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A REVIEW OF RISK MANAGEMENT IN CONSTRUCTION PROJECTS

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ABSTRACT

The construction industry faces a significant challenge in identifying potential risks associated with construction projects. While past studies have sought to improve risk recognition skills, there is still much ground to cover. This article aims to provide a comprehensive summary of current research on construction risks, highlighting knowledge gaps and addressing potential risks that may arise during construction projects. To locate relevant research, this study conducted keyword searches at various levels, including recognizing and identifying construction risks. Our investigation has underscored the need for greater emphasis on political, economic, financial, and cultural risks associated with construction. This focus should be complemented by a heightened prioritization of quality assurance measures and promoting occupational health and safety. Our study also emphasized the crucial necessity for a more comprehensive exploration of risk reporting in this sector. These findings will serve as a valuable resource for researchers and construction leaders, providing insight into the current state of recognizing construction risks and identifying areas for future research.

Keywords: construction industry, Construction risk management, Construction risk identification

Introduction

In the 1960s, incorporating construction risks into decision and management theories was a novel concept. Considering that a considerable amount of time has elapsed since the mentioned event, it is of utmost importance to evaluate the advancements made in the field of construction and project risk management. Furthermore, we must identify and explore the untapped opportunities for further improvements in this domain. This comprehensive study delves into the literature on construction risks. The text refers to the process of evaluating the potential risks associated with construction projects from various angles. It suggests three key ways to approach this task: firstly, by utilizing analytical tools specific to the construction industry; secondly, by developing a comprehensive and structured approach to managing risks throughout the project lifecycle; and thirdly, by adopting a "soft systems" perspective that takes into account the human factors and qualitative aspects of risk management. When discussing and evaluating potential risks, it's crucial to remember

the following definitions: A risks refers to the possibility of an unfavorable event happening within a particular location and timeframe [1]. This could be anything from a natural disaster to a workplace accident or a cyber-attack. Organizations and businesses must identify potential risks and assess their risk level to take appropriate measures to prevent or mitigate any potential harm.

Definitions

To properly review and discuss, it is important to consider the following definitions:

The likelihood of a negative event occurring within a specific area and time interval is known as a risk [1]. Organizations and the environment are evaluated through risk analysis, which aims to determine the possibility of adverse events that could cause negative effects [2]. Various entities typically carry out this process, including banks, construction groups, healthcare providers, and nonprofit organizations [3]. The risk analysis process includes identifying potential risks, setting assumed limits of associated uncertainties, and measuring the potential impact of a risk event [4]. Organizations implement risk management strategies to manage these risks that involve identifying, assessing, and controlling threats to their capital, profits, and operations [5]. These threats can arise from various sources, such as financial uncertainty, legal obligations, strategic management errors, accidents, and natural disasters [6] and [7]. Failing to anticipate and prepare for unexpected events can have significant consequences for an organization, ranging from increased costs to potential closure [6]. Therefore, organizations must conduct thorough risk analyses and implement effective risk management strategies to prevent or mitigate negative outcomes.

Analytical review of risks

The rationale behind selecting a chronological approach for analyzing literature is that it closely mirrors gaining knowledge in any field. First, fundamental principles are studied and explored, then applied to the specific area of interest. During the application phase, a systematic and well-planned approach is followed to ensure that the benefits of the process are fully realized while minimizing the potential risks associated with it. This helps to ensure that the outcome of the application phase is favorable and meets the desired objectives. Finally, the system is examined to enhance its effectiveness in real-world situations. This same logic was applied to articles and texts from reputable English-language publications, with some limitations. Outdated materials on risk mathematics were excluded, and the vast literature on decision theory was not exhaustively covered. Instead, the focus was on the literature related to construction and project management, specifically regarding risks and uncertainty. While earlier publications may have touched on these topics, the use of quantitative theories and techniques in construction has gained traction in recent years. Applied research on construction risks began almost 20 years ago and has since entered a prolific phase. Systems theory has emerged as a popular approach to managing construction risks, and research publications on this topic have increased accordingly. This paper explores the geographical and graphical shifts in construction and project management publications, focusing on evidence from journals in the UK. However, it is important to note that these shifts do not necessarily indicate a higher risk in the UK. According to the analysis, research in construction risk applications in the UK is significantly lacking compared to American publications, with a gap of 10 to 15 years. On the other hand, authors from the United Kingdom have demonstrated exceptional proficiency in developing and publishing methodologies related to "soft systems" when it comes to constructing comprehensive risk management frameworks. We can objectively examine the research literature by comprehensively viewing construction and project risks. This paper will review only the oldest and most significant papers on the topics and materials considered. These articles can be viewed as landmarks in the field.

Applications on construction

To give meaning and relevance to assessing risks analysis in the construction industry. It would be helpful to categorize the associated risks [8].

Beginning with the source of the risks, we can differentiate between natural risks, which occur outside of human influence, and human risks, which stem from human-made systems [9][10]. In the construction industry, there are various types of risks that are associated with human factors. There are several identifiable categories of risks that organizations face in their operations. These categories include social risks, which comprise factors related to public opinion and societal norms; political risks, which are associated with the actions of governments and political instability; economic risks, which involve macroeconomic factors such as inflation and exchange rates; financial risks, which concern the financial stability of an organization; legal risks, which encompass legal and regulatory compliance; health risks, which involve risks to the health and safety of employees and customers; administrative risks, which relate to the management and administration of an organization; technical risks, which involve technology-related issues such as cybersecurity; and cultural risks, which involve factors related to cultural differences and misunderstandings. Each of these risks presents unique challenges and obstacles that must be addressed in order to ensure a successful outcome for any construction project. It is important for construction professionals to be aware of these risks and to take steps to mitigate them [11].

Social risks

This category of human risk encompasses criminal behaviour, such as vandalism and arson, as well as civil wrongdoing, like trespassing, damage to property, and unauthorized graffiti. These actions not only put the project proposal at risk of appearing as a plaintiff or prosecution witness, but they may also result in counterclaims by the perpetrators. Social risks are more prevalent in projects exposed to armed protest lobbyists [12]. Managing social risk is considered "easy" compared to other risk factors for large projects, as it is challenging to quantify [7]. In the realm of occupational health and safety, drug abuse in construction sites has been a topic of much discussion. However, despite its significance, many researchers have tended to overlook the associated risks that come with it.

Political risks

In recent times, the consideration of political risk factors associated with construction projects has gained significant significance. As the political climate of nations across the world is constantly evolving, it has become crucial for stakeholders to assess the potential risks and uncertainties that could impact the successful completion of construction projects. Therefore, identifying and mitigating political risk has become a critical aspect of the construction industry. Ashley and Bonner's 1987 paper highlighted the risks of foreign government interference in business operations, particularly for multinational construction companies and developers working abroad. Political risks can also stem from actions taken by local governments against other countries, such as trade embargoes, or from changes to domestic laws; the amendment of industrial relations legislation often changes after a new government comes into power, which can significantly impact the workforce and their rights.

Economic and financial risks

It has been proposed that bidding models for construction projects should take into account the prevailing economic conditions surrounding the project. Furthermore, the looming threat of inflation necessitates careful consideration of decisions related to managing construction costs, profit planning, and other crucial aspects of construction projects. It is imperative for construction companies to factor in these variables while bidding on projects and managing their operations to ensure long-term sustainability and success [16]. These issues fall under the crucial category of economic risks in construction, yet they are often given little attention. For example, despite its importance in determining project feasibility, financial risk in construction projects is frequently overlooked in risk research [17]. During a recent demonstration of Monte Carlo simulation techniques, an effective illustration was offered that involved two key variables: debt interest rates and rental rates for construction. The example was

designed to showcase how these variables can be incorporated into a rate of return model, which can be used to assess investment opportunities and make informed decisions based on statistical probabilities. Overall, the demonstration served as a valuable learning experience for those interested in using Monte Carlo simulation techniques for financial analysis [18]. During a detailed review of past events or situations, a Monte Carlo simulation method was demonstrated using a particular scenario as an example to highlight the practicality and efficiency of this approach. In the example, variables such as debt interest rates and rental rates for construction were used as inputs in the rate of return model, which allowed for a comprehensive analysis of the potential outcomes and associated risks. During the demonstration, we aimed to showcase the practical application of Monte Carlo simulation in analyzing complex scenarios and generating insightful data to facilitate decision-making. Specifically, we utilized the simulation to explore the impact of various factors such as cost, delay, occupancy differences, and interest rates on the internal rate of return of a historic office construction project. The simulation allowed us to simulate a range of possible outcomes and evaluate the probability of different scenarios, which can be incredibly valuable for making informed decisions that take into account all potential outcomes [19]. The authors concluded that conducting a real-life project risk assessment as part of a smart pre-construction approach can help reveal vulnerabilities and potential financial viability issues, particularly in a real estate recession. It is quite common to associate corporate construction failures, which are typically characterized as bankruptcy, with a variety of economic and financial factors. These factors may include inflation, high debt interest rates, and inadequate capital. The interplay of these factors can lead to a situation where a company cannot sustain its operations or meet its financial obligations, ultimately failing to continue as a viable entity [20]. Overall, conducting thorough case study research can be crucial in filling a critical gap in understanding the economic risks associated with construction.

Legal risks

In the 1980s, an audit was conducted on how risk was distributed through contractual aspects of building purchases. This marked a shift away from solely quantitative approaches to managing uncertainty in pre-construction contractor agreements and instead took into account the risks faced by customers. Many of these risks fall under legal risks, such as subcontractor default. Despite being addressed in construction contract literature, little research has been conducted on these risks [21]. As alternative procurement methods gain popularity for achieving project objectives, researchers need to consider their associated risks [22].

Health risks

There has been no risk management analysis of the pandemic's effect on construction projects [23]. However, construction sites are particularly susceptible to viral and infectious diseases [24]. Unfortunately, there is limited data available regarding the frequency of such risks.

Management risk

Although there is an increasing recognition and emphasis on several vital aspects such as quality assurance, human resource management, and occupational health and safety in the construction and project management field, a considerable gap appears to exist in tackling these concerns from a risk or risk management standpoint. This gap may result in potential hazards and challenges that could negatively impact the project's success and the well-being of the workers involved. Therefore, it is crucial to address these concerns comprehensively and proactively to mitigate any risks and ensure a safe and successful project outcome. This means not enough attention is being paid to mitigating potential risks associated with these factors, which could ultimately lead to negative consequences for projects and their stakeholders [19]. Nonetheless, progress has been made in enhancing knowledge of occupational health and safety management in construction by emphasizing improving worker safety behavior.

Technical risks

Probability theory is an indispensable quantitative tool for evaluating the risks associated with construction and project management. The field of construction management involves various technical tasks that require a high level of expertise and attention to detail. Among these tasks are tendering, cost estimation, and construction scheduling. Each of these areas is crucial to the success of a construction project and falls under the broad category of technical risks. Proper management of these technical risks is essential to ensure that the project is completed on schedule, within budget, and to the expected quality standards. By utilizing probability theory, construction professionals can effectively analyze and address potential risks, helping to ensure the successful completion of their projects. Additionally, portfolio theory is often employed to encourage contractors to distribute risk when selecting projects for tender [25]. In the field of investment, Bowen expressed disapproval towards the concept of portfolio theory, stating that it is a contrived amalgamation of finance and mathematics. He believed that the two fields are distinct from each other and should not be artificially combined [26]. When considering bidding models, various factors come into play. These may include the current economic climate, the size and complexity of the project, as well as the contractor's risk position. By analyzing these factors, contractors can better determine the most effective way to bid on a project and increase their chances of success [27]. Regarding cost estimation, probability estimation has emerged as a significant focus of probabilistic techniques. It has been one of the most comprehensive approaches, encompassing multiple types of probability density function distributions and utilizing Monte Carlo simulation [28]. In the early days of the construction industry, the issue of risk management was not explicitly discussed. However, it was quietly addressed in the various topics explored, such as bidding and estimation. In construction estimates, both "fixed" and "variable" risk allowances were included. Fixed risk allowances were allocated for risks with known consequences and assessed probabilities. Variable risk allowances were allocated for situations with unpredictable likelihoods and potential outcomes. While the former referred to specific events, the latter encompassed a range of potential scenarios with varying levels of risk [29]. The objective mentioned above aimed to demonstrate a pragmatic approach for achieving a calculated estimation probability that surpasses a certain threshold without resorting to intricate statistical operations. This was a deliberate endeavor to integrate the intricacies of theory with practical needs. The approach to assigning allowances has been modified to incorporate weighted mean values instead of fixed maximum values. This method involves providing an additional declaration that specifies the probability of a less favorable result. By incorporating weighted mean values, there is a greater degree of flexibility and fairness in the allocation of allowances. Furthermore, the accompanying statement provides transparency and helps stakeholders make more informed decisions [30]. Although Monte Carlo simulation has been suggested as an analytical technique, its practical application can be challenging due to the interdependence of risks. In fact, during the demonstration of the @RiskTM program, it was highlighted how this issue can significantly impact the results of risk analysis values [19]. During the discussion, a proposal was presented to address the problem of interrelated risk factors and their impact on the overall risk assessment. The objective was to find a solution that could effectively mitigate the dependencies or correlations among the risk variables that were highlighted earlier [31]. Back in 1974, Dressler devised a novel technique for project scheduling that incorporated the element of randomness or probability, thus challenging the traditional deterministic approach. By doing so, Dressler drew attention to the limitations and drawbacks of the conventional scheduling method, which failed to capture the inherent uncertainties and risks that are often associated with complex construction projects [19]. Crandall (1976) expanded on his work, which was later built upon by Bennett Ormerod (1984), who specifically researched the employment of Monte Carlo simulation in the UK. The ready availability of inexpensive and accessible computing power has aided these efforts. One fascinating pattern that

has emerged in this field is a gradual transition of focus from the initial bidding phase to more detailed aspects such as process estimation, project planning, and scheduling. This shift in emphasis highlights the importance of careful planning and execution throughout the project lifecycle to ensure its success. This implicitly acknowledges the necessity to trace construction risks back to their origin. Technical risks, such as equipment and system failures, new technology malfunctions, collisions, and accidents, are often not well-documented. The risks associated with implementing new technology are significant areas of study; strategic analysis and examination of the construction procurement process and technology information are underway. However, it is also important to investigate the associated risks.

Cultural risks

While international construction companies may face unique challenges when navigating local cultural customs, these issues are not limited to projects abroad. Cultural risks can be present in any construction project, whether in a company's home country or not. Recognizing this, the CIB Group has launched a new initiative called TG23, "Culture in Construction," to explore these risks further. Additionally, it is important to consider the time aspect of construction and project risks. The likelihood and impact of various risks may change throughout a project, and it is crucial to remain vigilant. For instance, while severe flood risk may decrease as a building nears completion, civil engineering projects may face persistent risks throughout the contract period [32]. Seasonality can impact the likelihood of flooding, making it a crucial factor to consider when planning sensitive projects. It is observed that as the construction project moves forward, the likelihood of fatal accidents occurring tends to reduce in the later stages. This can be attributed to the fact that the scaffolding is generally removed by this time, and the emphasis shifts towards the internal work of the building or structure. As a result, the workers are exposed to fewer hazards and are better equipped to perform their tasks safely. This is because the removal of scaffolding and other external structures reduces the risk of falls and other accidents that could be fatal. Additionally, during the internal work stage, workers may be more familiar with the site and its potential hazards, which can improve their safety awareness and reduce the likelihood of accidents. It is important to recognize and take into account that the probability of accidents occurring during a civil engineering pipeline project remains consistent throughout the entire process. This means that the potential for incidents must be considered at every stage of the project, and appropriate safety measures should be implemented accordingly [33]. It's important to keep in mind that the possibility of accidents occurring during a civil engineering pipeline project can remain consistent throughout the entire duration of the project. This means that regardless of the stage of the project, the risks associated with accidents and other related incidents should be taken seriously and managed appropriately to ensure the safety of all workers and individuals involved. any, and in this case, the negative event effect will remain unchanged.

Risk Management Systems

Construction risk management has been approached in various ways, including risk identification, analysis, and resolution. There exist several written materials that have explained various mathematical methods for carrying out risk analysis. For instance, Hertz and Thomas presented some techniques in 1983 and 1984 respectively, while Bern and Cadman also provided their own approach in 1984. Hayes et al. (1986) took an alternate route by demonstrating how probabilistic cost distribution curves may transform as a project advances and uncertainty decreases. Meanwhile, Byrne and Cadman (1984) proposed the opposite. Other researchers, such as Sochuk (1996) and the Project Management Manual Institute, have explored three-dimensional temperature and other factors. In 1987, Cooper and Chapman delved into the subject of risk management, with a particular focus on risk analysis. They used case studies to illustrate the importance of moment analysis techniques and impact diagrams. Similarly, Raftery (1994a) tackled the subject of risk management by using simple analyses for his examples. He also employed case studies to provide a comprehensive

understanding of the topic. In 1994, the book "Chicken" delved into the subject of risk analysis, with a particular emphasis on the evaluation of technical, economic, social, and political risks that are often involved in government decision-making processes for large-scale infrastructure projects. The book offers valuable insights and guidance for professionals and stakeholders who are involved in such projects, helping them to better understand and manage the risks associated with these initiatives. In his work, Cooper showed that by using subjective evaluation, it is possible to generate risk ratings for different project solutions. Although his emphasis was on risk analysis, Cooper also provided a clear and concise explanation of the importance of formal risk management. In his argument, he emphasized the crucial role of formal risk management in enabling informed decision-making regarding projects that entail substantial capital investments, unpredictable cash flows, untried and untested technologies, intricate contractual agreements, significant political implications, as well as environmental or regulatory matters that require particularly delicate handling. He stressed that without a comprehensive risk management strategy in place, these projects could be exposed to a range of potentially damaging uncertainties and setbacks that could jeopardize their success and long-term viability. Experts in risk management have also attempted to use systems techniques to analyze and manage risks [34]. Expert systems have also been proposed to deal with uncertain logic in construction-related legal matters. In the field of risk estimation, there have been various methods proposed over the years. One such method is the use of linguistic methods, which involve the use of "Mysterious groups" to combine different risk factors. This approach was first proposed by Kangari & Riggs in 1989. Another approach that has gained traction in recent years is the use of "fuzzy groups." This method was advocated by Mack and Wong in 1997 and involves combining different risk factors in a more flexible and nuanced way. Beston's work in 1986 also touches upon these concepts. In the field of construction cost estimation, Li (1995a, 1995b) introduced the neural network approach as a means of dealing with uncertainty. This innovation was significant as it allowed for more accurate cost predictions. However, Chapman (1994) cautioned against the unrestrained use of emergency risk allowances. He pointed out that these allowances are often used for unintended purposes, as they are not tied to any specific emergency. Hence, their use should be judiciously evaluated to prevent their misuse. One potential area of research could be the examination of how pre-construction risks in emergency situations are managed financially within the context of contract management. Such research could explore the various strategies and approaches used to mitigate and manage financial risks associated with pre-construction projects in emergency scenarios. There have been proposals for guidelines to aid development, particularly in the field of risk management. These guidelines include the use of "Risk Severity Matrices", which can be found in Risk Management (AS/NZS 3931 1995; AS/NZS 4360 1995). Additionally, the concept of AA, which stands for "Acceptable Action", has been introduced within the project life cycle as a means of managing risk proposals (Ward & Chapman, 1995). In 1994, Raftery introduced a unique and innovative method to identify risks, which has not received adequate attention in the current body of literature on risk management. The evidence presented in the current study lends support to Raftery's proposal and underscores its significance for effective risk management. Another noteworthy contribution to the field of risk management was made by Williams in the same year. Williams recommended the incorporation of a "risk register" component in project management systems. This would enable the creation of a user-friendly repository of risk experiments that can aid in identifying and managing risks more efficiently. However, the approach managers employ in identifying potential risks is equally crucial. In the field of risk management, there is a growing emphasis on analytical methodologies as a means of understanding and mitigating risk. In the construction industry, it is important to focus on setting clear and achievable goals for projects, managing potential risks that may arise during the construction process, and developing effective strategies to respond to those risks. This involves implementing comprehensive risk control and

review procedures to ensure that risks are identified, evaluated, and addressed in a timely and effective manner. By prioritizing these key areas, construction projects can be completed successfully and efficiently, while minimizing potential setbacks and delays. By doing so, organizations can better identify and address potential risks, leading to improved project outcomes and greater overall success.

Aspects of "soft systems" for risk management

The challenges surrounding risk and analysis implementation in organizational contexts are complex and not easily resolved. We advocate for increased attention in the literature towards methods for effectively addressing these issues [19]. The primary research areas on human elements of construction and project risk management have been centred on three aspects. The first area is concerned with examining inferences and biases. The second area of interest involves exploring and cultivating subjective possibilities. This means examining the potential outcomes and opportunities that may arise from various situations, based on individual perspectives and interpretations. The third area is centred around investigating risk management practices within the construction industry. This entails studying how construction companies identify, assess, and mitigate potential risks that may arise during a project's lifecycle. Despite the complexity of risk analysis, some researchers have attempted to address the challenges associated with applying probabilistic techniques to this field. These efforts aim to refine the accuracy and effectiveness of risk management practices used in construction projects. Such as selecting appropriate probability distributions and creating subjective probabilities, results have been limited. Some approaches, such as Delphi's self-probability deduction and knowledge-based systems utilizing qualitative thinking and knowledge deduction, have been proposed for risk analysis. However, construction professionals have not adopted these methods, as measuring probability is not a common practice in decision-making. Research studies have delved into the various behaviors and decision-making approaches adopted in construction and project risk management. The findings of these studies have revealed that biases and patterns of inference demonstrated by the people in these industries are quite similar to those observed in the general population. Most construction professionals would benefit from a deeper understanding of decision-making processes [37]. Using the sed technique to handle uncertainty can effectively manage risk issues within a project team. However, a study found differences in perception between clients and consultants regarding the method and effectiveness of communication [40]. Despite minor variations due to different forms of nodes, the study revealed that both countries had similar attitudes towards risk. Nonetheless, the researchers expressed concern over the differing perceptions of consultants, which could lead to biased decision-making in project management. The success of a project largely depends on the management approach, including effective group communication and a clear understanding of project objectives. Expertise in project management is crucial for successful risk management, especially for riskier projects [22]. According to a study, checklists were the preferred method for identifying risks, while Monte Carlo simulations were frequently used for risk analysis. It's important to mention that the individuals who responded to the study were predominantly from the defence and management consulting industries in the United Kingdom. This means that the study results may not be fully representative of the construction industry alone [41]. According to a recent survey conducted among seven contractors, all of them classified risks into two categories - "quantifiable" and "non-quantifiable". The contractors either incorporated the estimated costs of these risks into their estimates or added lump sums to the initial cost estimates. This approach allowed them to better account for the potential risks and uncertainties involved in the project [42]. It is quite intriguing that when it comes to making building purchases, only a handful of participants employ structured and calculated methodologies or formal mathematical techniques to mitigate potential risks. This lack of systematic approaches to risk management is a noteworthy observation. Yeet's interviews with six project managers revealed that time mismanagement was a common risk in projects with less than successful outcomes [43]. A set of 85 contractors based in Hong Kong were sent a questionnaire via postal service, which requested them to assess eight different types of construction risks that might lead to project delays [44]. It is not surprising that contractors tend to categorize risks that are beyond their regulatory control, such as inaccurate design information, unfavorable weather conditions, unforeseen ground conditions, delays caused by subcontractors, and insufficient availability of

materials and resources. To enhance the practices of construction risk management, it is crucial to conduct research in the aforementioned areas. Ultimately, risk management techniques are only effective if project participants are knowledgeable and skilled in using them.

Conclusions

A literature review reveals that risk management in construction has primarily relied on quantitative risk analysis techniques. However, recent studies have shown a growing interest in developing risk management systems involving human participation. Most quantitative risk analysis research has focused on managerial and technical risk categories, such as contractual bidding, cost estimation, and construction scheduling. The available research literature has paid limited attention to various risk categories, such as political, economic, financial, cultural, quality assurance, and occupational health and safety. These risk categories are crucial in determining the overall risk profile of an organization or a project, but they have been largely overlooked in the existing body of literature. To better address the evolving global landscape, future research should concentrate on increasing political independence and shifting towards market-based economies. While the literature has provided comprehensive explanations of risk management systems, more research is required to investigate construction risks, including exploring the nature, impact, and response alternatives of risk categories and considering the temporal characteristics of risks. Furthermore, significant research efforts are needed to examine the "people issues" associated with construction risk management, including different risk-related attitudes among project participants, how risk learning occurs, and how interpersonal communication about risk occurs in construction projects, which are multi-structured temporary organizations.

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