS7) were excluded from the adjusted model. Average Variance Extracted (AVE) is another way to measure convergent validity, with a cutoff of 0.50 [34]. The adjusted PLS-SEM model for this research yielded AVE values ranging from 0.512 to 0.694 (Fig. 3), indicating that all constructs exhibit moderate to high convergent validity.

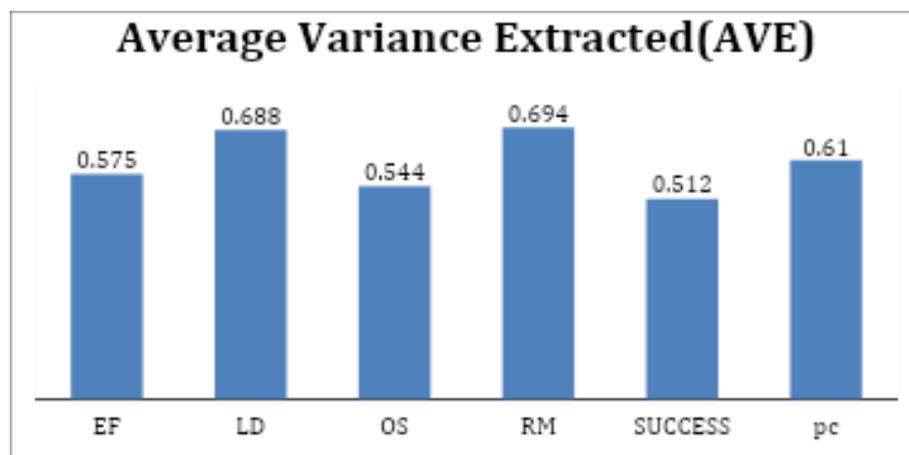


Figure 3. AVE values

AVE and outer loadings exceed standard cut-off values for minimum requirements; therefore, it can be said that the construct being studied meets the criteria of convergent validity.

B-Discriminant validity

Discriminant validity is a measure of the extent to which indicators differentiate between concepts and is established by correlating potentially overlapping scales [37]. The Fornell-Larcker criterion, HTMT, and cross-loadings are common approaches in assessing measures' quality. Reflective constructs can

only demonstrate discriminant validity when they meet the Fornell-Larcker criterion as well as the cross-loading method and HTMT.

Heterotrait-Monotrait (*HTMT*) Criterion

HTMT is a statistical estimate that approximates the correlation between two constructs. HTMT refers specifically to average inter-construct correlations relative to average intra-construct correlations across all items measuring each construct, where these correlations would be expected to fall within certain limits [30]. The indicator-level mean correlation across distinct latent variables divided by its geometric counterpart over the same-variable-average indices is called the Heterotrait-Monotrait ratio (HTMT) index, with a value greater than 0.90 indicating poor discriminant ability between compared groups [28]. In this research, all the HTMT ratios were below 0.9 (Table 4), which means there were stronger similarities among items belonging to the same variable than dissimilarities across different variables, thereby providing further evidence for discriminant validity.

	EF	LD	OS	RM	SUCCESS	pc
EF						
LD	0.693					
OS	0.511	0.578				
RM	0.215	0.489	0.667			
SUCCESS	0.798	0.706	0.405	0.329		
Pc	0.241	0.677	0.508	0.833	0.529	

Table 4. HTMT Value

Fornell-Larcker criterion

The Fornell-Larcker criterion is commonly used to test the soundness of a measurement instrument. The evaluation is done by comparing the square root of average variance extracted (AVE) for each construct with the correlation analysis between that particular construct and other constructs. Discriminant validity of a construct is achieved when its average variance extracted (AVE) exceeds the correlation between that construct and other constructs [28]. According to the Fornell-Larcker criteria values (Table 5), this research has found favourable discriminant validity among the investigated constructs. Each construct in the research measures a specific feature of itself and is separate from the other constructs examined.

	EF	LD	OS	RM	SUCCESS	Pc
EF	0.758					
LD	0.554	0.829				
OS	0.407	0.432	0.738			
RM	0.082	0.409	0.524	0.833		
SUCCESS	0.608	0.583	0.288	0.244	0.716	
Pc	0.108	0.564	0.405	0.702	0.434	0.781

Table 5. Fornell-Larcker criterion values

Cross-loadings

A cross-loadings analysis was conducted based on the Fornell-Larcker criterion. Cross-loadings results showed that items from one factor didn't load much on any other scales except their own. This is more proof that these tools are valid for discriminating between different factors.

In short, this result strongly supports the idea that the studied variables are discriminant valid in the research project. It means that if one is sure that the indicators measured what they were supposed to, then those indicators must show real differences between the factors they represent.

C-Internal consistency

There are two criteria that can be used to set internal consistency reliability standards. 1) Cronbach's alpha (the lowest value for reliability) and 2) Composite Reliability (the highest value for reliability). If the composite reliability is less than 0.6, it means that the internal consistency is not good. If the Cronbach's alpha is more than 0.7, the internal consistency is good [34].

Construct	Cronbach's alpha (α)	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
EF (External Environment Factor)	0.815	0.824	0.870	0.575
LD (Leadership)	0.773	0.778	0.868	0.688
OS (Organisational Structure)	0.718	0.728	0.826	0.544
RM (Risk Management)	0.853	0.860	0.901	0.694
Success	0.761	0.811	0.833	0.512
PC (Project Culture)	0.839	0.849	0.886	0.610

Table 6. Cronbach's alpha, composite reliability and AVE (Reprinted from [77])

The Cronbach's alpha values for all the items in Table 6 are between 0.718 and 0.853. This means that they measure the factors they are supposed to. Composite reliability (rho-a and rho-c), which ranged from 0.728 to 0.901 and should be greater than 0.7 for each construct [38], showed that there was internal consistency. Key constructs like the external environment, leadership, organisational structure, project resilience, risk management, project culture, and success showed that they were reliable enough.

D-Evaluation of the Importance and Relevance of Indicators

The outer weights and outer loadings were determined to see how important and relevant each indicator was. The confidence intervals of outer weights and outer loadings show the true value lies within a range of 95% confidence level.

A brief summary of assessing the measurement model follows:

- Cronbach's Alpha: All constructs exceeded 0.7, indicating good internal consistency.
- Composite Reliability: Values ranged from 0.728 to 0.901, surpassing the recommended threshold of 0.7.
- Most of the indicator loadings were 0.4 to 0.7; Average Variance Extracted (AVE) values ranged from 0.512 to 0.694, establishing adequate convergent validity.

- Discriminant Validity: Both the Fornell-Larcker test and the HTMT adequately established discriminant validity.
- The confidence intervals are within 95% confidence interval.

3.6. Evaluation of the structure model

In PLS-SEM, structural model assessment looks at how latent variables are connected and how important, relevant, and strong the model's paths are [39]; [28].

3.6.1. Issues with collinearity

The Variance Inflation Factor (VIF), which measures the interdependence of predictors, is used to check for collinearity problems during evaluation. The structural model was strong because all of the VIF values in this research were less than 5, which means that the model variables were not very collinear [28] (Table 7).

CONSTRUCTS	RESILIENCE	SUCCESS
EF	1.782	
LD	2.297	
OS	1.693	
RESILIENCE		1.000
RM	2.343	
Pc	2.552	

Table 7. Collinearity statistics (VIF)-Inner model matrix

3.6.2. Path coefficient

To examine this, one may analyse path coefficients, standardized values typically ranging from $\beta = -1$ to $+1$. Path coefficients near $\beta = +1$ indicate strongly positive correlations, while those near $\beta = -1$ indicate weaker relationships [28].

The empirical t-values and p-values can be calculated for each structural path coefficient using bootstrapping standard errors. If the empirical t value exceeds the critical value, the coefficient can be considered statistically significant (at that level of significance or error probability). The critical value usually used in two-tailed tests at the 5% significance level is 1.96 [28].

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
EF -> RESILIENCE	0.292	0.293	0.036	8.179	0
LD -> RESILIENCE	0.274	0.272	0.026	10.567	0
OS -> RESILIENCE	0.227	0.225	0.03	7.666	0
RESILIENCE -> SUCCESS	0.631	0.638	0.05	12.695	0
RM -> RESILIENCE	0.23	0.225	0.034	6.813	0
pc -> RESILIENCE	0.324	0.326	0.039	8.294	0

Table 8. Path coefficients- mean, standard deviation, T statistics and P-values

Table 8 shows that T statistic values greater than 1.96 and P-values less than 0.05 show that there are statistically significant relationships between independent and dependent variables [28]. The non-zero in the 95% confidence intervals for path coefficients makes this even more important. The PLS path

model shows that all of the indicators have significant, positive standardised path coefficients with project resilience ($p < 0.05$). This supports the idea that these indicators are strongly linked to project resilience. So, none of the proposed hypotheses should be taken out of the model (Table 9).

Hypothesis	Path coefficient	T-statistics	P-Values	Confidence interval		Hypothesis supported?
				2.5%	97.5%	
Hypothesis H1: Project resilience has a significant impact on project success.	0.631	12.695	0	0.516	0.714	Yes
Hypothesis H2: High performance culture has a positive impact on project resilience.	0.324	8.294	0	0.249	0.401	Yes
Hypothesis H3: Resilient leadership behaviour has a positive impact on project resilience.	0.274	10.567	0	0.227	0.231	Yes
Hypothesis H4: Resilient organisational structure has a significant impact on project resilience.	0.227	7.666	0	0.174	0.290	Yes
Hypothesis H5: External environmental factors have a significant impact on project resilience.	0.292	8.179	0	0.217	0.357	Yes
Hypothesis H6: Risk management practice has a direct effect on project resilience performance.	0.230	6.813	0	0.169	0.301	Yes

Table 9. Hypothesis testing results (Reprinted from [77])

3.6.3. Assessment of coefficient of determination (R^2)

The coefficient of determination (R^2) measures how well a model can predict something. A small difference between R^2 and adjusted R^2 means that the model fits well [40]. In latent variable research, R^2 values of 0.75 or higher are high, 0.50 is moderate, and 0.25 is weak [28]. Models that are more than two-thirds complete are strong, and models that are more than one-third complete are pretty accurate [41]; [42]. The R^2 for RESILIENCE in this research was very high (0.972), and the R^2 for SUCCESS (Table 10) was moderate, which means that the model fit well overall.

	R-square	R-squared adjusted
RESILIENCE	0.972	0.972
SUCCESS	0.379	0.376

Table 10. R^2 values

3.6.4. f^2 effect sizes

Effect sizes are used to determine whether a particular exogenous construct in the model has potential for large effects on endogenous constructs. Khalid et al. (2020) [43] state that $f^2 = 0.20$ implies small size, $f^2 = 0.15$ means medium, and $f^2 = 0.35$ indicates large size. The obtained effect size is >0.35 ;

therefore, there are no exogenous constructs in the model that have no effect on the endogenous constructs they correspond to, i.e., this shows the completeness of the research model (Table 11).

	RESILIENCE	SUCCESS
EF	1.079	
LD	0.874	
OS	0.477	
RESILIENCE		0.611
RM	0.736	
SUCCESS		
PC	1.29	

Table 11. f^2 effect size

A brief summary of assessing the structural model:

- **Collinearity Issues:** All VIF's for our predictors were less than 5, and thus there is no problem of collinearity.
- **Path Coefficient:** It is found that all paths were statistically significant ($p < .05$, $T > 1.96$), which supports each of the hypotheses that were tested.
- **Coefficient of determination (R^2):** There is a very high R^2 value for RESILIENCE (0.972) and a moderate R^2 value for SUCCESS (0.379), which indicates that the model fits the data well and has a great deal of predictive power.
- **Effect Size (f^2):** Each of the independent variables in the model had a large effect size (> 0.35) on the dependent variable in our model, which demonstrates that our model was complete as well as had strong prediction capability.

Overall summary

Both the structural and measurement models have shown good reliability and convergent and discriminant validity. In addition, both the structural and measurement models showed no evidence of collinearity issues; all hypothesized paths were significant; the structural model demonstrated high predictive power and large effect sizes, further indicating that the structural model was both robust and complete.

3.7. Mediation analysis

When a third variable fully explains the relationship between independent and dependent variables, mediation takes place [28]. In structural model testing, it is essential to determine all direct and indirect interactions between latent variables. Specific indirect effects are graphically represented by the spider web diagram (Fig.4), where a larger mediation effect is indicated by a farthest distance from the centre. A more significant mediation process is indicated by higher Variance Accounted For (VAF) values, which are computed as $(\text{Indirect Effect} / \text{Total Effect}) \times 100$ and measure the percentage of the indirect effect in relation to the total effect [44]. Organisational structure (OS) demonstrated a moderate indirect impact with a VAF of 54.02% in this research, whereas leadership (LD) displayed a VAF of 68.36% (partial mediation) (Table 12). Partial mediation is indicated by VAF values greater than 20% but less than 80%; full mediation happens when VAF is greater than 80% [44].

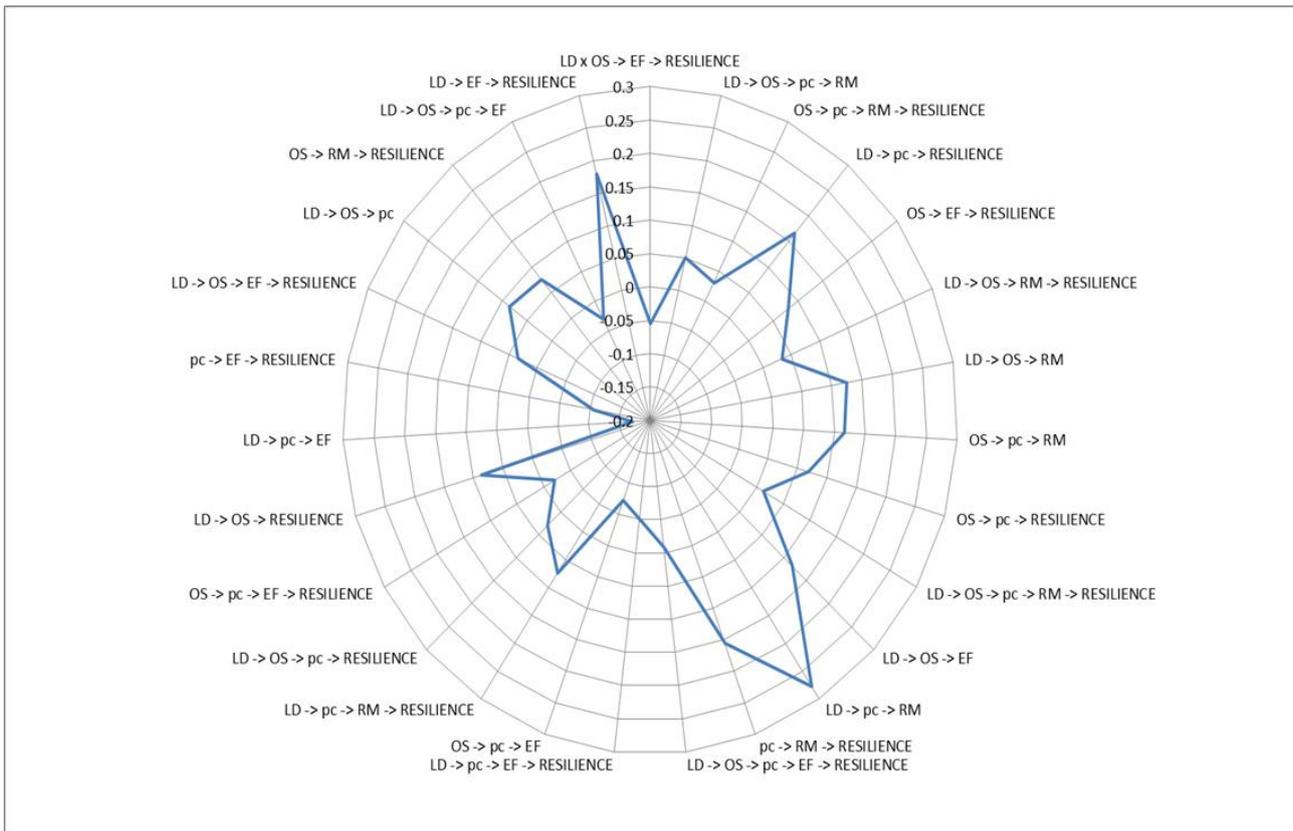


Figure 4. Spider web diagram-specific indirect effect

	Total Direct Effect	P-values	Specific indirect effect	Total indirect effect	P-values	Total effect	P-values	% VAF
LD -> RESILIENCE	0.262	0	LD -> pc -> RESILIENCE	0.165	0	0.828	0	68.36%
			"	0.192				
OS -> RESILIENCE	0.200	0	OS -> EF -> RESILIENCE	0.081	0	0.435	0	54.02%
			OS -> pc -> RESILIENCE	0.069				
			OS -> RM -> RESILIENCE	0.077				

Table 12. VAF (Variance Accounted For) values

The mediation analysis examined the influence of organizational structure (OS) and leadership (LD) upon resilience through other intermediate variables. The indirect effect for organizational structure (OS) on resilience was .081, with a variance accounted for (VAF) of 54.02%. This suggests a partial mediation. In other words, a portion of the relationship between OS and resilience is explained through intermediate variables; however, a direct relationship exists as well. Likewise, the indirect effect of leadership (LD) on resilience was 0.192, with a VAF of 68.36%, suggesting partial mediation. A larger VAF indicates a stronger mediation effect, and VAFs > 80% indicate full mediation. Therefore, both OS and LD represent moderate levels of partial mediation. This implies that the relationship between each of these variables and resilience is influenced, to some degree, by intermediate variables; yet, a direct effect from each variable remains.

3.8. IPMA

Importance-Performance Map Analysis (IPMA) helps us understand what drives corporate success by identifying key factors that contribute to it. IPMA is a graphical tool where, on the x-axis, there is “Importance” (“Total Effect”) of business drivers for success represented using a scale of 0-1, while “Performance” is plotted against the y-axis using a scale of 0-100. Researchers are able to pinpoint the preceding structures that exhibit a significant overall impact (high relevance) but demonstrate average latent variable scores (poor performance), which can then be targeted for subsequent operational enhancement. According to [45], IPMA requires either metric or equidistant scales with balanced positive & negative categories around a neutral category in the middle.

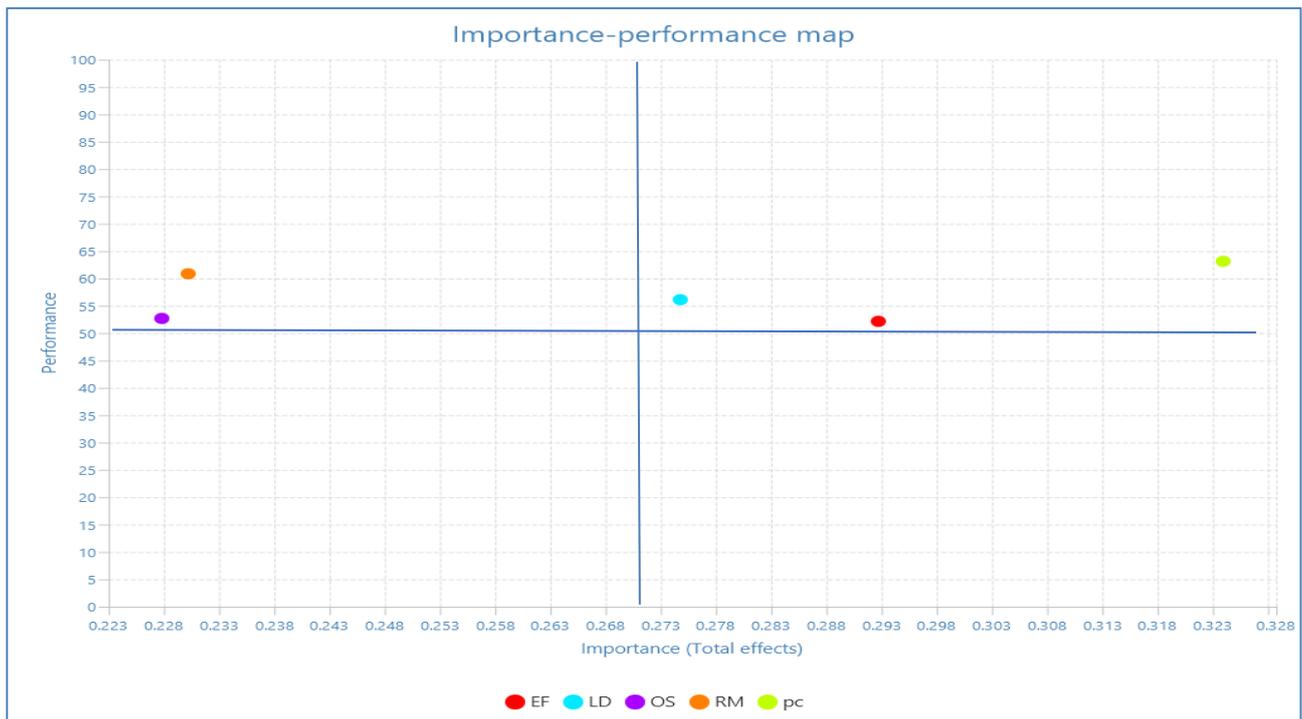


Figure 5. IPMA of constructs (Reprinted from [77])

Most constructs are located in Quadrants I and II, according to Fig.5. In most cases, this means that high levels of reliability and validity are exhibited by the constructs. Constructs' importance is indicated by large outer loading, while high composite reliability shows their reliability; hence, both of these aspects should be considered when assessing quadrant one-located constructs. Conversely, quadrant two-situated constructs represent those with strong validity, where they also have high importance demonstrated through average variance extracted (AVE). This implies that such measures can be trusted since not only do they have good dependability, but also a correct reflection of what they are intended to measure theoretically as well. Generally speaking, if areas fall within either or both the first and second quadrants, it would imply that the respondent's responses support the importance of resilience factors and their performance in bringing resilience to the construction sector of Ethiopia.

3.9. Model fit

In the PLS-SEM area, it is necessary for researchers to appraise the fitness of the model. The term 'model-fit assessment' refers to how accurately a research model reflects data [46]. SRMR is short for standardised root mean square residual, and it was first introduced by [31] as a measure of fit in PLS-SEM [47]. One can say that a model fits well when the value of the standardised root mean square residual (SRMR) is less than 1.00 [36], and below 0.1 implies satisfactory according to [48]. A perfect fit happens at zero standardised root mean square residual (SRMR). 0.08 or below are considered acceptable by [45], while [49] and [50] regarded 0.11 as acceptable scores for SRMR. The chi-square value exceeding 0.9 is an indication of a good model fit [36]. The GFI (Good Fit Index), NFI (Normed Fit Index), and CFI (Bender's Comparative Fit Index) are all measured within a range from 0 to 1. The closer they are to 0.9, the better the model fit [51].

	Saturated model	Estimated model
SRMR	0.123	0.123
d_ULS	0.802	0.682
d_G	0.259	0.259
Chi-square	283.603	275.334
NFI	0.754	0.754

Table 13. Model fit criterion of the higher-order construct model-based on PLS-SEM (for LOC)

As per Table 13, the SRMR value of 0.123 is a bit higher than the threshold value (0.11), the NFI (0.754) is nearer to the limit value, and chi-square (283) > min value. These show minimal divergence between estimated and saturated models on top of fulfilling minimum requirements for fit values; hence, they support that the hypothetical model fits empirical data finally.

While the SRMR and NFI show some difference from their related criteria, the general similarity in the values of the estimated and saturated models (Table 13), and the low discrepancy on the chi-square difference, together support that the model is a reasonable fit to the data. More refinement of the model or the use of other fit indices (e.g., CFI, TLI, RMSEA) would be needed for a complete assessment of the model's fit. However, at this time, the results provide evidence for acceptable model performance.

3.10. Moderating effect analysis

Moderation occurs when the relationship between two variables is influenced or conditioned by a third one, which acts as a moderator [52].

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (O/STDEV)	P values
pc x EF -> RESILIENCE	0.009	0.009	0.004	2.405	0.016
LD x OS -> EF	0.187	0.189	0.082	2.265	0.024

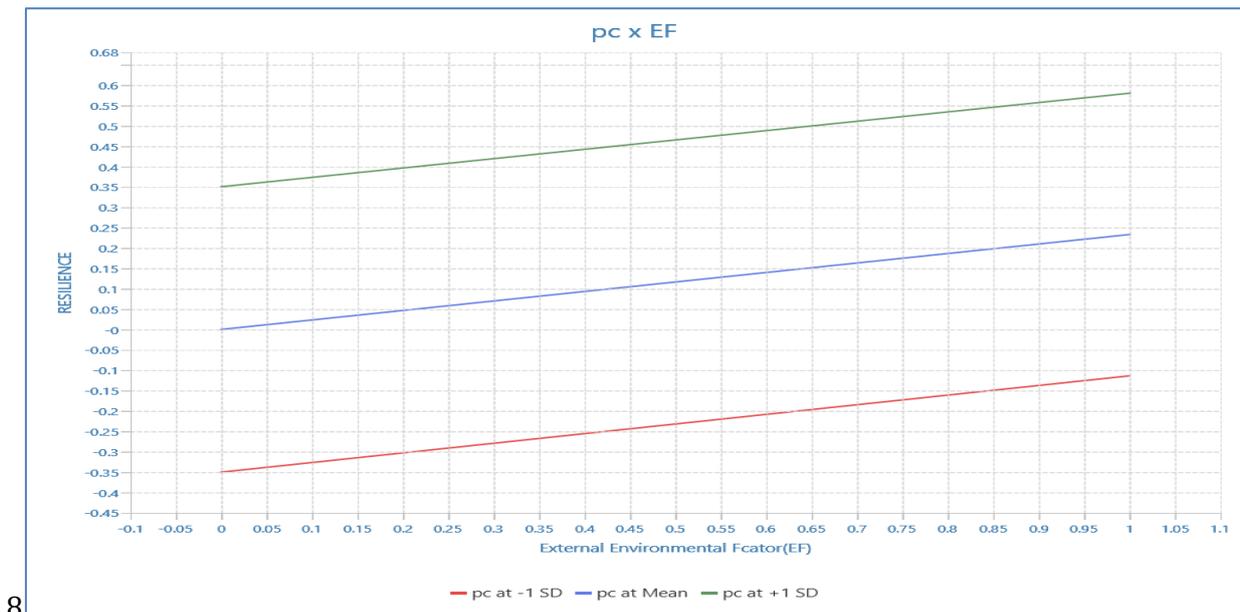
Table 14. Path Coefficient for moderators

The moderation analyses indicated that leadership (LD) significantly moderates how organisational structure (OS) affects external environment factors (EF), however, the project culture (PC) does not significantly moderate the effects of EF on resilience (Table 14; Fig. 6/7). From the simple slope analysis,

it was clear that the nonlinear interaction between OS and EF is significantly influenced by LD, as indicated by the converging slope pattern (Fig. 7). The data indicate that the same changes in LD directly affect the OS-EF relationship.

The bottom line is that leadership (LD) acts as an important moderator to the relationship between organisational structure (OS) and external environment factor (EF). The simple slope analysis of PCXEF (Figure 6) shows that the lines are parallel. Which means Project culture (PC) has no impact on the relationship between EF and resilience?

In summary, these results show that strong leadership will determine whether organisational structure influences effectiveness positively or negatively and therefore show that leadership is critical to an organisation's success and resilience.



8

Figure 6. Simple slope analysis-PCXEF

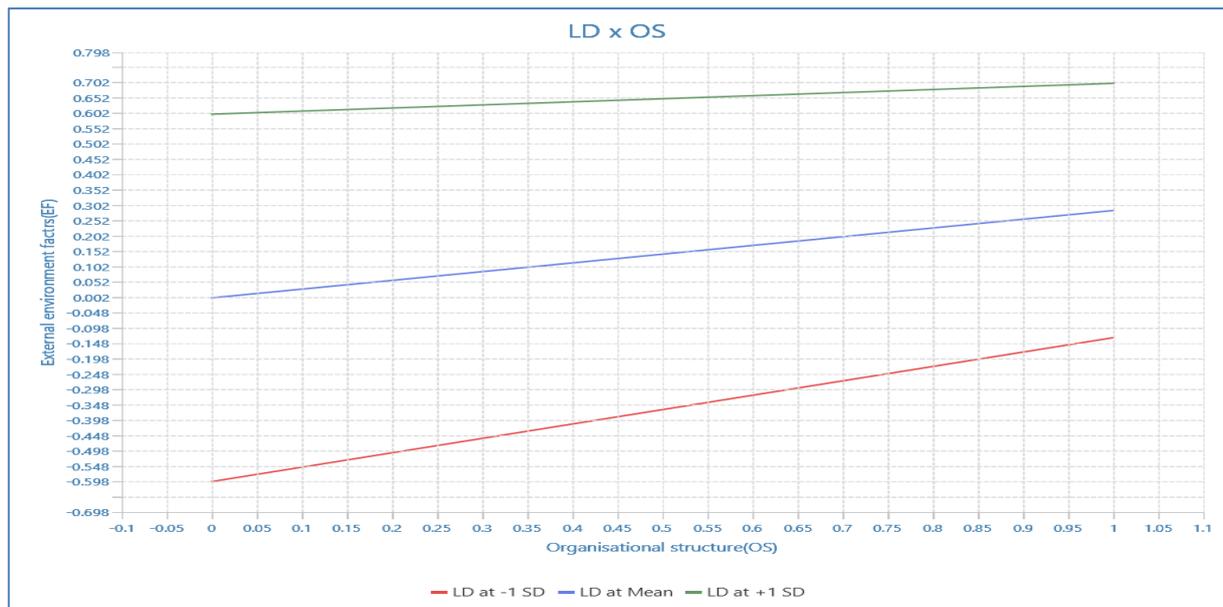


Figure 7. Simple slope analysis-LDXOS

3.11. Likert scale interpretations

The 4 Likert scale agreement level will be used to discuss the hypotheses and their factors, which will be interpreted as follows:

	Decision Type	Likert Range
1	Strongly Disagree (SDA)	1 to 1.74
2	Disagree (DA)	1.75 to 2.49
3	Agree(A)	2.50 to 3.24
4	Strongly Agree (SA)	3.25 to 4.00

Table 15. Likert Scale: Interpretation of Averages

In the following, the Likert Scale Interpretation is based on averages of the degree of agreement with each factor of "Strongly Disagree", "Disagree", "Agree", and "Strongly Agree". Two types of data are being analysed: first, descriptive statistics and acceptable PLS-SEM data analysis (Table 3); second, Likert-scale data (Table 15).

After PLS-SEM, the overall measures of the **success factors** were identified as general critical components of resilience. The Likert Scale was used to interpret the specific degrees of agreement. For example, PR1 had a high degree of agreement at 3.47, and PR5 had a high degree of agreement at 3.41. However, PR2 and PR4 had moderate agreement at 2.90 and 3.09, respectively.

For the leadership factors, the data indicate that three factors (flexibility, LD1; learning from a subordinate, LD2; and risk-taking, LD6) have moderate degrees of agreement among the participants with respect to these factors, where LD1 = 2.71, LD2 = 2.66, and LD6 = 2.75.

Similarly, the initial items measuring Project Team Culture (trust, PC3; passion, PC4; recognition, PC7; right team members, PC8; and training, PC9) have moderate agreement regarding recognition (PC7 = 2.98) and moderate agreement/right team (PC8 = 2.97), as well as moderate support/neutral agreement for trust (PC3 = 2.94) and passion (PC4 = 3.19). Training (PC9 = 2.49) has been removed from the study as there was no agreement on this item.

All the indicators for organisational structure (i.e., process assignment, OS1; job rotation, OS3; close supervision, OS4; and narrow span of control, OS5) were initially accepted, but only after the Likert scale were some of them found to have been rated in a manner that would indicate no agreement. Process Assignment (OS1) had a mean of 2.27; therefore, it is possible to say there was no agreement. Job Rotation (mean = 2.64), Close Supervision (mean = 2.75), and Narrow Span of Control (mean = 2.66) all had positive mean values; therefore, agreement existed among respondents for these items.

Low inflation impact (EE3), economic stability (EE4), absence of breach of contract (EE5), legal compliance (EE6), and enforcing legal certainty (EE7) were initially accepted as valid for the External Environment category. EE3 (2.974), EE4 (2.672), and EE7 (2.516) had mean values on the Likert scale indicating agreement among respondents. Both the absence of breach of contracts (EE5) and legal compliance (EE6) had low mean values on the Likert scale, indicating little or no agreement between respondents on these two items (EE5=2.31; EE6=2.48).

Finally, in the Risk Management category, communication (RM2), knowledge on risk management (RM3), risk integration (RM4), and financial allocation (RM5) were all initially accepted. After the Likert

scale interpretation, moderate agreement levels were observed: RM2 = 2.78, RM3 = 2.91, RM4 = 2.83, and RM5 = 2.77.

Overall, the Likert scale provides a detailed view of the various influences on project resilience and validates the agreements seen in the Smart PLS 4 results. This validation will be useful for developing the focus of the important factors that are seen as being most important, and those that require further study or implementation in the final discussion.

3.12. Final empirical research model

The final empirical research model, after measurement and structural model assessment and moderation and mediation effect analysis, is shown in Figure 8. It is based on this model that the next sections on discussion and recommendation deal with. The accepted constructs and indicators shown in the final empirical research model are well coded, and their interpretation is shown in Table 16.

Construct	Indicator Code	Description
Leadership	LD1	Flexibility during management decisions
	LD2	Learning from subordinates
	LD6	Risk-taking during management decisions
Project team culture	PC3	Teams Trust
	PC4	Team's passion for meaningful contribution
	PC7	Team recognition schemes
	PC8	The right team member for the right job
Organisational structure	OS3	Job rotation
	OS4	Close supervision
	OS5	Few number of direct reports
External Environment	EE3	Low inflation rate
	EE4	A stable economic environment of the country favours performance
	EE7	Enforcing proper legal certainty
Risk management	RM2	Project risk management communication or knowledge
	RM3	Skill or knowledge in risk management
	RM4	Risk management integration with routine operation
	RM5	Allocation of budget for risk management
Project success factors	PR1	Quality
	PR2	Cost
	PR3	Time
	PR4	Safety
	PR5	Satisfaction

Table 16. Codes interpretation for the empirical model indicators

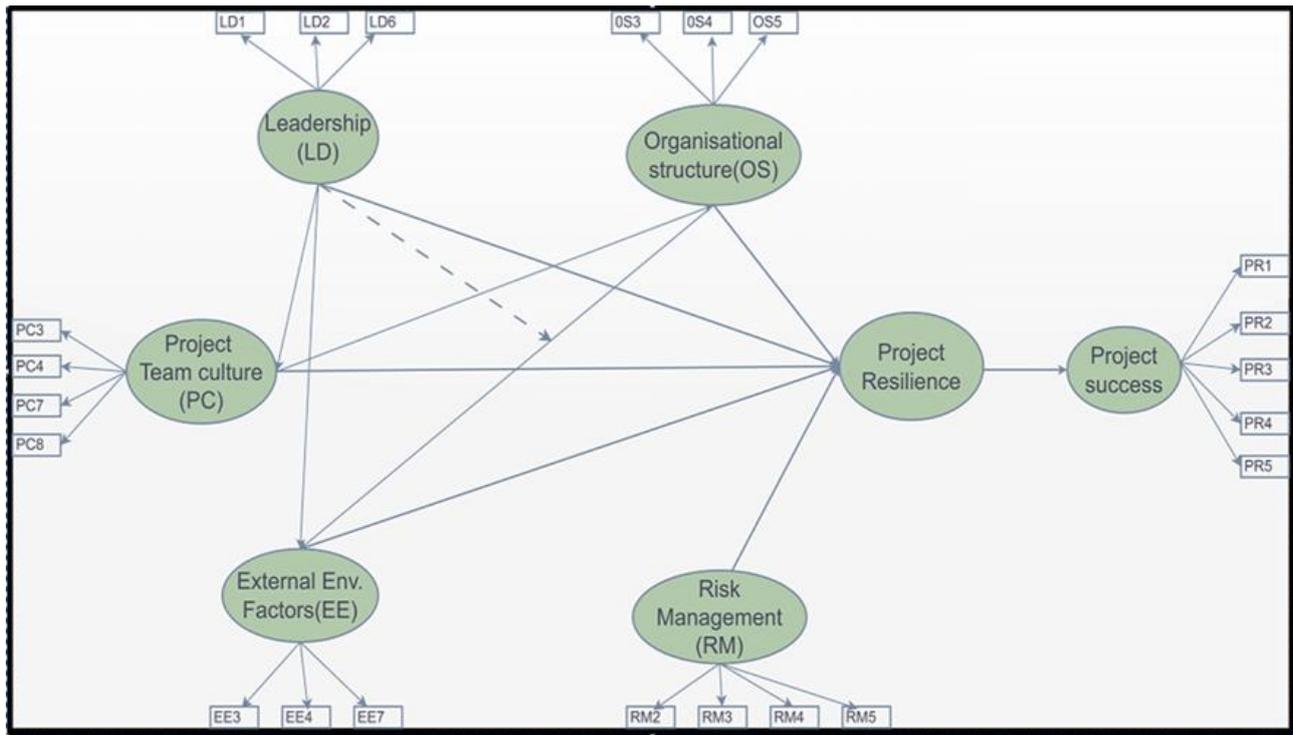


Figure 8. Final empirical research model

This final empirical research model demonstrates the complex relationships among different resilient factors, which are significant determinants of project success. The model consists of seven major variables:

1. Leadership (LD): Leadership attributes, represented by the items LD1 (flexibility in making decisions regarding the project), LD2 (learning from subordinates), and LD6 (risk-taking when making decisions). Leadership has a positive effect on resilience and then on project success. It also has a direct impact on the other two variables, such as project team culture and external environment factors. Therefore, leadership represents the focal point to understand project-related dynamics.

Leadership acts like a moderator on the direct relationship between external environment factors and organisational structure.

2. Organisational Structure (OS): The official configuration of roles and responsibilities and communication mechanisms, represented by the items OS3 (job rotation), OS4 (close supervision), and OS5 (few number of employees that report directly to one manager). Organisational structure has a positive effect on both project resilience and project success. It also has a direct impact on external environment factors. Overall, organisational structure will have an impact on project performance.

3. Project Team Culture (PC): Shared beliefs and practices within a project team are represented by the items PC3 (trust among team members), PC4 (team members' passion for meaningful contributions to the project), PC7 (team recognition schemes), and PC8 (the right team member for the right job). This variable is important because it will affect project resilience and, in turn, project success. It also has a direct impact on organisational structure and will be influenced by leadership.

4. External Environmental Factors (EE): Influences outside the control of the project team, including market conditions, regulatory requirements, and social/economic conditions (EE3: low inflation rate,

EE4: a stable economic environment for the company, favouring performance, EE7: legal certainty). These factors are significant because they will positively affect project resilience and the project's success. It also has a direct impact on organisational structure and is impacted by leadership. Therefore, environmental factors should be considered during project planning.

5. Risk Management (RM): The process of identifying, assessing, and managing risks related to a project, represented by the items RM2 (communication knowledge related to project risk management), RM3 (knowledge or skill of risk management), RM4 (integration of risk management into routine operations), and RM5 (budget allocated to risk management). Risk management positively affects project resilience, underscoring the need to incorporate it to prepare the project for the uncertainty inherent in projects.

6. Project Resilience: Measures the project's ability to withstand and respond to adversity. This will be affected by the constructs of leadership, team culture, organisational structure, external environmental factors, and risk management. Project resilience is a primary mediator between the organisational variables and project success.

7. Project Success (PR): This is the objective outcome, defined by the items PR1 (Quality), PR2 (Cost), PR3 (Time), PR4 (Safety), and PR5 (Stakeholder Satisfaction). It represents all aspects of project completion, e.g., achieving goals within the budget and the stipulated quality level, meeting stakeholder expectations, and completing on time and safely.

Significant Relationships

- Project resilience is influenced by leadership, project team culture, organisational structure, external environmental factors, and risk management.
- Project success is, in turn, influenced by project resilience.
- Leadership has an impact on team culture and external environment factors. Similarly, project team culture (PC) and external environment factors (EF) have an impact on organisational structure.
- The model captures both direct and indirect relationships between the internal and external factors that affect project outcomes.
- This empirical model, overall, helps to understand the multifaceted nature of project resilience factors and then success, and highlights areas for managerial focus to enhance project performance.

4. Discussion of findings and recommendations

The findings are used to examine the five research hypotheses. The results also broaden the knowledge base of resilience as it relates to the successful completion of projects in developing countries, specifically Ethiopia.

The study's primary contribution lies not only in confirming the importance of resilience-related factors for project success but also in providing a contextual application in Ethiopia, where there is limited empirical evidence on this subject.

Although the core resilience constructs, such as leadership, team culture, organisational structure, external environment, and risk management, are consistent with the established models, this research tested and adapted these models using the socio-economic, political, and cultural characteristics of

Ethiopia. Thus, the study provides a contextualised understanding of what resilience looks like in an Ethiopian environment.

Moreover, the study demonstrates how resilience can manifest differently based upon the socio-economic and political climate of Ethiopia (i.e., political instability and economic uncertainty) than in other regions (e.g., Western or developed countries) where the majority of studies related to resilience have been conducted.

Therefore, the originality of this study relates to the empirical verification of resilience-related constructs relevant to Ethiopia. Therefore, it will provide practical and policy-relevant information specific to the environments of other developing countries.

4.1. Hypothesis H1: Project resilience has a significant impact on project success.

The H1 hypothesis examines whether resilience factors – leadership, project team culture, organisational structure, risk management, and the external environment – are significant in project success. The dimensions of project success are identified as quality, time, cost, satisfaction, and safety. There is considerable literature supporting this relationship, as [6] found that organisations exhibiting resilience were more likely to be successful, as resilience can be incorporated into their everyday processes. Resilience is particularly beneficial to construction projects operating in uncertain environments [53], [17]. The criteria for project success typically consist of quality, time, cost, satisfaction, and safety [54].

Project resilience affects all key areas for successful project completion – including cost ([78]; [64]), quality [64], time ([78]; [64]), safety ([78]; [79]; [80]) and client satisfaction ([80]; [81]), where resilient projects can more easily handle unexpected events, control their budget, adjust to delays in the timeline, provide a safe working environment for employees, and satisfy the needs of clients, with support from literature from across the globe.

4.2. Hypothesis H2: High-performance team culture has a positive impact on project Resilience.

The H2 hypothesis proposes that a high-performance team culture would enhance project resilience. Organisational empowerment, purpose, trust, and responsibility enhance performance in a resilient culture [55]. Poor organisational culture and cultural norm integration hurt performance and shareholder returns [56]. Culture matters in maximising individual and collective potential. In other words, culture fosters effective teamwork and successful project delivery. Data analysis using PLS-SEM verified that some aspects of team culture are enablers of resilience. These are team trust, team's passion for meaningful contribution, team recognition schemes, and assigning the right team for the right job.

There is a positive relationship between high levels of trust among team members and increased likelihood of successfully completing projects under uncertain conditions ([83]; [84]; [13]). In addition, passion for making a meaningful contribution to a project contributes to both long-term and short-term

resilience and project performance [85]. Additionally, recognition of contributions made by team members can increase motivation and team effectiveness. Finally, when individuals have jobs that are appropriate to their skills and abilities, it leads to greater efficiency and results ([86]; [87]).

4.3. Hypothesis H3: Resilient leadership has a significant impact on project resilience.

Resilient leadership is fundamental to organisational resilience and project resilience. Leadership agility, adaptability, and risk-taking as a leader are essential [57], [58]. This research found that in the context of the Ethiopian construction industry, senior management leaders who exhibit flexibility when making their management decisions, learn from their subordinates, and have the ability to take risks during management decisions are more likely to engender project resilience.

Leadership flexibility and adaptability to learning from employees, along with encouraging calculated risk-taking, are key drivers of resiliency within Ethiopian construction companies. This is supported by Medina (2021) [88], who recommends leaders be adaptive in their decision-making and suggests that leaders develop an organisational learning-oriented culture around risk-taking [89]. Thus, these recommendations support the evidence from other global and regional African-based research on best practices of resilience. Leaders need to include employee input in their decision-making processes and see managed risk as an opportunity for company growth.

4.4. Hypothesis H4: Resilient organisational structure has an impact on project resilience.

Research that lays out an argument showing that structured and flexible organisations are resilient.[59]. A strong structure in an organisation provides stability and flexibility, which are very important for resilience. This research found that job rotation, close supervision and few numbers of direct reports support resilience in organisational structure and enhance efficiency to support resilient responses to adversity.

Project success within the Ethiopian construction industry has also been influenced by various other practices, such as formal job rotation and the ability of a team leader to directly supervise and communicate with all members. Flexible, adaptive organisational structures with resilient leaders who provide flexible team structures and collaborative decision-making enhance both the resilience and success of projects [89]. On the other hand, the rigidity of certain practices and inadequate communication contribute to unsuccessful project completion, thereby emphasising the importance of organisational adaptability [91]. Additionally, organisations that foster high-quality performance evaluations and feedback (common in flat organisational designs) have demonstrated significant improvements in employee performance, which is vital for successful project completions [92].

4.5. Hypothesis H5: External environmental factors significantly impact project Resilience.

The external environments, consisting of politics, economics, and social factors, moderately affect the success of a project manager. These aspects are fundamental elements for institutional resilience [60]; [60];[61] . The need for managing unpredictability in projects is exacerbated in dynamic or unstable contexts. The research identified low inflation, economic stability, contract enforceability, and legal compliance as important external factors influencing construction project resilience in Ethiopia. Having a low inflation rate and a stable economic environment in the country accounts for project performance, and enforcing proper legal certainty accounts for a resilient external environment.

Inflation and economic uncertainty have significant external influences that negatively affect project resilience in Ethiopia's construction sector. In 2022-23, inflation peaked at almost 34%; however, it moderated significantly (to approximately 17%) by the end of 2024, largely because of foreign exchange rate devaluation and associated impacts on supply chains and conflict-induced instability [92]. The overall impact is to increase construction costs, impede cash flow and ultimately create less resilient projects [93].

4.6. Hypothesis H6: Risk management practice directly affects project resilience.

In resilience, effective risk management has an important role, particularly in environmental complexity and uncertain circumstances [61];[62];[63]. Factors that aid resilient risk management are effective project risk management communication, risk management skills or knowledge, risk management integrated with routine operations, and, finally, an adequate allocation of budget for risk management. Risk management is important for project success, with effectiveness determining success and influencing resilience [64]; [65].

Risk management in construction within Ethiopia has been found to be highly dependent upon an organisation's capability to manage their employees' knowledge and skills and support a productive workplace environment. The recent literature identifies that lack of skills/knowledge and inadequate funding are major barriers to implementing effective risk management in Ethiopia [40], with risk practices being reactive (i.e., unplanned) versus planned and systematic integration into an organisation's operational processes [94]. Sufficient budgetary allocations will also remain a significant issue since funding limitations restrict organisations from adopting strong/risk management systems [95]. It is therefore recommended that companies integrate risk management into their company cultures and operational processes to increase their ability to recover from unexpected events and improve the success of projects [94].

4.7. Recommendations

4.7.1. Recommendations for Industry Practice

This research attempts to identify and investigate resilience factors that would provide enhanced project success in the Ethiopian construction industry. Traditional success is measured by quality, cost, time, safety, and customer satisfaction. This research reveals that improved resilience factors would have a positive effect on project outcomes.

Key recommendations include:

1. Cultivating high-performance team culture: trust, commitment to contribution, effective recognition systems, and assignment of the right team for the right job will help the construction teams to be adaptive. Managers should encourage open communication among their team members to foster trust within the team. Formal recognition programmes keep up, maintaining commitment and morale.
2. Institutionalising flexible leadership development: resilient leaders are adaptive or flexible, ready to learn from subordinates, and make decisions based on risks. Organisations must set up leadership development programmes for Ethiopian construction leaders in their quest to manage a crisis situation. It shall be infused with mentorship and other forms of learning.
3. Optimising Organisational Structure for Agility: Resilient project execution requires flexibility of job rotation, close supervision, and a small number of direct reports. More flexibility enables knowledge transfer across different areas, which can be achieved through job rotations, fewer reports, and close supervision.
4. Proactively managing external environmental uncertainties: The Ethiopian construction sector is highly affected by high inflation, economic uncertainty, and legal and regulatory uncertainties. Stakeholders, together with policy judges and legal professionals, should proactively develop systems to cover and continuously interpret these external factors to maintain a perception of a stable, nonsupervisory environment.
5. Integrated risk management throughout project phases: Risk management should be practised throughout project phases, to include open risk communication and ongoing risk assessment, and also include a budget for managing risks. Learning and using digital risk management tools increases monitoring and response speeds towards perfecting issues in project delivery.

Applying these strategies enhances the ability to build resilience and attain success in projects within the construction industry of Ethiopia.

4.7.2. Policy Recommendations

From a policy perspective, cross-sector collaborations and better regulation are welcomed. Therefore, it is an obligation for both government bodies and industry associations to pave the way for mechanisms that allow construction firms with similar exposure to share information on resilience practices among themselves. This will institutionalize the feeling of continuous improvement and innovation at all levels of service delivery. Policies must also enforce legal and economic issues in a harmonized and transparent manner.

4.7.3. Research Contribution

The research has shown the importance of project resilience in the Ethiopian construction industry. The research identified project resilience factors: leadership, organisational structure, risk management, team culture, and external environmental conditions. It has also identified the accepted success factors such as quality, cost, time, customer satisfaction, and safety.

This research adds to the body of knowledge in construction management by proposing a resilient approach developed specifically for the Ethiopian context. The research introduced dynamic adaptability to construction projects and is there to show how resilience is crucial to facing unpredictable threats, such as VUCA (Volatility, Uncertainty, Complexity, and Ambiguity). The findings of this research provide a framework that links constructs to defined success parameters: quality, cost, time, safety, and client satisfaction. This research not only fills a known gap in the literature regarding Ethiopia but also provides Ethiopian construction practitioners with actionable knowledge, improves overall project performance, and establishes a framework for adapting to changes in the construction context.

From a policy perspective, this research provided attention to important factors that could contribute to construction project resilience, success, and sustainability. The research provides recommendations to embed resilience-related aspects into building codes and national standards and encourages the fostering of a resilience culture to reduce vulnerabilities in construction projects.

For construction practitioners, the research provides strategies to improve project outcomes by infusing a resilience discussion in planning and decision-making processes. The research also proposed the continued culture of learning and adaptability and highlighted the key role of leadership, organisational structure, risk management, external environment, and team culture in embedding project resilience.

This research thereby constitutes a comprehensive model to improve project resilience and success in the construction industry in Ethiopia.

5. Conclusion

The contributions to the body of knowledge of this study include empirical evidence for the variables affecting the resilience and success of construction projects in Ethiopia, which is an area of study with limited representation in previous research related to resilience.

Resilience and project success are well-known as individual concepts; however, they were combined into one model through this research, which demonstrated how the concepts interacted with each other in different socio-political and economic settings within Ethiopia.

This study demonstrated that variables such as resilient leadership, team culture, organisational structure, managing the external environment, and risk management practices all have regional implications, and therefore an adaptation of resilience frameworks may be necessary due to the context.

Therefore, the study's originality lies in its regional application, which provides its uniqueness, as it develops a locally relevant and adaptable resilience model that may be used to inform policy-makers and practitioners working in Ethiopia and other regions that share similar challenges.

5.1. Summarised key findings

Project success is heavily dependent on the ability of projects to be resilient. Factors of project resilience, such as leadership, team culture, organisational structure, external environment, and risk management, all contribute greatly to project success. Project leadership with flexible decision-making, learning from subordinates, and risk-taking will create project resilience, and a high-performance team culture (assigning the right person for the right team, team recognition, team trust, and team passion for contribution) will promote teamwork and team resilience. Organisational structure (job rotation, close supervision, narrow span of control) can aid in creating a resilient organisation. External factors (low inflation rate, economic stability, and legal enforcement) have an influence on project resilience. Therefore, it is very important to mitigate potential negative externalities through proper planning. Effective risk management (communication, training, integrity, and finance or budget allocation) also helps in creating an overall successful project through creating a resilient project. Overall, project resilience is the key to being able to overcome the many obstacles and achieve goals in an ever-changing and uncertain environment.

5.2. Research limitations

Gathering online Google Forms data from 192 respondents in the Ethiopian construction environment has some risk of sample bias. Using self-reported data filled in by Ethiopian construction professionals could have bias due to and especially about their experience, perspectives on project success, resilience strategies, and organisational issues. Cultural norms may sway respondents' replies, or negative biases caused by personal reputation, risk, or social desirability will have the respondents reply in particular ways. In addition, cultural differences may affect how respondents perceive and respond to survey items, thereby biasing the collected data.

Although this research substantially focuses on the Ethiopian construction industry, it may have limited applicability outside this specific setting because of the individual country's particular socio-economic status, legal framework, and cultural practices that may differ from those of many other surrounding and worldwide countries [66].

There was very limited literature regarding this situation concerning the construction project. Therefore, this kind of research needs to continue to fill this knowledge gap. The analysis reveals new avenues for exploration while acknowledging the significance and requirement to elaborate upon the existing literature.

5.3. Future research

This study discussed the determinants of successful construction projects within the construction industry of Ethiopia. Other studies may define the interaction between resilience and other important

key performance indicators, generalise, and validate the resilience model. Longitudinal research designs are encouraged, as they would help further articulate resilience factors' contributors across a project life and under changing external conditions. It also calls for more specific research on the external environmental factors mediating leadership's effect on resilience, and different leadership styles affected by organisational resilience in different external environmental conditions. These effects would provide very valuable information to leaders to help them internalise resilience under external pressure when managing projects in uncertainty.

The study has brought out inadequacies with the model fit criteria of high-order constructs (HOC) models under PLS-SEM and hence necessitates further review as to how model fit criteria can be estimated and what possible parameters may be brought into consideration in the process of HOC-PLS-SEM modelling. The present research recommends that future researchers adopt a mixed-methods approach by integrating quantitative and qualitative research designs to get an in-depth understanding of resilience and various resilience factors that contribute to project success.

The researchers noted that there were few studies on the resilient organisational structure of construction companies in Ethiopia, which may prove useful for future researchers who are looking specifically at the nature or types of resilient organisational structures appropriate for an industry sector working in a VUCA business environment. The research produced some important resilience factors and success criteria, although there are more aspects that could be included for future consideration in the context of Ethiopia.

Disclosure statement

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Author Contributions

Kebede Bekele Desta and Dr. Lunga Msengena both contributed to the conception and design of the study. Kebede Bekele Desta conducted the research and drafted the manuscript. Dr. Lunga Msengena supervised the study and revised the manuscript. Both authors approved the final version.

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