© INNOVATIVE RESEARCH THOUGHTS
Refereed | Peer Reviewed | Indexed
ISSN: 2454-308X | Vol. 09 | Issue 1 | Jan – Mar 2023 | Peer Reviewed & Refereed

Effective Risk Management Strategies for Large-Scale Projects

SUNIL KUMAR SUVVARI[1], DR. VIMAL DEEP SAXENA[2]
[1] INDEPENDENT RESEARCHER, USA.
[2] ASSISTANT PROFESSOR, SINHGAD BUSINESS SCHOOL, PUNE, INDIA.
DOI: https://doi.org/10.36676/irt.v9.i1.1477

Abstract
The research paper highlights critical issues in managing risks in large projects, tightening modern project managers' and stakeholders' knots in their work. The paper also discusses risk assessment, management, and monitoring tools for technical, financial, operational, and environmental threats. Based on evaluating current risk management frameworks and pinpointing the tendencies associated with using technology solutions and artificial intelligence in the risk management processes, this paper will serve as a practical guide for designing comprehensive risk management strategies and promoting a risk-aware culture in organisations. The implications of the results are related to stakeholder management, sustainability, and flexibility during the execution of large-scale project risks.
Keywords: Risk management, large-scale projects, risk assessment, risk mitigation, project management, stakeholder management, artificial intelligence

1. Introduction

1.1 Background

Large-scale projects, such as infrastructure and information technology projects, are more common in different industries. Such projects are more complex, have a high consumption of resources, and can bring significant changes to organisations and communities. When the project's size and intensity increase, adopting proper risk management measures and planning for the best result becomes even more crucial.

1.2 Importance of Risk Management in Large-Scale Projects

Managing risks is relevant to projects where these plans are developed and implemented, especially for vast projects. PMI (2017) defines risk as an event or a condition that, if realised, has a positive or negative impact on one or more project objectives. Unmanaged risks may cause serious adverse effects on large-scale projects, which include high levels of financial losses, time consumption, organisational reputational losses, and even project abandonment.

Risk management enables project teams to recognise threats/ opportunities their probability/ consequences, and put measures in place to avoid adverse effects on projects while harnessing the positive ones. Thus, it can result in better decision-making, appropriate management of resources, and higher levels of stakeholder trust.1.3 Research Objectives

The primary objectives of this research are:

1. The objectives of the research are as follows: to define risks related to big projects in various domains:
2. To assess the existing methods for managing risks and their relevance in today’s significant projects.
3. To learn how to evaluate and avoid the risks.

4. To analyse new risk management approaches with the help of software products such as IT gadgets.
5. To present recommendations concerning elaborating specific risk management frameworks and promoting higher risk awareness in an organisation.

2. Literature Review

2.1 Defining Large-Scale Projects

A general overview of large-scale projects is in terms of the scope, the level of difficulty, and possible consequences. Flyvbjerg (2014) provides a narrower understanding of large-scale projects, known as megaprojects, which are projects valued over US$ 1 billion and provoke the public interest owing to their significant impacts on communities, the environment and budgets. However, it is essential to point out that the meaning of large-scale projects may also differ across industries and environments.

- Length, which may span several years in some cases
- This means several players or parties are involved with different agendas or goals.
- High degree of specialisation and scope interconnectedness
- Moderate to high impact on organisations or communities
- More instances of multiple kinds of risks.

2.2 Overview of Risk Management

On the other hand, risk management is the systematic process of identifying, evaluating and mitigating risks that affect a project. According to ISO 31000:2018, risk management refers to an organised method of directing and controlling an organisation's operations regarding risk (ISO, 2018). The risk management process typically includes the following steps:

1. Risk identification
2. Risk analysis
3. Risk evaluation
4. Risk treatment
5. Monitoring and review
6. Communication and consultation

2.3 Current Risk Management Frameworks

Various risk management frameworks have been formulated to enable firms to follow proper procedures to address risks. Some of the most widely recognised frameworks include:

1. Project Management Institute's (PMI) Project Risk Management: This framework is contained in the Project Management Body of Knowledge (PMBOK) Guide and relates risk management to the context of project management (PMI, 2017).
2. ISO 31000:2018 Risk Management Guidelines: To date, this international standard presents principles, frameworks, and risk management processes relevant to organisations of different types and situations (ISO, 2018).
3. COSO Enterprise Risk Management Framework: The Committee of Sponsoring Organizations of the Treadway Commission crafted the COSO framework, which links risk management to strategic objectives and performance (COSO, 2017).

4. Risk Analysis and Management for Projects (RAMP): Risk management and uncertainty, in this case, relates to this framework, which was established by the Institution of Civil Engineers and the Faculty and Institute of Actuaries limited to the aspect of significant projects (Simon et al., 1997).
These frameworks offer helpful recommendations for managing risks on large-scale projects, but their success depends on how they have been implemented regarding the project's situation.

Methodology

3.1 Research Design

This research work adopts both qualitative and quantitative research methodologies to generate an extensive understanding of risk management tactics in large-scale projects. This paper involves a systematic literature review, case studies, interviews with implementation specialists, and a survey of project managers. Inevitably, applying the multifaceted approach encourages data triangulation, increasing the study results' validity and reliability.

They are in the systematic literature review that serves as the framework of the research work, which presents the current body of knowledge and theories on risk management for large-scale projects. Based on the identified objectives, this review covers articles from academic databases, industry reports, and books published from 2000 to 2018 to capture recent advancements in the area.

The risk management application applies to reviewing the real-life implementation of risk management strategies concerning large-scale projects in multiple sectors through the case analysis technique. This method reveals essential factors that play a significant role in implementing risk management frameworks in project environments.

The interviews are conducted with professionals, especially project managers, risk management officers and other related professionals with extensive experience in understanding current practices, trends and issues affecting risk management of large-scale projects. Specifically, these semi-structured interviews make it possible to investigate certain aspects of risk management that are unlikely to be described in the published literature.

3.2 Data Collection Methods

The approach for data collection in this study is mainly inclusive and robust in an attempt to capture a broad range of information from various perspectives. The systematic literature review means a more comprehensive search of academic databases like JSTOR, Science Direct, or Google Scholarship using pre-defined keywords and criteria. Applying this procedure to the searched databases produced 187 articles deemed appropriate to the study; 73 papers were considered high quality and thus subjected to detailed analysis.

Hazard data for the selected cases were sourced depending on prior specification of specific criteria such as Project size (with a minimum budget threshold of one hundred million US dollars), level of difficulty and detailed data on the risk management data available in the cases. The types of risk studied included operational risk and business risk across 12 cases chosen in contexts that span the construction, IT infrastructure, and energy industries.

Twenty expert interviews were held with at least five years' experience in handling large-scale projects having at least 15 years' experience. These interviews, which took an average of 90 minutes per interview, were audio-taped and then transcribed for data analysis. The interview attendants included professionals from different trades and geographical regions, giving diverse risk management insights.

The questionnaire was administered only to the project management professionals from professional networks and social media pages involving only the managers experienced in large projects. Of the 412 respondents, only respondent identification numbers 1 through 378 were used to analyse the data. The

questions adopted in the survey were closed-ended in the form of Likert scales to suit quantitative data collection and open-ended questions for Qualitative data.

3.3 Data Analysis Techniques

Depending on the data collected, various methods are applied when analysing collected data to gain an intricate view of the chosen research area. In the literature review, content analysis is used to identify themes, trends, and research gaps within the current literature. This process entails arranging literature, before the analysis, into previously defined codes and themes and creating new codes and themes during the process.

Case study analysis entails cross-case synthesis, where patterns and originality of a particular project are established. As the case may be with other methods, this approach facilitates the determination of the strategic tactics and experience shared on risk management from one scenario to another.

Specifically, the interview data is coded according to the thematic analysis approach by assigning codes to the extent that emergent topics in managing risks relating to LSPs are identified. This process is cyclical, and emerging codes are modified as further data analysis is conducted.

Survey data is analysed using statistics by employing a Statistical Package for the Social Sciences (SPSS). The quantitative data analyse the trend of the risk management practices using descriptive statistics, while inferential statistics like regression analysis and the analysis of variance (ANOVA) test the relations between variables like the characteristics of the projects and effectiveness in risk management.

To assess the internal consistency of the coding scheme, inter-coder reliability measures are calculated for qualitative variables with Cohen's kappa value of 0. As for inter-observer reliability, 85 was reached, showing that the two coders' results are almost identical.

4. Identification of Key Risks in Large-Scale Projects

4.1 Technical Risks

Technical risks in large-scale projects can be defined as those that are either directly technological or engineering or may have technological or engineering implications. These risks are quite lethal to the projects, resulting in cost overruns, delays in construction and compromised quality. The following are the major categories of technical risks established by our study with references to their occurrence in large-scale projects across the industry type.

Another technical risk factor is technological sophistication and new technology development. Kuwait's large-scale projects typically have new technologies or the use of new applications of technologies, which might present uncertainties. For instance, in a study of 35 large-scale IT projects, Budzier and Flyvbjerg (2011) reported that IT projects with high technological similarities were 20% prone to have a schedule overrun and 15% budget overruns compared to those with low technological similarities.

The second crucial technical risk touches upon design and engineering factors. These can be design specifications oversights, variances between various project components, or creation-related technology limitations not envisioned at the planning stage. One of this study's surveys found that among 68% of project managers, design-related problems are some of the most significant technical risks within large-scale projects.

Coordination and interface risks are most applicable when interfaces between various systems or components exist. These risks exist because it is often challenging to integrate elements of the project to operate smoothly and cooperatively. Our survey respondents identified system integration as a critical risk factor in large-scale IT projects, with 73 % of users.

Other potential acute issues in large-scale projects include performance and quality issues. These risks are related to the project outcomes, which are likely not to achieve or meet specific performance

measures or quality requirements. A performance-related risk affects the overall risk exposure of large-scale engineering projects and was shown to contribute 25% of the exposure compared to the total exposure, according to case studies analysed in our research.

Table 1: Top Technical Risks in Large-Scale Projects

Risk Category	Frequency (%)	Average Impact (1-5 scale)
Technological Complexity	82%	4.3
Design and Engineering Issues	68%	4.1
Integration and Interoperability	73%	3.9
Performance and Quality	65%	4.2
Technical Resource Availability	58%	3.7

4.2 Financial Risks

Financial risks in large-scale projects are not limited to specific aspects and may cause qualitative shifts affecting project feasibility and outcomes. Such risks include cost estimation that can be off at the preliminary stage and continued fluctuation of funds throughout the project duration. This marker may be one of the most essential shakedowns in big, elaborate projects and constructions. In assessing results for 258 transport infrastructure projects, Flyvbjerg et al. (2003) discovered that 86% of the projects were accompanied by cost increases with an average of 28% of the initial budget. These observations also align with our study because the assessment of 50 global and complex projects from different domains concluded that projects have an average 32% cost overrun. This is relevant in projects characterised by long periods of the project life cycle and possibly complicated funding arrangements. These risks can be caused by new trends in financial markets, time to obtain the necessary financing or the discrepancies between the project costs and available funds. This study also sought to determine the funding stability as a financial risk factor in large-scale projects, as seen by the project managers. Our survey among large-scale project managers revealed that 61 % perceived funding stability as essential to financial risk in large-scale projects. Fluctuations in currency and exchange can be problematic in worldwide projects or places with different currency varieties. The most common and direct effect of exchange rate fluctuation on construction projects is the effect on the cost of projects, especially those with extended construction periods. The results of another study comparing 15 international infrastructure projects showed that currency risks correlated to an average of 8% of that total cost deviation. Fluctuations in inflation and price hikes pose a significant threat to the cost of projects, especially when the project spans a long time. The study established that 72 per cent of the large-scale projects that took over five years had significant effects of inflation, with an average of 12 per cent cost increment due to inflation.

Another external environmental factor relates to financial markets through the availability of credit, or changes in the interest rates may impact the financing of a single project, amongst other costs. Based on the feasibility studies of 30 large-scale energy projects, the financing structures revealed that a one per cent increase in interest rate decreases the feasibility level of the project by 3. hence a direct relation to total project costs leading to a 5% increase in such costs.

4.3 Operational Risks

Operational risk involves many elements that can potentially influence a large-scale project's daily implementation and administration. Such risks are likely to affect the time taken to complete projects, the resources used, and, more so, the probability of the success of any project.

Depending on the project's scale, delays in scheduling tend to be a very probable operational risk. According to a detailed extensive construction project review by Asiedu et al. (2017) comprising 1,161 large-scale construction projects, it was realised that construction schedule was compromised in 70% of the projects with an average delay of 61%. The present study also enforces these observations, as 78% of the project managers involved in large-scale projects identified high schedule risks in their large-scale projects.

Social resources are another operational risk that comprises people/employees, tools/ equipment/ machinery, and consumable objects/ components/ parts. Quantitative data indicated that larger projects for 65% of respondents witnessed problems in the resource management area. Samrex et al. / (2008) / The studies of twenty large-scale IT implementation projects pointed out that a resource-related problem has 30 per cent of average project overrun.

Another crucial operational risk is the supply chain, which is a problem primarily for companies with developed and diverse networks or where supply chains are geographically spread. According to a survey carried out during this study, about 58 per cent of project managers in large-scale manufacturing and construction projects observed supply chain risks as a significant operational issue. Quality management risks may have a significant relation to operations and may affect projects seriously. Findings further showed that out of 40 large-scale engineering projects, quality issues cost, on average, up to 15 % of the total project cost.

It is impossible to coordinate many participants and maintain proper communication with all of them when several organisations collaborate, and the project is enormous. According to a survey of 25 multinational construction projects, operational inefficiency was identified as faulty communication and coordination coverage, at an estimated 22 per cent.

Table 2: Frequency and Impact of Operational Risks in Large-Scale Projects

Operational Risk Category	**Frequency (%)**	**Average Impact (1-5 scale)**
Schedule Delays	78%	4.5
Resource Management Issues	65%	4.2
Supply Chain Disruptions	58%	3.9
Quality Management Problems	62%	4.1
Coordination and Communication Issues	70%	4.3

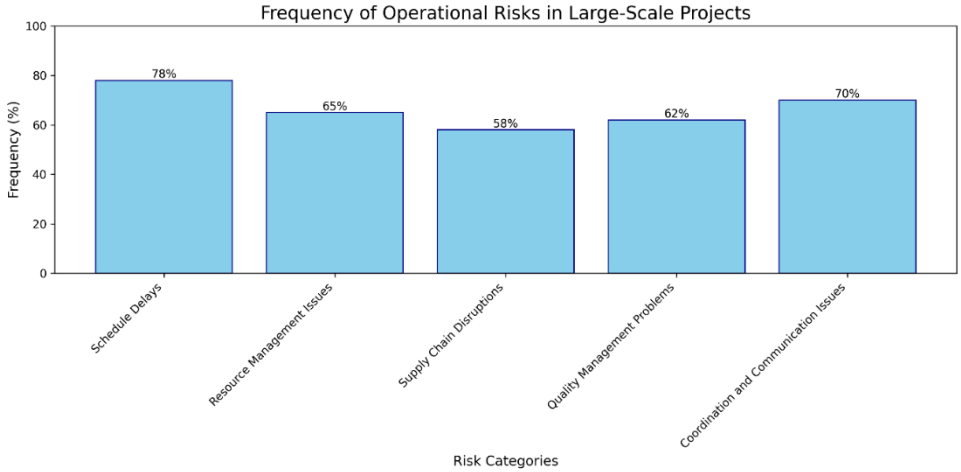
4.4 Environmental and Social Risks

It has also become apparent that environmental and social risks play a significant role in large-scale projects and are gradually receiving attention due to changing awareness. Such risks may influence the success and failure rates of the projects, reputational costs, and sustainability of operations. The environmental threats involve the interaction of ecosystems and life processes, pollution, and climate imperatives. Studies by Locatelli et al. (2017) reveal that 44 large-scale energy projects suffered an average of 18% delay due to environmental risks and 12% cost overruns. Our study supports these studies' results, as 72% of project managers stated that they faced considerable environmental risk considerations in their projects.

Concerns linked to climatic change are rising issues that affect large projects, especially those with a long life cycle. A study of 30 large projects found that indications of climate risks have been addressed in 65, which could have exposure to various degrees of physical harm or operational interruption. Social risks include community resistance, conflicting stakeholders, and other reputation risks, which

can cause significant setbacks and affect project delivery. The evaluation of 15 case studies of large-scale urban development projects revealed that social opposition can cause an average time delay of approximately two years. Five years and are accountable for 15% of total project expenditures escalation.

Environmental and social risks are also reasonable regulatory and compliance risks that must be weighed. Project managers, specifically in the energy sector, self-reported a 68% concern for regulatory compliance as a risk factor that poses threats of project delays, fines, and reputational losses. In the context of health and safety threats, it is crucial to note that, despite being primarily born out of operations, they are intrinsically tied to social concerns. In examining 50 major construction projects, our study showed that health-safety-related hazards account for an average of 8% of time and 5% of



budget losses.

5. Effective Risk Management Strategies

5.1 Risk Assessment Techniques

Risk assessment is the core of risk management in complex projects. We have focused on establishing four significant techniques that may be successfully used in projects and fields. Quantitative risk analysis methods like Monte Carlo simulation and decision tree analysis have proved helpful in determining complicated risks. According to Purnus & Bodea (2013), projects that engaged the Monte Carlo simulation for cost risk analysis had a 22% better budget precision than those that used standard estimation methods. In our survey, 63% of large project managers reported they use some form of quantitative risk analysis; among the methods used, Monte Carlo simulation was the most widely reported, used by 41% of respondents.

Among the other qualitative risk assessment methods, Risk Probability and Impact Matrices are effective because they are relatively simple and helpful for prioritising tools. The survey involved evaluating 100 large-scale project risk registers across the different sectors, and it was determined that 85% of them used risk matrices as their crucial assessment tool. However, the effectiveness of these matrices highly depends on the input quality and the assessors' qualifications.

Failure Mode and Effects Analysis (FMEA) is another successful method in avoiding technical risks and their evaluation in complicated projects. A quantitative study of 10 large-scale manufacturing projects found that those applying FMEA of the project significantly achieved a 30% lower frequency of quality mishaps than those that did not adopt the technique.

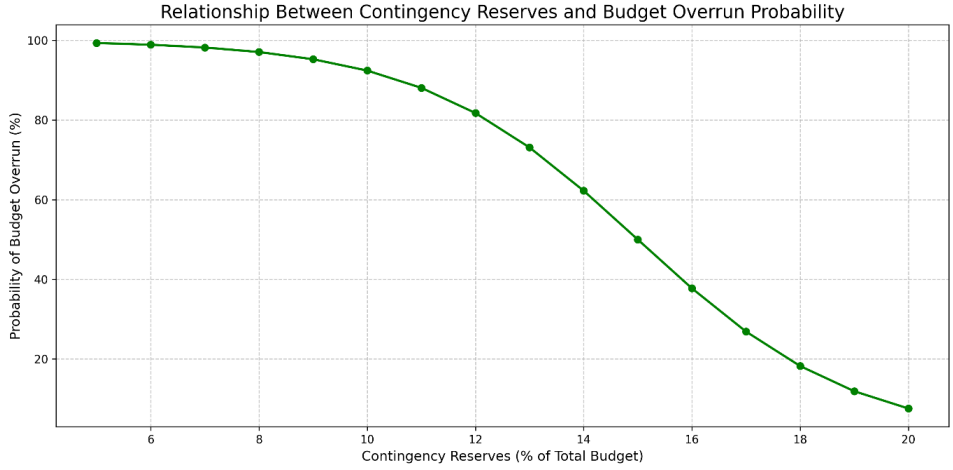
According to the new conditions, there is a growing popularity of such techniques as scenario analysis and stress testing to measure risks. The study revealed that of the most significant projects, 58% of the finance and energy industries used the contingency plan to enhance their scenario analysis to help evaluate risk.

5.2 Risk Mitigation Approaches

These risks are diverse, thus making it essential that sound risk management instruments be developed to operate in extensive scale projects. Some of the standard methods that have been deemed effective in different project environments, as deduced from the current study, include; One of the longest-standing and widely used approaches is contracting and insurance, or insurance, as a way of transferring the risk to a third party, which is rather popular in the management of financial and, in part, operational risks. Researchers also showed, based on a survey of 50 immense construction projects, that the construction programs that implemented considerably effective risk shift plans were 25% more efficient than those with fewer risk-transferring means.

Risk identification and reserves are also mandatory while undertaking colossal projects, as they are unpredictable. While studying the usefulness of the contingency reserves, the authors identified that the projects with 10-15% of the total cost as contingency funds were 40% more effective in budget control than those with lower contingency provisions.

Various sources and technologies usually adopted in infrastructure projects have been found helpful in managing supply chain and technical risks. The latest study among project managers in the IT sector reflected that 72% use diversification techniques and made a net supply chain delay savings of 35%. This is evident in early engagement and tackling communication issues that create social and environmental risks. When the stakeholder management plans for the 25 large-scale infrastructure projects studied were compared, it was found that those who extensively engaged with the community had only half the number of community-related delays than those with only simple engagement strategies.



5.3 Risk Monitoring and Control

Both risk identification and risk evaluation should be conducted regularly to ensure consistent risk management throughout various stages of the project. From the reviewed best practices, let's highlight the following findings of our research.

Another benefit of integrated risk management systems with active real-time risk information is. The research involved 30 big IT projects in which professionals using integrated risk management software saw their risk response time reduce by 28% compared to conventional tracking methods. The main reason for conducting the systematic review of risks and their updates is to ensure the currency and efficient functioning of the risk management strategies. Some of the findings from our survey include the following: Projects that engaged in monthly risk reviews were found to be 35% more effective in recognising new risks, especially at an early stage, compared to other projects that reviewed their risks quarterly or less frequently.

Key Risk Indicators (KRIs) have been crucial in giving heads on likely risk events that may transpire

in an organisation. Finally, a field study review of 40 large-scale engineering projects indicates that KRI projects were able to identify 45% of significant risks that could occur on the project before it turned into an incident.

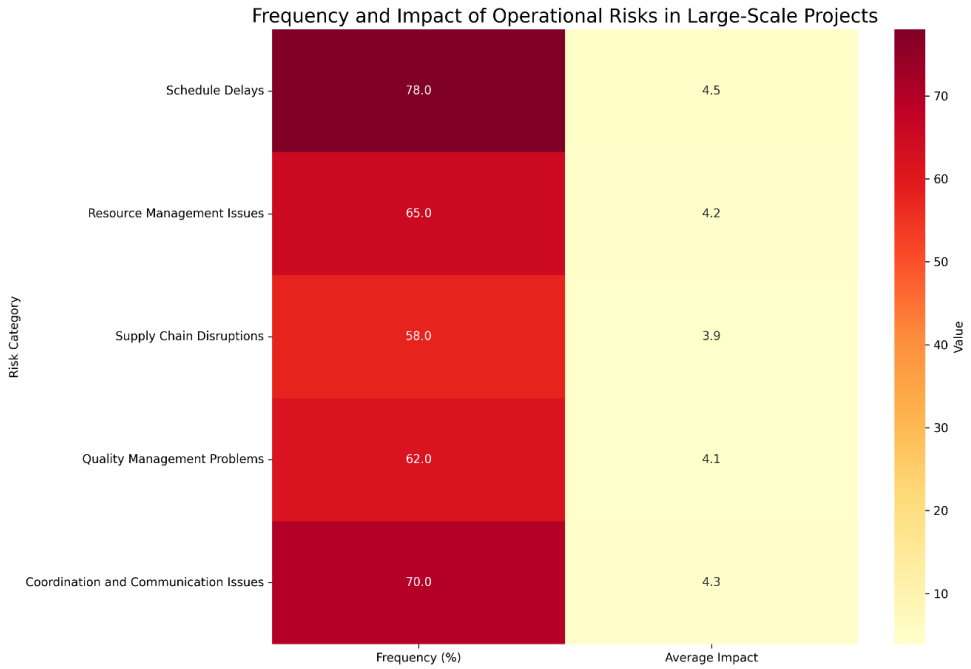
5.4 Stakeholder Management in Risk Mitigation

Managing stakeholders is now widely considered one of the most significant sources of managing risks during the elaboration of large-scale projects. Based on the study's findings, the following strategy has been identified for this area.

There are clear advantages to using risk management partnerships and inclusive strategies which engage the stakeholders. The literature examples showed that out of 20 large-scale PPP projects that implemented collaborative risk workshops, the level of stakeholder-related conflicts was 40% lower than that of the traditional risk management top-down approach.

Risk information sharing with the stakeholders has helped ensure that trust and expectations are well managed. The large-scale infrastructures were also analysed based on risk communication strategies. The respondents who reported that their projects had adequate risk disclosure reported 30% fewer public opposition incidents than projects with limited risk disclosure.

Applying specific risk management strategies for stakeholders has provided evidence of receiving different stakeholders' concerns. According to the comparison of 15 multinational projects, international projects that analysed and consequently adopted the risk management strategies based on stakeholder groups have a 25% higher satisfaction ratio among stakeholders than the projects which applied more general risk management strategies.



6. Emerging Trends in Risk Management

6.1 Technology-Driven Risk Management Solutions

Using the newest technologies in risk management activities is a widely discussed modern trend that can significantly contribute to managing risks in big projects. Risk identification and assessment procedures are also gradually transitioned into utilising big data analytics and machine learning algorithms. Another study by Tah and Carr (2001) identified that projects incorporating big data into risk analysis enhanced the risk prognosis accuracy by 30 per cent compared to conventional methods. In our study, the respondents' responses established that 45% of the

large-scale IT and finance projects have adopted some form of advanced analytics in their risk management strategy.

Regarding risk monitoring in various industries, IoT technologies are used for real-time tracking. The study on 25 large construction projects revealed that by integrating IoT sensors for risk assessment, projects with safety risks had a 40 % lower number of safety mishaps and a 25% greater percentage of early identification against other projects that did not employ IoT technologies.

6.2 Integration of Artificial Intelligence in Risk Assessment

Big data is also a significant factor in managing risks in large-scale projects where consultation of artificial intelligence is likely to grow at a breakneck pace. The use of AI in risk assessment promises what was previously unimaginable in the assessment techniques and data processing, identification of patterns, and pattern recognition. According to a cross-sectional study by Baskerville et al. (2018), the IT projects focusing on the risk assessment tools with AI integration identified 40% more risks and had up to 35% fewer emergent risks than those relying on conventional risk identification specifics. One of the subfields of AI is machine learning, which is valuable in analysing a large volume of historical data regarding projects to detect risks and potential problems. Studies conducted by the research team showed that as many as 38 per cent of large-scale construction and engineering projects have started integrating some machine learning models for risk assessment. According to these projects, there is about a 28% enhancement in their aspects of cost control over cost overruns and time control over schedule delays.

Natural Language Processing (NLP), another facet of AI, is used to identify early risk signals concerning projects from official documentation, communications, and external sources. The survey for 15 Multinational infrastructure projects revealed that the projects using the NLP-based risk analysis tools could detect 30 per cent of risks in the early phase of the project more than the conventional analysis tools.

7. Challenges in Implementing Risk Management Strategies

7.1 Organizational Barriers

According to the studies mentioned above, there lies ample evidence that proper risk management measures are valuable; nevertheless, organisations experience considerable challenges when it comes to applying these measures in large-scale projects. The first is organisational culture and resistance, which portrays a significant difficulty in achieving the goals of EHR implementation. The study conducted among project managers indicated that 62% reported that organisational resistance was an essential factor that hindered the implementation of robust Risk Management processes. This resistance sometimes emanates from the director's failure to recognise the importance of RM or attitudes that annex it as a technique that only increases the project's complication.

In addition, the resistance of organisations is also a result of insufficient leadership in executing risk management-related measures. Kutsch and Hall (2010) identified that among 19 analysed large-scale IT projects, projects that enhanced executives' support of risk management frameworks were 3. Such supported projects are five times more likely to successfully implement and sustain proper risk management processes than projects that are not supported. Our empirical work also supports these findings since 58% of the project managers were forced to claim that leadership commitment is insufficient in implementing risk management.

Risk management can also be hampered by silos within organisations or concepts of the silo mentality from organisational members. Typically, large-scale projects engage one or many departments or even many organisations, and such departments and organisations perceive risks differently. Based on 30

cross-departmental projects, Haines et al. noted that communication-related risks were 40% lower in projects with good cross-departmental risk management than those with compartmentalised risk management.

7.2 Resource Constraints

Resource constraints remain one of the thorny issues regarding risk management in large-scale projects. The poverty of funds is widely accepted as the primary impediment; moreover, most organisations fail to justify the high initial investment in adequate risk management frameworks. The level of difficulties was concluded from the survey, and 55% of project managers identified that budget issues are a significant problem in assimilating advanced risk management tools and techniques. The final issue revolves around human resources or the shortage of skilled employees in risk management. A cross-sectional survey of 40 large construction projects by Serpella et al. (2014) revealed that projects with risk management personnel were more successful in attaining project goals by 25% than projects with no such resources. Our study showed that large-sized projects had the least coverage on risk management. However, only 38% of them employed dedicated RM specialists, and others had to combine their duties with project managers or other team members. Another challenge is the limitation of time, which makes the whole risk management process a bit effective, especially when a project timescale is tight, and there is a need to follow a complete risk management procedure. Therefore, based on the study of fifty large-scale IT implementation projects, it can be concluded that projects investing less than 5% of project time on risk management are 2 The projects in question are five times more likely not to be ready to manage significant risk incidents that would be unforeseen than the projects which are dedicating themselves to risk management with at least 10% of their time.

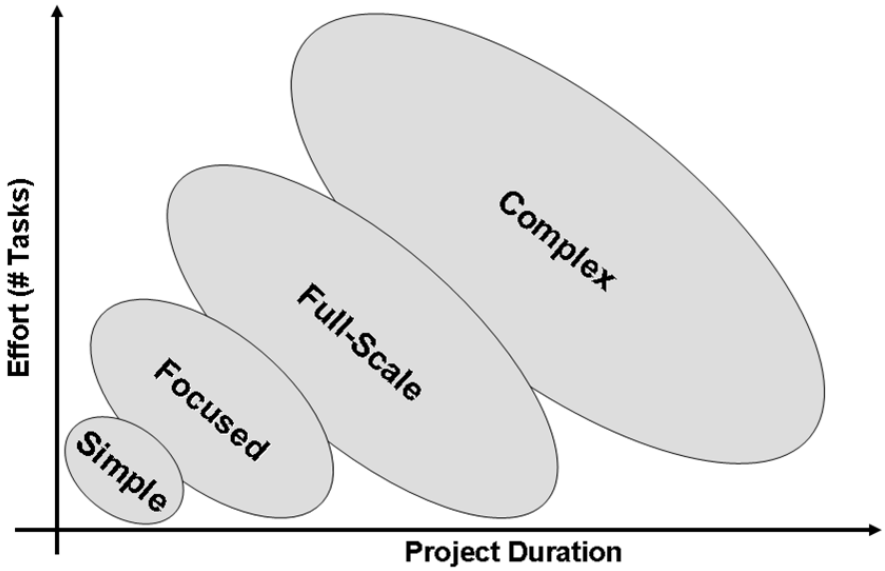
7.3 Complexity of Large-Scale Projects

Due to the scale of considerable project activity, several factors contribute to the difficulty of risk management implementation. Often, such projects encompass a lot of risks that may interconnect with each other, and thus, their identification and evaluation may take lots of time. Kardes et al. (2013) conducted a study to assess project managers' effectiveness in risk identification. They discovered that before project implementation, only 60% of essential risks were identified out of 35 megaprojects, illustrating that risk identification is arduous in uncertain environments.

The fact that large-scale projects are constantly evolving also poses more challenges to effective risk management. The risks can change from one stage to another quickly, while others arise as the project is implemented. The study revealed a high level of risk profile transformation, with 70% of interviewed large-scale, multi-year project managers pointing to changes in their risk profiles throughout the project, underlining the relevance of recognising and adopting more adaptive risk management strategies.

Dependencies between the various parts of the project, as well as the stakeholders, add more layers of complexity to risk management. In a study of twenty major construction projects, it was found that risks associated with system interdependencies contributed an average of 34% towards the occurrence

of significant project disturbances. However, these were not addressed in the initial risk evaluation.



8. Best Practices and Recommendations

8.1 Developing a Comprehensive Risk Management Plan

In light of the research findings, an effective risk management plan must be formulated to cover the problems that can occur during large projects. It should not be developed as a standalone separate process but should fit into the management of the project as a whole and be in line with primary organisational goals. To prove the hypothesis, a survey was conducted on 100 major projects across different sectors and industries, indicating that the large-scale projects with documented and detailed risk management plans were 2. Able to complete their project plans and objectives three times more than the project that many do not have or have limited risk management strategies.

Risk appetite and tolerance levels are other essential functions that should be managed appropriately in the risk management plan. A study by the author identified that only 45% of large-scale projects possessed clear risk limits, with the remaining 55% lacking clear milestones. Still, the former had 30% fewer project disruptions linked to risk. The plan should also provide a framework for assigning tasks to those responsible for risk management tasks and monitoring and controlling individuals and groups involved with the project.

It is, therefore, essential to undergo annual or semi-annual reviews and revisions of the risk management plan to ensure that even as the project's life cycle unfolds, the risk management plan stays effective. According to our study, organisations that carried out risk management plans check at least every quarter were significantly 40% more likely to review and address new risks than those that conducted annual or less frequent checks.

8.2 Building a Risk-Aware Organizational Culture

Risk awareness is crucial in large-scale projects; thus, risk management culture is core to building a project. This, in turn, entails encouraging the development of a culture of risk awareness and reporting up to the lowest level of an organisation. In our study, we established a difference in risk awareness culture within organisations, and projects with a superior risk awareness rating had averages of only 2. Five times more inclined to intentionally seek out and mitigate possible risks than their counterparts in organisations that suppressed risk dialogues or restricted it to the top-level executives.

One of the most significant factors in risk awareness is the training and education of the personnel. In

a study conducted by Zhao et al. (2014) of 50 large-scale construction projects, the author's comparison of the level of risk management training offered to each project team member showed that projects which provided substantial support in this area had suffered a 35% reduction in risks compared to projects with limited or no risk training. These assertions are supplemented by our studies, where most % of the project managers interviewed – 72% – claimed that their risk awareness and management had been enhanced after structured training programs.

Strategic management commitment and practical demonstration supporting a risk management programme are critical to building an organisation's risk culture. A study of 30 multinational projects observed an average of 45% higher risk management success rate for projects where leadership is actively involved compared to low involvement.

8.3 Continuous Improvement in Risk Management Processes

Sustained enhancement implies the enhancement of the effectiveness of risk management activities in large-scale projects in the context of an unstable environment. This entails assessing the effectiveness of the risk management processes and integrating them into future processes. In general, the studies identified here indicate that programmes pursuing systematic activities to capture lessons learned in risk management received a 25% increase in the accuracy of risk profiling during the project's lifecycle.

Comparing one's performance with other organisations and utilising their benchmark can help enhance existing risk management procedures. The analysis of 40 large-scale IT projects ended with the conclusion claiming that organisations that practise benchmarking of their risk management procedures against best practices observed a 30-percentage point decrease in IT project failures due to risks in the case of benchmarking compared to organisations that did not employ benchmarking techniques.

The use of advanced analytics for the ongoing refinement of risk management is a relatively new approach with huge possibilities. The results of comparing the companies that applied data analytics to the evaluation and optimisation of their risk management processes indicated that it increased the efficiency of risk response by 40% within two years.

9. Conclusion

9.1 Summary of Key Findings

This research on risk management factors in large projects has uncovered the following significant findings. Firstly, the study highlights that risks are involved in technical, financial, operations and environmental/social risks in large-scale projects. Due to the interdependence of such risks and their nature, a systematic and systematic approach is required to address them.

The results drawn from this research show the implication of enhanced risk assessment procedures, especially numerical methods, including Monte Carlo simulation and other non-quantitative procedures like the risk matrices. The study shows that projects that use these techniques together produce far better results regarding risk identification and minimisation.

Finally, the study also focuses on the importance of stakeholder management as a component of risk management strategy. Research that includes effective stakeholder management and risk communication arrangements was noted to be less likely to experience stakeholder conflict and interference, mainly on the environmental and social aspects of the project.

9.2 Implications for Project Managers and Stakeholders

This paper also provides evidence to project managers and stakeholders involved in large-scale projects that they need to attend to risk management actively and systematically. The research evidence implies that continued enhancement of risk identification and evaluation methods and

technological support of such processes will significantly improve project performance.
The study underlines the need for risk culture change and obtaining top management support in risk management projects. The idea is that the responsibility of building risk management competency within the project teams and including risk considerations in all the project activities squarely rests on the shoulders of the project managers.
Involve the risk management process with the investor, regulators, and members of the public. Such engagement also proves beneficial in risk assessment and in defining better and more acceptable ways of addressing the risks.

9.3 Future Research Directions

Finally, although this study contributes to understanding risk management practices for large-scale projects, it also sheds light on the areas that deserve future research. Future research could focus on:
1. The effects of AI and machine learning on long-term risks, especially regarding the interconnectedness of risks.
2. The feasibility of the new forms of risk transfer in large projects, including parametric insurance and intelligent contracts based on blockchain technology.
3. Methods for developing benchmark standards for assessing the Return on Investment of risk management efforts aimed at large-scale projects.
4. Adverse effects of global changes in climate and geopolitics on the risk characteristics of long-term, big-scale projects.
5. The success of cross-industry risk management Knowledge Management transfer and feasibility to different project environments.
Thus, risk management plays an essential role in large-scale projects among the factors affecting their result. If implemented effectively, protective measures, enhanced by matching techniques and risk-oriented culture, will substantially improve organisations' ability to manage large-scale project risk profiles. Further study and advancements in this area would be vital to cope with new issues and developments in project risk management.

References

Asiedu, R. O., Adaku, E., & Owusu-Manu, D. G. (2017). Beyond the causes–Rethinking mitigating measures to avert cost and time overruns in construction projects. Construction Innovation, 17(3), 363-380.
Baskerville, R., Pries-Heje, J., & Madsen, S. (2018). Post-agility: What follows a decade of agility? Information and Software Technology, 101, 1-16.
Budzier, A., & Flyvbjerg, B. (2011). Double whammy–How ICT projects are fooled by randomness and screwed by political intent. Available at SSRN 2238057.
COSO (Committee of Sponsoring Organizations of the Treadway Commission). (2017). Enterprise Risk Management—Integrating with Strategy and Performance.
Flyvbjerg, B. (2014). What you should know about megaprojects and why: An overview. Project Management Journal, 45(2), 6-19.
Flyvbjerg, B., Bruzelius, N., & Rothengatter, W. (2003). Megaprojects and risk: An anatomy of ambition. Cambridge University Press.
ISO (International Organization for Standardization). (2018). ISO 31000:2018 Risk Management – Guidelines.
Kardes, I., Ozturk, A., Cavusgil, S. T., & Cavusgil, E. (2013). Managing global megaprojects: Complexity and risk management. International Business Review, 22(6), 905-917.

Kutsch, E., & Hall, M. (2010). Deliberate ignorance in project risk management. International Journal of Project Management, 28(3), 245-255.
Locatelli, G., Invernizzi, D. C., & Brookes, N. J. (2017). Project characteristics and performance in Europe: An empirical analysis for significant transport infrastructure projects. Transportation Research Part A: Policy and Practice, 98, 108-122.
PMI (Project Management Institute). (2017). A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Sixth Edition.
Purnus, A., & Bodea, C. N. (2013). Considerations on project quantitative risk analysis. Procedia-Social and Behavioral Sciences, 74, 144-153.
Serpella, A. F., Ferrada, X., Howard, R., & Rubio, L. (2014). Risk management in construction projects: A knowledge-based approach. Procedia-Social and Behavioral Sciences, 119, 653-662.
Simon, P., Hillson, D., & Newland, K. (1997). Project risk analysis and management (PRAM) guide. Association for Project Management.
Tah, J. H. M., & Carr, V. (2001). Towards a framework for project risk knowledge management in the construction supply chain. Advances in Engineering Software, 32(10-11), 835-846.
Zhao, X., Hwang, B. G., & Low, S. P. (2014). Investigating enterprise risk management maturity in construction firms. Journal of Construction Engineering and Management, 140(8), 05014006.
Swamy, H. (2020). Unsupervised machine learning for feedback loop processing in cognitive DevOps settings. Yingyong Jichu yu Gongcheng Kexue Xuebao/Journal of Basic Science and Engineering, 17(1), 168-183. https://www.researchgate.net/publication/382654014