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Impact of external environment and risk management on resilience and success in Ethiopian construction projects: A PLS-SEM/IPMA study

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Abstract

This research examines external environmental factors and risk management practices to explore how they affect resilience and success in construction projects in Ethiopia's fast-developing construction industry, using quantitative surveys of 192 professionals and modelling techniques. The research adopted an integrated research methodology of Partial Least Squares Structural Equation Modelling (PLS-SEM), Importance-Performance Map Analysis (IPMA), and descriptive statistics to systematically analyse/assess the complexities between the external environment, risk management practices, resilience, and project success. It is found that external risks, as exemplified by low inflation, economic stability and legal certainty, favour resilience and then project success. Similarly, in line with effective risk management practices such as communication, knowledge and integration of risk management and resource allocation help increase resilience. The research provides a contribution by identifying the significance and relevance of best practices to buffer the effects of external shocks and improve risk management practices, as well as be resilient to develop sustainably in the construction industry in Ethiopia.

Keywords: *external environment, risk management, resilience, success, Ethiopia, PLS-SEM, IPMA*

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1. Introduction

Ethiopia's construction industry is growing rapidly due to increased urbanisation, infrastructure development and economic growth (UNDP, 2022). However, such growth comes with a myriad of challenges, from political challenges like funding limitations, policy instability and corruption to socio-economic challenges like economic uncertainty, and labour issues, unforeseen project demands, etc., which all have a significant influence on overall project performance (Tekla Bedada, 2023) .These external environment conditions can plague the success and resilience of construction projects, resulting in delays, budget issues and poor or incomplete quality of work and overall project outcomes.

It is essential to recognise the relationship and/or interaction between any external environment conditions and risk management practices to enhance the resilience of any future projects to allow for sustainable project success. Resilience in this case means the ability for a project to foresee, change, or recover from future responses and actions or disruptions in a context of external environmental conditions that are beyond the scope of project management decisions (Lv et al., 2023). Ultimately, without developing resilient project frameworks, project participants could incur sometimes detrimental financial losses, decreased performance and meeting societal needs based on portfolio developments, as Ethiopia develops its own trajectory and ultimately its development agenda amidst complex challenges at socio-political and environmental levels and increasingly moves as an emerging economy.

While these issues are important, there is limited understanding of how external environment factors and risk management affect project resilience and success specifically in the Ethiopian construction sector. Studies to date have focused on either external environmental factors or risk management, thus seeing this as a singular, looser factor, and have not merged these issues as a whole so that stakeholders can research and develop effective resilience-based strategies for construction in the context of Ethiopia's unique challenges.

This study seeks to address this gap by examining the role of external environment factors and risk management on construction project resilience and success using an integrated research design and methodological approach, including PLS-SEM, IPMA, and descriptive statistics. The study aims to explore important external and internal factors that affect project outcomes, which have implications for practitioners, policy, and research. This study will contribute to advancing knowledge on resilient construction practices in Ethiopia and provide recommendations for practices that will enhance project performance despite the on-going socio-economic and political issues.

The importance of this study is not limited to academia, as there are implications for construction stakeholders trying to deliver resilient and successful projects in Ethiopia. An improved understanding of the interdependent relationship of external environment factors and risk management can also inform future policies, strategic plans, and risk mitigation for development objectives in support of Ethiopia and wider Africa's agenda for sustainable development and economic advancement.

2. Literature Review

2.1. Project Resilience

Success in project management contexts is frequently described in a multitude of ways, and it is seldom defined by the profession. Criteria of success generally include references to efficiency and effectiveness, which are typically presented/expressed as predetermined/bound targets surrounding time, cost, and quality measures (Crawford & Bryce, 2003; Tesfaye et al., 2017). In addition, project success had historically included consideration of stakeholder satisfaction and the ability to realise benefits in alignment with wider organisational goals and strategies (PMI, 2017; Brower & Mahajan, 2013). Resilience has been identified as an important performance characteristic on projects and for the project disciplines, particularly within unpredictable environments, which is often a characteristic of construction projects. Resilient projects are defined as the ability to accept uncertainty, respond to unexpected disturbances, recover quickly, and maintain efficiency in meeting objectives (Thakur, 2016; Yang & Cheng, 2020). Further, it is identified in the literature that systems with resilience exhibit superior financial and operational performance, therefore creating cost savings and value creation (Cottam et al., 2019).

Project resilience is planned, coordinated, and influenced by external environment factors. External factors are often summarised as external factors (often applied using the PESTLE lens): political, economic, social, technological, legal, and environmental. All external factors will influence how projects and organisations respond to uncertainties (Arefieva et al., 2019; Khalid & Rahman, 2019). External influences will inevitably impact project outcomes and stakeholder relationships by influencing decision-making and risk management within organisational flexibility (PMI, 2017). Because many external factors are unpredictable and beyond organisational control, understanding and managing external environments is essential in developing resilience in organisations to support project sustainability in changing and uncertain contexts (Ali et al., 2019; Amoah et al., 2021).

Risk management is important in the development of project resilience, which itself is continuous through identifying, assessing, and mitigating risks to your project throughout the life of the project (PMI, 2021; ISO-31000, 2018). Effective risk management is a key behaviour allowing projects to manage the unknown, provide flexible responses to risk events, and support decision-making under uncertainty. The need for continuous risk assessments signalling a project team's preparedness and being open to adaptive and timely responses to disruptions, instead of informing a one-time assessment. Effective risk management principles contribute towards developing resilient construction projects; projects do not need to always be affected by unforeseen events (PMI, 2017). Management commitment and resourcing needs to support risk management principles and practices are necessary to integrate and emphasise resilience as a practice to support project outcomes (Chileshe et al., 2016; ISO-31000, 2018). However, recent studies highlight that comprehensive resilience models are rarely integrated into project management in developing countries such as Ethiopia, indicating a clear gap in the literature (Amoah et al., 2021).

2.2. Resilience of African and Chinese Construction Companies

Construction project resilience in Africa has many obstacles. Many African contractors do not have access to modern technologies that help build, sufficient financing to complete a project, trained staff or favourable labour relations to work on a project efficiently, thus lowering project resilience (Esaiyas & Kahssay, 2020; Seriki, 2020; Zhao et al., 2023). In contrast, although China's contractors generally deliver construction projects as scheduled, they have been criticised for their labour practices, their failure to engage with local communities and for their inability to adapt to local conditions, which may add time and complication to a project (Seriki, 2020).

Construction enterprises from China operating in Africa are successful in being resilient, as they seek out additional resources, expand their market presence and mitigate risk through diversification. In spite of this success, research, particularly with respect to Chinese firms in Ethiopia, has demonstrated a number of concerns related to labour relations, namely an absence of collective bargaining between workers and managers, limited worker representation within the management process and limited input from external stakeholders, all of which would be best served by improving labour practice while at the same time continuing with business strategy (Bahiran & Ran, 2016; Olalekan & Haibin, 2024). Inadequacies of infrastructure, shortages of professional skills, and inconsistent regulations will continue to make it difficult for both local and international-based companies to create and manage projects in Africa which are both resilient and sustainable (Zhao et al., 2023; Esaiyas et al., 2020; Haibin, 2024).

2.3. Project Resilience Conceptual Framework

According to the theory of dynamic capabilities, organisations can and must acquire the ability to combine their internal and external skills to be able to answer the changing conditions of their environment. There is now empirical evidence supporting this view. It was found in a recent study in the field of technology that technological competence, especially with regard to digitalisation and data-based decision-making processes, will lead to a better adaptation of organisations to crisis situations if they are supported by innovation leadership (Kamal et al., 2025).

The Resilience Engineering Theory highlights the ability of an organisation to react to, to learn from and to adapt to disruptions as well as to anticipate them. The study of Tierra-Arévalo et al. (2025) on the construction sector presented and tested a tool called the Resilience Assessment Grid (RAG), which provides a systematic approach to measuring the ability of an organisation to react to disruptions through four main pillars (Learn, Anticipate, Respond and Monitor). Although some prior studies have evaluated the impact on project outcomes of environmental conditions surrounding the organisations and their own risk management processes, few of those studies have combined both of those factors with a resilience-based conceptual structure, particularly in the case of Ethiopia (Desta & Msengana, 2025). Although there is limited literature using data-driven methods (such as PLS-SEM or IPA) to model the relationships between various environmental conditions and risk management in developing countries where there is significant external uncertainty (Chladkova, 2018; Khalid et al., 2019; Sehanovic, 2021), a recent study completed in Ethiopia has demonstrated numerous varieties of internal and external risks that can affect construction projects, which highlighted the need for a greater understanding of risk management, which also demonstrates the applicability and timeliness of this research (Tilahun et al., 2022).

This study integrates Dynamic Capabilities Theory and Resilience Engineering Theory to conceptualise external environmental factors and risk management practices as key factors determining both the resilience and success of a project. The theoretical integration thus justifies the use of modern empirical techniques to investigate these relationships extensively in the Ethiopian construction industry.

For this research the conceptual model that comprises the two resilient factors is shown in Figure 1. Their indicator code interpretation is shown in Table 1.

Figure 1

Original conceptual research model

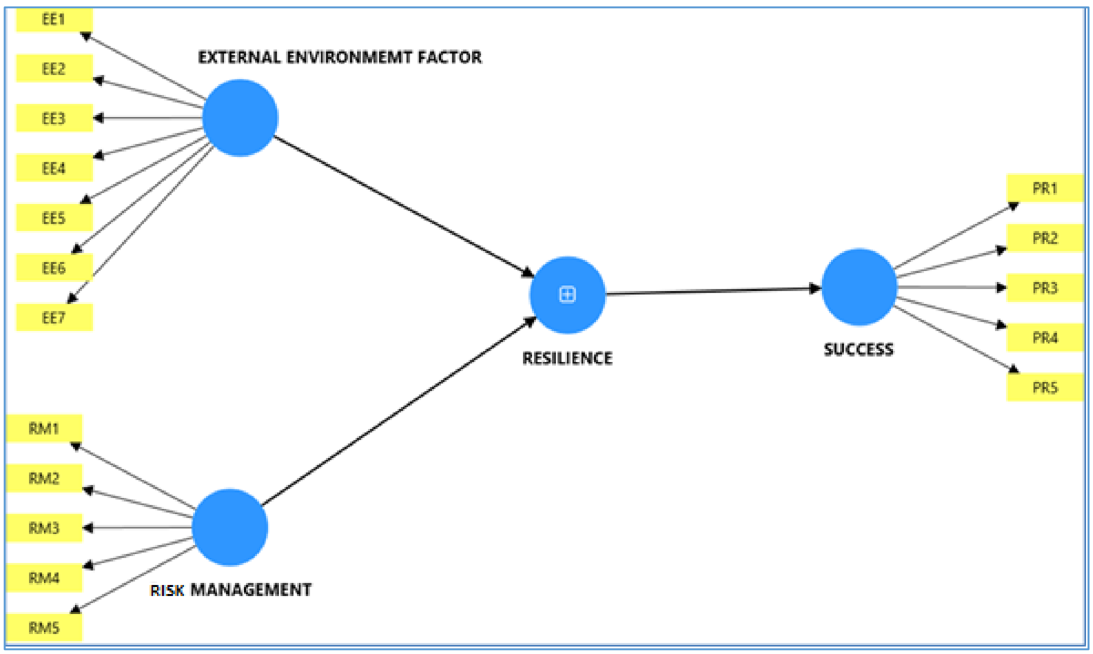


Table 1

Indicators code interpretation

Construct	Indicator Code	Description
	EE1	There are favourable government regulations that expedite business performance.
	EE2	The company is benefiting from the government's anti-corruption and anti-bribery policy .
	EE3	The low inflation rate in the country has positively favours the company's project performance rate.
	EE4	The unstable economic environment of the country has seriously affected the company's project performance rate.

Construct	Indicator Code	Description
External Environment	EE5	There is an absence of breach of contract by project parties ,which favours the project success.
	EE6	The company is practicing fulfilling and complying with rules and regulations.
	EE7	Enforcing the proper execution of legal judgement can encourage businesses to seek legal recourse and pursue justice.
Risk management	RM1	The project team and its members are aware of project related risk management related changes.
	RM2	Project risk management aspects are frequently communicated to the project team and its members.
	RM3	The organisation
	RM4	Risk management practice is integrated in the execution of existing project management.
	RM5	There is sufficient allocation of finance for risk management facilitation in the company.
Project success factors	PR1	Quality
	PR2	Cost
	PR3	Time
	PR4	Safety
	PR5	Satisfaction

3. Research Methodology

This research evaluates the impact of the external environment and risk management strategies on the ability to recover from and perform well with respect to construction projects in Ethiopia. To accomplish this goal, the research has followed a deductive research strategy and applied a positivistic research philosophy; it has referred to existing literature to create hypotheses, which were tested using empirical evidence.

3.1. Research Design

Quantitative data were collected using a cross-sectionally designed survey methodology, allowing researchers to obtain empirical information about the ways that political, economic, legal, social, technological, and environmental external factors and risk management practices affect project resilience and success. The survey methodology applied by this research represented a confirmatory design, based on deductive reasoning, and is an effective means of testing predetermined hypotheses among a large and diverse population (Guenther et al., 2023).

3.2. Participants of the Study

The target population included all construction professionals practising in Ethiopia, including consulting firms, contractors, clients, and other stakeholders within the construction industry (i.e., architects, engineers, surveyors, etc.) who are actively involved in construction projects. Using a purposeful sampling methodology to ensure respondents had the necessary experience and knowledge to respond to the questions appropriately increased the validity of the data (Shela et al., 2023). There were 192 valid respondents, more than the minimum number of respondents needed to support the research objectives.

3.3. Sampling Method and Sample Size

Best practice sample size estimation for PLS-SEM was employed based on four different methods: the "ten (10) times" rule, R^2-based estimates, the inverse square root formula, and Daniel Soper's a priori calculator. As it was estimated that the minimum number of respondents would be 156. However, 192 responses were obtained and thus provide greater reliability.

The demographic profile of the participants demonstrates a highly experienced population within the construction industry, with 66.7% of respondents having greater than 11 years of professional experience. In addition, 66.2% of respondents worked at highly regarded employers, which, very likely, should give better credibility to their responses on resilience-related issues. Most participants were employed with government agencies, clients, consultants or construction companies. A majority of respondents had master's degrees, suggesting a high degree of knowledge and capability to build their critiques of the resilience concept. The majority of the professional representation came from engineers, project managers, department heads, and architects. As a point of concern, only 59.6% of respondents stated they were familiar with resilience, and only 25.9% stated they applied it, suggesting a knowledge gap that could impact the growth of, and application of, resilience practices.

3.4. Instrumentation and Data Gathering Process

The researcher developed the instrument based on current literature and existing validated scales. Content validity was assessed by expert review through pilot testing to assess its clarity and relevance. After piloting, a 4-point Likert scale instrument with 41 items, covering leadership, project team culture, organisational structure, external environmental factors, risk management practices, project resilience and project success, was finalised.

Data were collected through Google Forms, from March 8th to May 13th, 2024. The survey link was distributed via WhatsApp, email, and Telegram to increase the reach of the survey. For individuals who had no access to the Internet, hard copy surveys were made available. Of the 203 professionals contacted, 192 valid responses were received, and therefore a response rate of 94.6% was achieved.

The reliability test was conducted by Cronbach's Alpha, which gave a result of 0.95 for the entire scale. Therefore, the internal consistency of the scale is high. Cronbach's Alpha > 0.7 is generally accepted as good enough (Cheung et al. 2024; Sun et al., 2018).

3.5. Data Analysis Tool

Descriptive statistics were utilised to describe respondent profiles and project characteristics. The relationships among latent variables were analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM). PLS-SEM is well-suited for complex models with many latent variables, for small samples, and for data distributions that are non-normal (Guenther et al. 2023). PLS-SEM allows for simultaneous estimation of measurement model(s) and structural model(s); thus, it is particularly well-suited for hypothesis testing in this study. All statistical analysis was completed using SPSS and Smart PLS 4.

3.6. Research Ethics

Before the beginning of data collection, ethical approval was received from the University of South Africa. Respondent participation was voluntary, informed consent was received, no incentives were provided to reduce potential bias and all responses were kept confidential at all times.

4. Data Analysis

4.1. Descriptive Analysis

Descriptive analysis showed that means and medians were similar across most categories, which showed a lot of consistency in data and a relatively symmetric distribution.

Z-scores detected outliers, and the suggested cutoff was ±3.29 (Tabachnick & Fidell, 2013). The Z-scores that exceeded this cut-off were dropped from the analysis (i.e., Z = 3.8676) (after removing one response; Mowbray et al., 2019). Kurtosis and skewness values were evaluated for normality, with acceptable ranges between -3 and +3 for normal distribution (Aburumman et al., 2023). Skewness values were between -0.937 and 0.126, and the kurtosis values were found between -1.794 and 0.364, suggesting an approximately normal distribution. Additionally, the Cramér-von Mises P-values for the variables were below 0.05 (Oluwaseyi & Geraldine, 2023). These indicated that the variables were not perfectly normally distributed.

This research tested the respondents' attitudes in four categories: i.e., scores between 1.00 and 1.74 indicate 'Strongly Disagree' (indicating a strong negative response); 1.75 and 2.49, 'Disagree' (indicating a generally unfavourable view); 2.50 and 3.24, 'Agreement' (indicating a positive stance); and 3.25 and 4.00 indicate 'Strongly Agree' (a strong positive response). These ranges help in treating the survey data by categorising the respondents' opinions in terms of their score.

Table 2

Responses on resilient risk management

Significant factors	Very Poor	Poor	Good	Very Good	Average	Interpretation
RM1- communicating project risk management aspects	21 10.94%	87 45.31%	74 38.54%	10 5.21%	2.38	DISAGREE
RM2-communicating project risk management aspects	13 6.77%	55 28.65%	86 44.79%	38 19.79%	2.78	AGREE
RM3- skill or knowledge required in dealing with project risk management aspects	7 3.65%	44 22.92%	99 51.56%	42 21.88%	2.92	AGREE
RM4- Integrating risk management with the company project management system.	6 3.13%	62 32.29%	82 42.71%	42 21.88%	2.83	AGREE
RM5- Allocate sufficient budget for risk management facilitation in the company.	14 7.29%	54 28.13%	87 45.31%	37 19.27%	2.77	AGREE

Legend: Likert scale interpretation: 1.00–1.74 = Strongly Disagree (SDA); 1.75–2.49 = Disagree (DA); 2.50–3.24 = Agree (A); 3.25–4.00 = Strongly Agree (SA)

Table 2 presents that for the management of risk, communicating elements of project and risk management received various responses with supporters and non-supporters. For instance, for RM1, 45.31% were reported as disagreeing that communication was effective; however, for RM2, there are at least 44.79% who agreed that communication was good. The respondents largely agreed that having some skill capability (RM3), creating a risk-based quality management system (RM4) and developing appropriate budgets (RM5) were the best practice factors, as the average rating was in the range of 2.78 to 2.92, which is largely in the "Agree" category. Hence, the research factors identified in the means are the risk management factors to be considered for the PLS SEM, being all factors to consider except RM1 (communicating project risk management aspects).

Table 3

Responses on resilient external environment factors

Significant factors	Very Poor	Poor	Good	Very Good	Average	Interpretation
EE1-There are favourable government regulations that expedite business performance.	9 4.7%	66 34.4%	112 58.3%	5 2.6%	2.58	AGREE
EE2- The company is benefiting from the government's anti-corruption and anti-bribery policy.	19 9.8%	60 31.3%	109 56.8%	4 2.1%	2.51	AGREE
EE3 –low inflation rate favours resilience	3 1.56%	38 19.79%	103 53.65%	48 25%	3.02	AGREE
EE4- stable economic environment in the country favours resilience.	20 10.42%	71 37%	53 27.60%	48 25%	2.67	AGREE
EE5-There is an absence of breach of contract by project parties, which favours the project's success.	23 11.98%	94 49%	68 35.42%	7 4%	2.31	DISAGREE
EE6-The company is practising fulfilling and complying with rules and regulations.	19 9.90%	78 41%	78 40.63%	17 9%	2.48	DISAGREE
EE7- Enforcing proper execution of legal judgement favours performance	18 9.38%	72 37.50%	87 45.31%	15 7.81%	2.52	AGREE

Table 3 shows how external environmental factors affect project performance independently. EE1 – favourable government regulations, EE2 – presence of anti-corruption and anti-bribery policy, low inflation rate (EE3) and EE4 – stable economic environment are considered to favour resilience and to project performance. Most respondents generally agreed (i.e., 3.02 and 2.67 on average). However, EE5 – absence of breach of contract – and EE6 – compliance with rules and regulations – were not reported as very satisfactory, with respondents leaning towards disagreement regarding their influence on project success by reporting lower averages (2.31 and 2.48). This indicates an ambivalent view of the EE7 – enforcement of proper legal execution to be moderate (2.52). Thus, for the subsequent PLS

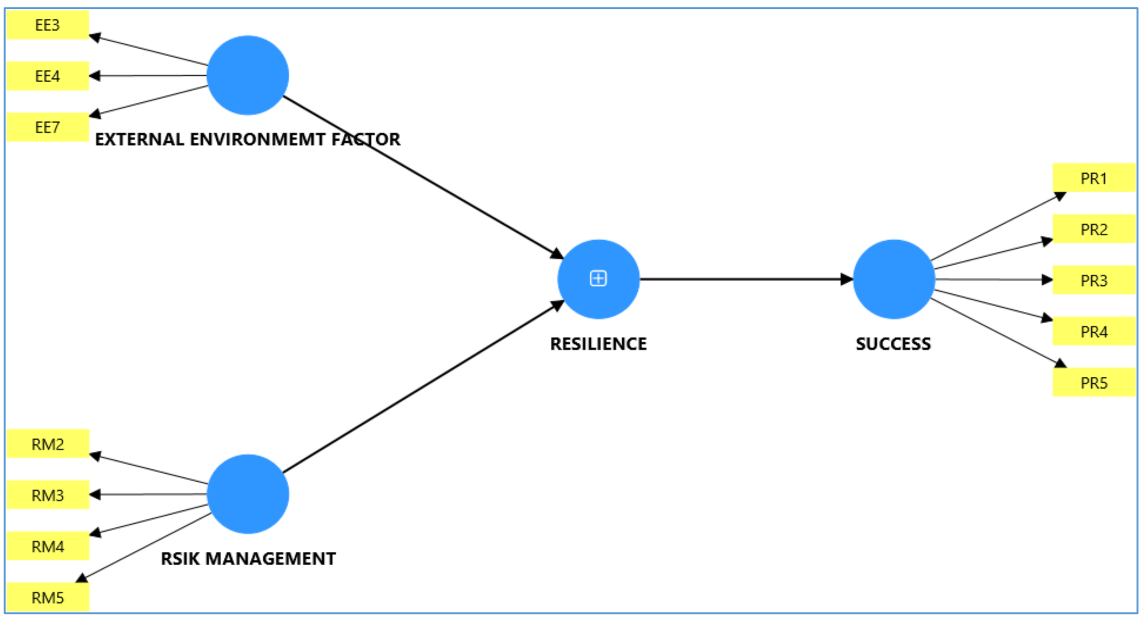
SEM, the external environmental factors to evaluate comprise all the factors (EE1/EE2/EE3/EE4/EE7) excluding EE5 (Absent breach of contract) and EE6 (Compliance with rules and regulations).

4.2. PLS-SEM Analysis

PLS-SEM uses a measurement model (Figure 2) to evaluate validity, provide reliability and ascertain the nature of the relationship(s) between constructs.

Figure 2

Modified research model after respondent analysis



At the first analytical stage of the research study, descriptive analysis was utilised because it was suitable for understanding how respondents perceived their responses; the complex constructs were not modelled, the sample size was small, and the data was not normally distributed (Matthews & Hair, 2016). The data included reflective constructs, measured on a four-point Likert scale, that justified the analysis with PLS-SEM because it can handle non-normality and exploratory study. This was the most suitable and feasible measure of analysis considering the exploratory nature of the study and the complex relationships of the constructs in the mixed context of Ethiopian construction. The measurement model was first assessed before any hypotheses were tested on the structural model to assess the hypothesised relationships of the constructs.

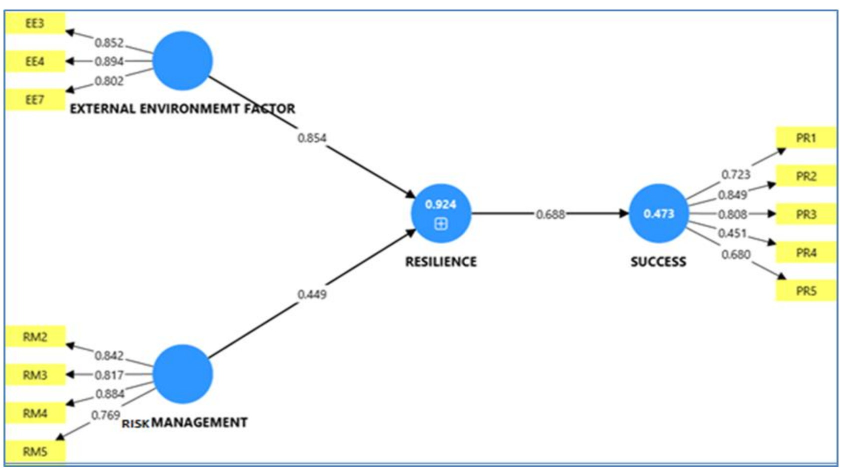
4.2.1. Measurement model assessment

PLS-SEM utilises a measurement model to provide validity, reliability, and a means to test relationships between constructs. Measurement variable indicators are treated as reflective, interchangeable & highly correlated, or formative, unrelated and substitutes for each other (Basbeth & Ibrahim, 2018). In addition to reflective and formative constructs, there are some newly emerging models that use both and integrity with holistic component modelling using higher-order constructs (Sarstedt et al., 2021). The detailed reporting of the measurement model as a part of the best practice analysis of the measurement model contained an evaluation of the quality of the measurement in terms of the indicator loadings, AVE, composite reliability, discriminant validity (Fornell-Larcker and HTMT) and cross-loadings that were examined systematically (Hair et al., 2021).

Convergent validity- "Outer Loadings" and "AVE" Values. The basic rule of thumb is that indicators should have outer loadings ≥ 0.70 for strong convergent validity; however, loadings between 0.4 and 0.7 will be fine, but removing them needs to improve AVE. (Hair et al., 2017; Russo & Stol, 2021; Fahmi et al., 2023). Indicators with outer loadings less than 0.4 (EE1, EE2) were removed from the model (see Fig. 3).

Figure 3

Outer loadings



Generally, AVEs that are 0.50 or greater are an indicator of good convergent validity, and most constructs in this study had an AVE at 0.50 or better. The AVE for resilience was, however, 0.297 and, as such, did not meet the criteria established by Fornell and Larcker. Although Fornell and Larcker suggest that while the AVE is below 0.50, the composite reliability (rho c) should be above 0.60 to establish convergent validity (Huang et al., 2013), the rho c for resilience was 0.810 and the rho a was 0.835, both of which were significantly above the threshold required to support inclusion in the model. The results from the bootstrap also indicated that AVE and outer loadings for all constructs were above the threshold levels after the analyses were conducted (see Table 4), which supports the convergent validity of the measurement model.

Table 4

AVE and composite reliability for each construct

Construct	AVE	Composite reliability rho_c	Composite reliability rho_a
External Environment Factor	0.723	0.886	0.808
Resilience	0.297	0.810	0.835
Risk Management	0.688	0.898	0.889
Success	0.513	0.835	0.823

Discriminant Validity-HTMT and Fornel- Larcker criterion, Cross loadings. Discriminant validity refers to the degree to which the indicators distinguish the various concepts it is measured against and is measured by the Fornell-Larcker criterion, HTMT, and cross-loadings (Rasoolimanesh, 2022).

HTMT Criterion. The Heterotrait-Monotrait Ratio (HTMT) index provides the average correlation between constructs and the average correlation within each construct (Sarstedt et al., 2021). HTMT is the average correlation across constructs divided by the geometric mean of the average correlations within constructs. A value greater than 0.90 indicated poor discriminant validity between the constructs being compared (Basbeth & Ibrahim, 2018). In this study, all ratios were below 0.9 (Table 5), thus indicating discriminant validity.

Table 5

HTMT values

	External Environment Factor	Resilience	Risk Management	Success
Resilience	0.835			
Risk Management	0.173	0.877		
Success	0.833	0.687	0.329	

Fornell-Larcker Criterion. This method compares the square root of AVE for each construct against its correlations with each other construct. Discriminant validity is established if the square root of AVE is greater than these correlations (Basbeth & Ibrahim, 2018). The results based on the Fornell-Larcker criteria (see Table 6) showed adequate discriminant validity among constructs, which shows that every construct measures different features and is different from the others. The Fornell-Larcker criterion further confirmed the discriminant validity of the constructs since the square root of AVE for each construct was greater than the correlation between each pair of constructs.

Table 6

Fornell-Larcker criterion values

	External Environment Factor	Risk Management	Success
External Environment Factor	0.85		
Risk Management	0.01	0.829	
Success	0.714	0.176	0.716

Cross-Loadings. Cross-loadings of all indicators were reviewed to determine the discriminant validity of the model (see Table 7); in general, most indicators load best on their appropriate construct rather than a different construct (Hair et al., 2021).

Each of the three external environment indicators (EE3, EE4, and EE7) had the largest loadings on their respective construct; values ranged from 0.629 to 0.805. It is particularly notable that EE3 (0.728), EE4 (0.805), and EE7 (0.775) have large enough loads so as to be clearly separate from the cross-loads of those same indicators on other constructs.

The highest loads on the "Success" construct occurred for each of the five project success indicators (PR1 – PR5), each indicating the highest load on the "Success" construct (e.g., PR2: 0.845; PR3: 0.802). On the other hand, highest loads on the "Risk management" construct also occurred for most of the risk management indicators (RM2-RM5). Most of the indicators for this construct had high loads (e.g., RM2: 0.788; RM3: 0.758; RM4: 0.820; RM5: 0.691). Overall, the cross-loading results provide strong support for the fact that the measurement model has discriminant validity, i.e., that each measure of an indicator is more closely related to its respective construct than it is to other constructs.

Table 7

Cross loadings

	External Environment	Resilience	Risk Management	Success
EE3	0.728	0.629	0.11	0.58
EE4	0.805	0.687	0.11	0.624
EE7	0.775	0.712	0.249	0.603
PR1	0.341	0.435	0.388	0.731
PR2	0.628	0.573	0.18	0.845
PR3	0.72	0.614	0.105	0.802
PR4	0.223	0.194	0.037	0.448
PR5	0.282	0.389	0.387	0.689
RM2	0.193	0.485	0.788	0.248
RM3	0.131	0.408	0.758	0.082
RM4	0.105	0.422	0.82	0.18
RM5	0.027	0.256	0.691	0

Internal consistency. Two criteria were applied for assessing internal consistency reliability: the first was the use of Cronbach's alpha, with a cutoff of 0.7 and above indicating satisfactory reliability; the second was Composite Reliability (with the cutoff of 0.6 indicating acceptable internal consistency) (Russo & Stol, 2021). If composite reliability was below 0.6, it implies lack of internal consistency. The Cronbach's alpha values of all items in Table 8 indicated that the measures had good internal consistency and that they were measures of the other latent factors. The composite reliability values (rho-a and rho-c) were both above the 0.7 cutoff (Chidambaram et al., 2021) and were consistent with the main constructs in assessing internal consistency, including external environment, leadership, organisational structure, project resilience, risk management, project culture, and success. Internal consistency was supported by both Cronbach’s alpha and composite reliability, as shown in Table 8, with all values exceeding recommended thresholds.

Table 8

Cronbach’s alpha and composite reliability

Constructs	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)
External Environment Factor	0.807	0.808	0.886
Resilience	0.792	0.835	0.810
Risk Management	0.853	0.889	0.898
Success	0.761	0.823	0.835

When studying reflective constructs, internal consistency and validity are typically evaluated by examining Cronbach's alpha and composite reliability (Hair et al., 2013; Aggarwal & Kapoor, 2021). Convergent validity and discriminant validity are important considerations, as all constructs showed reliable internal consistency.

Table 9

Outer weights

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values	5.0%	95.0%
EE3 <- External Environment Factor	0.373	0.375	0.039	9.545	0.000	0.346	0.405
EE4 <- External Environment Factor	0.403	0.403	0.042	9.629	0.000	0.375	0.439
EE7 <- External Environment Factor	0.401	0.395	0.040	10.056	0.000	0.352	0.442
PR1 <- Success	0.257	0.247	0.043	5.981	0.000	0.172	0.306
PR2 <- Success	0.351	0.353	0.042	8.445	0.000	0.310	0.402
PR3 <- Success	0.380	0.384	0.059	6.458	0.000	0.324	0.467
PR4 <- Success	0.121	0.123	0.039	3.068	0.001	0.259	0.383
PR5 <- Success	0.227	0.217	0.047	4.800	0.000	0.332	0.483
RM2 <- Risk Management	0.397	0.383	0.075	5.293	0.006	0.260	0.516
RM3 <- Risk Management	0.306	0.298	0.072	4.250	0.000	0.182	0.410
RM4 <- Risk Management	0.323	0.319	0.080	4.038	0.000	0.171	0.462
RM5 <- Risk Management	0.169	0.166	0.065	2.600	0.000	0.046	0.281

A preliminary assessment of the outer weights and loadings identified indicators that contribute to their constructs with statistical relevance. The findings of this assessment were further substantiated by a bootstrap confidence interval of 95% for each outer weight. If the confidence interval does not contain zero, then it has been established that there is a stable and significant contribution from each indicator to its respective construct in the model. Table 9 shows the results of the examination of the outer weights and loadings, as well as their corresponding t-statistic and associated p-value. All of the outer weights are statistically significant ($t > 1.96$, $p < .01$); therefore, all of the outer weights are relevant and reliable contributors to their respective constructs in the model. None of the indicators need to be dropped from their respective constructs.

4.2.2. Structural model assessment

In PLS-SEM, structural model assessment focuses on the connection between latent variables and how important, relevant, and strong the paths in the model are (Memon &

Rahman, 2014; Basbeth & Ibrahim, 2018). Using bootstrapping (resampling 5,000 times), the path coefficients, p-values, and confidence intervals were computed for all relationships postulated. In addition, it is recommended that one apply the PLS predict method in order to determine the out-of-sample prediction of the model as a measure of its external validity.

Collinearity. Multicollinearity was assessed by using the Variance Inflation Factor (VIF) to check for interdependence among predictors and to test for any possible collinearity problems. For assessment of multicollinearity, the VIF values are ascertained in Table 10 for all constructs from the inner model. The VIF values are below the threshold of 5, which does not indicate that there will be any multicollinearity issues (Basbeth & Ibrahim, 2018). In general, VIF values under 5 do not represent multicollinearity issues; therefore, it would be prudent to calculate VIF values for each predictor variable within the structural model, and if a value is over 5, then further investigation or revision of the model is warranted.

Common method bias (CMB) was also tested by calculating full collinearity VIFs with Smart PLS 4 for each latent construct (Kock, 2015). The results show that none of the VIF values exceeded 3.3, indicating that common method bias (CMB) is not a concern.

Table 10

Collinearity Statistics (VIF)

	VIF
External Environment Factor -> Resilience	1.000
Resilience -> Success	1.000
Risk Management -> Resilience	1.000

Path coefficients. Path coefficients, standardised between β = -1 and +1, indicate the strength and direction of relationships. The further the coefficient is from zero, the stronger the relationship. Values closest to +1 indicate strong positive relationships, and values close to -1 indicate weak relationships (Basbeth & Ibrahim, 2018). The strength of the path relationship can be determined using bootstrapped t-values. If the t-value is greater than the critical value of 1.96 at the 5% level, then that relationship can be said to be statistically significant (Basbeth & Ibrahim, 2018). In this study, the standardised path coefficients (β) ranged from 0.449 to 0.854, while all t-values were greater than 1.96 and all p-values were less than 0.05, thus indicating statistically significant positive relationships (Table 11). In addition, the statistical significance of these coefficients was determined by bootstrapping (i.e., 5,000 samples) to obtain t-statistics and p-statistics for each coefficient.

Table 11

Path coefficients, t-values, p-values

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
External Environment Factor -> Resilience	0.854	0.850	0.079	10.842	0.000
Resilience -> Success	0.688	0.697	0.047	14.553	0.000
Risk Management -> Resilience	0.449	0.386	0.192	2.340	0.010

Hypothesis testing. Table 12 indicates that T-values above 1.96 and P-values below 0.05 imply statistically significant relationships between the variables (Basbeth & Ibrahim, 2018). The 95% confidence intervals for the path coefficients are different from zero, further confirming this. The PLS path model indicated that statistically significant ($p < 0.05$) and positive standardised coefficients supported that all indicators were significantly related to project resilience, which supports a strong relationship, and validated all hypotheses (Table 12) (Basbeth & Ibrahim, 2018). All paths were supported in that the confidence intervals did not cross zero (Table 12).

Table 12

Hypothesis testing results

	Path coefficient	T statistics (|O/STDEV|)	P values	5.0%	95.0%	Hypothesis supported?
H1: External Environment Factor -> Resilience	0.854	10.842	0.000	0.722	0.974	yes
H3: Resilience -> Success	0.688	14.553	0.000	0.612	0.762	yes
H2: Risk Management -> Resilience	0.449	2.340	0.010	0.026	0.611	yes

The outcomes of hypothesis testing contained in table 11 describe the statistical significance and strength of the relationships between variables using the sample data. The summary table contained the original sample (O), sample mean (M), standard deviation (STDEV), the t-statistics (|O/STDEV|), and the p-values.

H1 (External Environment Factor → Resilience). Original sample value = 0.854. T-statistic = 10.842, p-value = 0.000 (the relationship was positive and significant). Given the confidence interval (0.722 to 0.974) and analysis of the p-value and t-statistic, this relationship was deemed significant and was marked as "yes".

H3 (Resilience → Success). Original sample value = 0.688. T-statistic = 14.553, p-value = 0.000 (the relationship was positive and significant). Given the confidence interval (0.612 to 0.762) and analysis of the p-value and t-statistic, this relationship was deemed significant and was marked as "yes".

H2 (Risk Management → Resilience). Original sample value = 0.449. T-statistic = 2.340, p-value = 0.000 (the relationship was positive and significant). Given the confidence interval (0.026 to 0.611) and analysis of the p-value and t-statistic, this relationship was deemed significant and marked "yes".

All the hypotheses that were assessed were supported through the sample data, and the proposed relationships within the model were supported.

Coefficient of Determination (R^2). The R^2 statistic measures how well a model accounts for the variation among latent variables (Basbeth & Ibrahim, 2018). Any R^2 statistic above 0.75 represents a high-quality model, above 0.50 moderate quality, and above 0.25 weak quality. A model is considered to have a "strong" quality fit when it explains greater than 66% of the outcome variance and "fair" when it explains greater than 33% of the variance (Hair et al., 2014; Sakinah et al., 2020). In the context of the current study, the R^2 for resilience is 0.924 and the adjusted R^2 is 0.923 (Table 13), indicating that almost all (92.4%) of resilience variance is accounted for by the predictors, showing an extremely strong fit overall between the model and the data and almost perfect correlation. For Success, the R^2 was 0.473 with an adjusted R^2 of 0.470 (Table 13), which means the model explained almost 45% of the variance, showing moderate to strong explanatory powers. The models' results suggest an overall very strong model for resilience and a good-fitting model for success (Tessema et al., 2022).

Table 13

R^2 values

	R-square	**R-square adjusted**
Resilience	0.924	0.923
Success	0.473	0.470

Effect Sizes (f^2). Effect sizes determine if exogenous constructs have an impact on endogenous constructs. Khalid et al. (2020) found that an f^2 value of 0.20 is considered small, 0.15 is medium, and 0.35 is large. In our study, effect sizes all exceed 0.35, suggesting that all exogenous constructs indeed had a significant impact on their endogenous constructs, so we can confirm that our model is complete as shown in Table 14. All constructs had large effect sizes (> 0.35), indicating they all had an impact on the endogenous variables.

Table 14

f^2 effect sizes

	f-square
External Environment Factor -> Resilience	9.571
Resilience -> Success	0.898
Risk Management -> Resilience	

This comprehensive evaluation confirms the robustness of the measurement and structural models, supporting the hypothesised relationships.

PLS-Predict results. Further investigation of the predictive capabilities of the PLS-SEM model with regard to the out-of-sample predictions, the "PLS predict" procedure was used. The method compares the predictive errors made by the PLS-SEM model to those of Linear Regression (LM) and Simple Mean-Based (Individual Average, IA) benchmarks, consistent with previously recommended procedures for evaluating the predictive ability of a PLS-SEM model (Ringle & Sarstedt, 2021). The Q^2predict statistic and the root mean square error (RMSE) and mean absolute error (MAE) values for each indicator are summarised in Table 15.

A summary of the Q^2predict statistics and Root Mean Square Errors (RMSEs) and Mean Absolute Errors (MAEs) for each of the indicators shows that for the seven accepted indicators (EE3, EE4, EE7, RM2, RM3, RM4, and RM5), all of the Q^2 predict values were positive, indicating that the PLS-SEM model had predictive relevance for the seven selected external environment and risk management indicators. Furthermore, for all of the seven indicators, the PLS-SEM model produced lower RMSE and MAE than the Individual Average approach, indicating that the PLS-SEM model demonstrated higher predictive accuracy than the Individual Average method for all seven of the indicators. Therefore, the results confirm both the reliability and generality of the PLS-SEM model for the seven core constructs remaining after the reduction in the number of indicators. However, although the predictive relevance for the majority of the performance indicators (i.e., PR1 through PR5) was generally positive, the predictive relevance for several of them was somewhat moderate, whereas for others (i.e., RM5 and PR4) the predictive relevance based on the Q^2 predict values was low. Thus, it can be concluded that, although the PLS-SEM model performed reasonably well overall, there may be an opportunity to improve its predictive capability for certain items.

Table 15

PLS-Predict

	Q^2predict	PLS-SEM_ RMSE	PLS-SEM_ MAE	LM_ RMSE	LM_ MAE	IA_ RMSE	IA_ MAE
EE3	0.425	0.553	0.418	0	0	0.729	0.537
EE4	0.51	0.678	0.54	0	0	0.969	0.85
EE7	0.506	0.544	0.42	0	0	0.775	0.674
RM2	0.208	0.751	0.59	0	0	0.844	0.688
RM3	0.135	0.716	0.561	0	0	0.77	0.562
RM4	0.144	0.744	0.6	0	0	0.803	0.656
RM5	0.036	0.831	0.662	0	0	0.846	0.691
PR1	0.185	0.579	0.463	0.571	0.435	0.641	0.579
PR2	0.343	0.549	0.41	0.53	0.412	0.678	0.51
PR3	0.392	0.754	0.604	0.641	0.528	0.967	0.827
PR4	0.026	0.813	0.687	0.831	0.688	0.824	0.678
PR5	0.136	0.621	0.513	0.598	0.479	0.667	0.604

4.3. IPMA Analysis

Important Performance Map Analysis (IPMA) is a tool that allows us to investigate what leads to corporate success through each identified factor that contributes to success. IPMA is a graphical representation where on the x-axis, there is "Importance" (or "Total Effect") of the business drivers for success represented on a scale from 0 to 1, while "Performance" is plotted on the y-axis on a 0-to-100 scale. There are instances where researchers can identify antecedent structures with overall relevance (high relevance) but average latent variable scores (poor performance), which can be targets for further operations improvement. Wong (2019) states that IPMA is on an underlying metric or equidistant scale but will have an uneven number of balanced positive and negative categories around one neutral category in the middle.

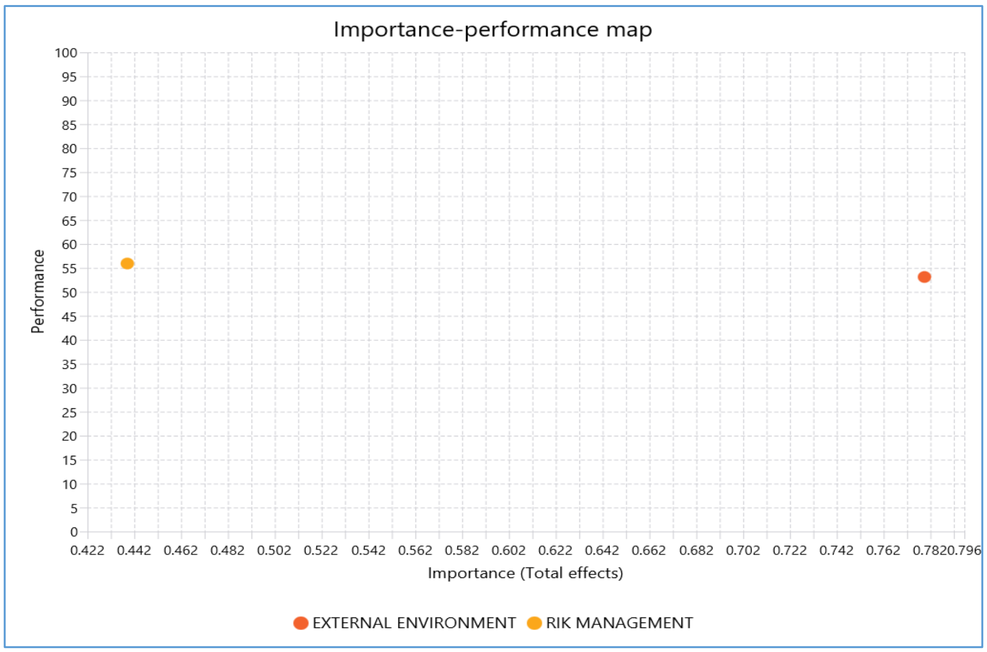
Table 16

Importance-performance map [RESILIENCE] (constructs)

	Construct total effects for [RESILIENCE]	Construct performances for [RESILIENCE]
External Environment	0.779	53.116
Risk Management	0.439	55.924

Figure 4

IPMA for major constructs



The results from the IPMA provide useful knowledge as to the items influencing resilience and success, identifying which items are most important but also how well they are performing. Constructs influencing resilience and success are shown in Table 16 and Figure 4. Risk Management is higher on the performance axis, with a relatively moderate importance score, indicating that it is performing relatively well; possibly it is not the most important item. On the other hand, External Environment factor is higher on the importance scale but lower on the performance scale, indicating this item is influential but currently performing poorly.

Specific importance and performance scores for key constructs identified by the IPMA are as follows:

Related to risk management (Importance = 0.439, Performance = 55.92). It was identified that risk management has moderate levels of importance; however, the performance level was found to be high, which would indicate that while risk management is an area of strength for this company, it will likely never be the number one priority in the organisation.

Related to external environment factors (Importance = 0.779, Performance = 53.12). The external environment factors were identified as having high importance; however, the performance was found to be low, indicating that there is a need for strategic intervention in order to improve in this area.

Factors influencing resilience and success with multiple variables (Table 17 and Figure 5). The results from the IPMA analysis on indicators (see Figure 5, Table 17) demonstrate that EE3 ("the high rate of inflation in the country has had a negative effect on performance"), EE4 ("unstable economic conditions"), and EE7 ("enforce the proper execution of a legal judgement") are the most important factors to affect the resilience of the construction projects in Ethiopia; specifically, EE3 was the best-performing factor. On the other hand, although RM2, RM3, RM4, and RM5 (Risk Management Practices) showed good performance in terms of risk management practice, there is no evidence to suggest that they have any significant influence on the overall resilience of construction projects in Ethiopia; therefore, resources may be allocated to better use. Therefore, these results will provide useful guidance to identify which improvement efforts should be prioritised in order to increase the resilience of Ethiopian construction projects.

In general, the results from this study highlight the critical nature of both economic stability and effective risk management to improve the resilience and success of construction projects in Ethiopia. Improving the performance of the external factors that have been identified to have the highest degree of importance but have low degrees of performance can potentially improve the overall outcome of the projects and the resilience of the projects.

The scatter of points conveys that many factors can be attached with different levels of importance and performance. For example, factors like EE3, EE4, and EE7 are located high on importance and higher on performance; these factors are areas to target for improvement. On the other hand, some factors (RM2, RM3, RM4, RM5) are located higher on performance than on importance; these factors are depicted to suggest the utilisation of resources could be a better allocation of resources. These in particular should be considered for strategic interventions to improve resilience and success. Factors which are high on performance but low on importance should be maintained with a low level of resources.

The IPMA for indicators related to resilience, summarised in Table 17, reveals distinct areas for managerial focus:

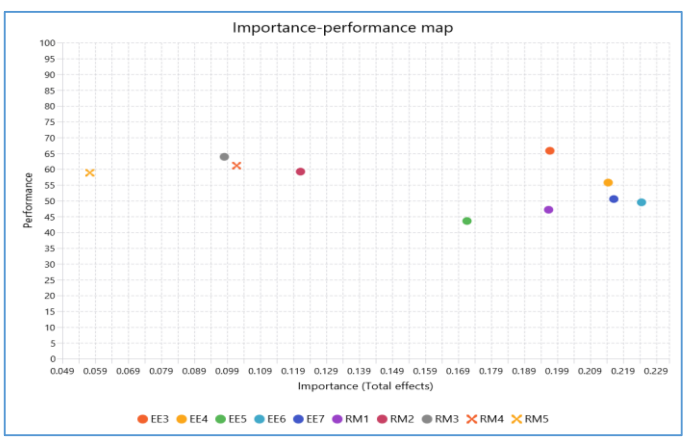
Table 17

Importance-performance map [RESILIENCE] (indicators)

	Indicator total effects for [RESILIENCE]	Indicator performances for [RESILIENCE]
EE3	0.196	65.799
EE4	0.214	55.729
EE7	0.216	50.521
RM2	0.121	59.201
RM3	0.098	63.889
RM4	0.101	61.111
RM5	0.057	58.854

Figure 5

IPMA for indicators



The findings displayed highlight the importance of economic stability and risk management that enhance resilience and ultimately project success in the construction environment in Ethiopia. Addressing all of the external and internal factors to some reasonable extent could improve project outcomes and enhance resilience.

4.4. Mediation Analysis

Table 18

Path	Indirect Effect	Total Effect	%VAF	Mediation Type
External Environment Factor → Success	0.587	0.588	99.80%	Full mediation
Risk Management → Success	0.309	0.309	100%	Full mediation

The %VAF values confirm that resilience plays the role of a nearly perfect mediator in the relationships between the two external environment variables and the three variables of risk management and success. The %VAF of the path between the first pair of variables of interest (external environment factors – success) was around 99.8%, and the %VAF of the path between the second pair of variables of interest (risk management – success) was around 100% (see table 18). These results suggest that almost all of the relationship effects of external environment factors and risk management toward success are mediated by resilience. As such, the findings provide strong support for the view that resilience serves as a central mediator in the context of this study and contributes significantly to the attainment of success. In terms of the mediation criteria set out in Sarstedt et al. (2021), %VAF values greater than 80% suggest full mediation, which further supports the significance of resilience as a mediator.

5. Discussion

H1: External environmental factors have a significant impact on project resilience

Funmilayo (2017) explores the matters which stimulate success as well as demotivating factors, stating that political, economic and social issues consider moderate determination of how the characteristics of a project manager influence success. These are vital considerations for an institution as it prepares resilience and are integral to this concept (Zhao et al., 2023). Development of proactive measures is essential for projects facing uncertainty/chaotic environments, helping the project take up emerging opportunities and visualise resilience to disruption.

The outcomes of this study show that external environmental factors that encourage resilience have a strong impact on being a promoter for project resilience in the Ethiopian construction sector. Which includes all factors such as high inflation rates impacting negatively on the company project performance rate (EE-3). The unstable economic environment of the country has broadsided the project performance rate (EE-4). The company values, including the means to seek recourse through legal certainty in court (EE-7), all demonstrate resilient external environment factors of the Ethiopian construction project.

H2: Risk management practice has a direct effect on project resilience performance

Inquiry into risk management practice shows increased complexity in projects; uncertain environments present challenges to project control methods, including risk management systems (Zhao et al., 2023:1). When a corporate culture grows a risk-management system in all environments of the organisation, there is an indication of sufficient capacity to be resilient (Kumar & Anbanandam, 2020). A significant problem for firms is trying to eliminate operating uncertainty in order to gain a competitive advantage in unpredictable, complex, globalised markets (Ghufran et al., 2022). Amoah et al. (2021) present research findings to show risk management is fundamental to project success in both developed and developing countries. The degree of success of a project is proportional to the degree of success of project risk management (PMI, 2017). These studies present evidence indicating research to consider the fundamental relationship of risk management practice to project performance, representing the precursor to research considering the direct effect of risk management practice on project resilience performance.

The analysis of the data using PLS-SEM indicates that contributors to a resilient team culture in the construction industry include the frequent communication of project risk management points to the team (RM-2); the organisation's capability to facilitate project risk management aspects (RM-3); the integration of risk management practices into existing project management execution (RM-4); and the availability of sufficient funds to enable risk mitigation measures within the company (RM-5).

Comparison and integration of IPMA and PLS-SEM results. The IPMA and PLS-SEM results offer a complementary perspective on what factors influence project success and resilience. The substantial relationship strength of 0.854 ($p < 0.001$) from External Environment to Resilience also indicates how important external factors (e.g., stable economy, low inflation, legally enforceable contracts) are to project success, as indicated by the importance score of 0.779 in the IPMA. Likewise, the moderate-sized relationship of Risk Management (0.449) in PLS-SEM is very similar to the importance score of 0.439 in the IPMA, which suggests that there is considerable value in risk management practices, yet they may not be the best place for strategy development. Most notably, while the IPMA shows that External Environment factors (i.e., inflation, economic instability, legal enforcement) have high levels of importance but poor performance ratings (approximately 53%), this clearly represents an opportunity for targeted interventions.

Conversely, the Risk Management practices appear to have stronger levels of performance than do the other two areas (External Factors and Project Management), indicating that they will likely be positive contributors to project resilience but that their relative importance is lower compared to the External Factors area. The overall results from both of the methodologies reinforce that it would be most beneficial for organizations to place greater emphasis on improving External Environmental Factors as part of their strategic approach and continue to maintain and optimize their Risk Management practices. A synergistic or integrated understanding of both of these methodologies reinforces targeted resource utilization to increase project resilience, specifically by identifying the External Environmental Factors that are important, but currently lack high performance.

H3: Project resilience has a significant impact on project success

The H3 is concerned with resilience factors, the context of leadership, project team culture, organisational structure, risk management, and the external environment, and how significant (or insignificant) they are in project success. Project success is identified as several dimensions: quality, time, cost, satisfaction, and safety. There is much literature that substantiates this connection. According to Santoro et al. (2020), organisations that have been resilient were better situated for success (simply because resilience is ingrained in their everyday practices). In fact, Ettouney (2022) and Essilfie-Baiden (2019) state that resilience is especially helpful for construction projects operating in uncertain environments (emerging from the risk process direct effects). Project definitions for success typically include quality, time, cost, satisfaction, and safety (Belay, 2017).

6. Conclusion and Recommendations

The analysis results indicate agreement, indicating that proper communication, knowledge of risk management, integration of risk management with routine operation and budget funding have the potential impact to make the project resilient. On the other hand, there was total agreement and recognition of the impact of external environmental factors such as low inflation, a stable economic environment and legal certainty as strong contributors to project resilience and outcomes.

In this research, it is shown that the effectiveness of external influences (i.e., financial stability, compliance with regulations) to ensure the resilience of a project is much lower than they have been in the past; as such there is a necessity to develop focused enhancements. The strength of the internal risk practices utilized by the firms involved in these studies have proven to be successful, however, their overall influence has been lower than the potential of the external conditions. By establishing the priority on improving the external conditions the ability to successfully complete a project will be significantly improved and by continuing to maintain and optimize internal risk practices will ultimately lead to long-term success of the project.

To build the resilience and future success of projects within the Ethiopian construction industry, several strategies will need to be developed. First, addressing external factors should be given top priority; as such the government needs to stabilize inflation, illegal markets, and regulatory uncertainty to provide an enabling environment. Second, companies need to further improve their risk management by creating effective lines of communication, developing a corporate risk awareness culture, integrating their risk practices into their day-to-day business activities, and making sufficient budgetary allocations. Third, if agreements are made amongst government institutions, financial organisations and industry stakeholders to support collective harm to externalities from non-compliance issues, they may find clarity in updating or positively disrupting these external shocks already addressed earlier. Ongoing assessments and scenario planning may support continuous project sustainability.

The core findings and structural relationships of the study are still valid, although some indicators have shown a reduced ability to predict. Further studies may be able to improve the predictive abilities of these indicators or identify other ways to measure them that will enhance their ability to predict. In addition, capacity-building efforts through awareness and training programmes focused on risk identification, assessment, mitigation practices, external environment factors and their impact on business operations will enable resilience practices to infiltrate the construction industry. Promoting resilience in other organisations and tracking resilience best practices and successful stories of firms supporting social responsibility in practice will enable improved project outcomes and support Ethiopia’s sustainable development goals in their context.

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