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Relationship Between Cost, Schedule Overruns, and Project Success in the Nuclear Construction Industry in the United Kingdom

Adesegun Francis Osadare
Walden University

Walden University

College of Management and Technology

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Adesegun Francis Osadare

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Dr. Edgar Jordan, Committee Chairperson, Doctor of Business Administration Faculty

Dr. Natalie Casale, Committee Member, Doctor of Business Administration Faculty

Dr. James Glenn, University Reviewer, Doctor of Business Administration Faculty

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Sue Subocz, Ph.D.

Walden University
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Adesegun Francis Osadare

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Abstract

Failure to achieve project success due to cost and schedule overruns may negatively affect an organization's financial strength, profitability, and competitive advantage. Organizational leaders must constantly monitor and control projects throughout the life cycle to reduce the impact of cost and schedule overruns and ensure project success. Grounded in the triple constraint model, the purpose of this quantitative correlational study was to examine the relationship between cost, schedule overruns, and project success. Data were collected from 66 project managers, project directors, project control, delivery integration managers, and construction project planners. The multiple linear regression analysis results were significant, F (2,63) = 19.002, $p < .05$, $R^2 = .38$. Schedule overruns provided the only statistically significant contribution to the model (β =.462, p = .002). A key recommendation is for organizational leaders to implement strategic trade-off plans by prioritizing project schedules over cost to improve project success, profitability, and competitive advantage. The implication for positive social change included the potential to empower the local community by creating jobs.

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Dedication

I dedicate this doctoral study to my family, who have always motivated and supported me to achieve my goals. I would never have completed this journey without the values and resolute work ethics instilled in me by my late father, Engr Lucas Adeboye Osadare and my loving mother, Mrs. Julianah Adenike Osadare. I am forever indebted to my loving wife for her unwavering support, endurance, devotion, and the sacrifices she made to ensure my success and completion of my dream of becoming a doctor. Thank you, sweetheart, and God bless! I further dedicate this doctoral study to my sons, Anthony, Alexander, and Andrew. I know I have denied you some playing time because of my study. But, I hope you can learn from me that the sky is no longer the limit; people are going to the moon!

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Section 1: Foundation of the Study

With the growing concerns around the adverse effects of global warming, most countries are shifting toward affordable and eco-friendly sources of energy (Bayulgen & Benegal, 2019). The United Kingdom has identified nuclear power as a reliable source of energy to help the nation achieve a four-fold increase in the generation of environmentally friendly energy (Cox, 2018). Currently, the United Kingdom depends on nuclear power to meet approximately 16% of its electricity demands (Kirikkaleli et al., 2021). With the continued reliance on nuclear power, the country's existing fleet of nuclear reactors will soon reach the end of its operating life (Johnstone & Stirling, 2020). The government has embarked on constructing eight new nuclear power plants to meet the expected demand for clean energy by 2050 (United Kingdom Department of Business and Industry, 2022). The implementation of these projects could be on hold because of schedule and cost overruns. The delayed implementation of these projects has adverse economic effects (Tshidavhu & Khatleli, 2020). For this reason, it is plausible to examine the relationship between cost, schedule overruns, and project success in the nuclear construction industry in the United Kingdom.

Background of the Problem

Energy is considered a key driver of economic growth. The findings of a study conducted by Ntanos et al. (2018) to determine the role of energy in promoting economic development indicated that the scarcity of energy imposed strong constraints on economic growth. Also, the findings indicated that the growth of the gross domestic product was significantly and positively related to the availability of energy. The findings of this study are consistent with the results of a study undertaken by Zafar et al. (2019) to determine the role of energy in economic development. Zafar et al. (2019) found a positive link between the availability of cheap energy and economic growth, especially in industries such as manufacturing and construction. These findings allude to the importance of investing in reliable and affordable energy.

Globally, nations have started to invest in renewable and eco-friendly energy sources such as solar energy, hydroelectric energy, and nuclear energy (Cox, 2018). The implementation of these projects continues to be delayed by schedule and cost overruns, which present two of the main project management concerns in a project life cycle. For example, in the United Kingdom, energy-related projects record approximately 30% delays and 70–80% cost overruns (Wealer et al., 2019). Since most of these projects are cost-intensive, the delays and the cost overruns translate into a significant economic loss (Tshidavhu & Khatleli, 2020).

Problem Statement

Construction organizations often experience project failure due to cost and schedule overruns (Johnson & Babu, 2018). The cost overruns have been as high as 69.78%, and schedule overruns have been as high as 65.4% for power generation projects (Callegari et al., 2018). Ma and Fu (2020) concluded that schedule and cost overruns lead to a low project success rate, which impacts the ambitions of a construction company. The general business problem is that project failure weakens organizational financial strength, profitability, and competitive advantage. The specific business problem is that some construction project managers do not understand the relationship between cost, schedule overruns, and project success.

Purpose Statement

The purpose of this quantitative correlational study was to examine the relationship between cost, schedule overruns, and project success. Cost and schedule overruns were the independent variables for this study, and project success was the dependent variable. The target population was nuclear construction project managers in the United Kingdom who had successfully adapted processes for projects to reduce cost and schedule overruns, thereby improving project success. The implication for positive social change included the socio-economic benefits from the savings on timely project delivery for an education program to motivate young people to develop their skills in science, technology, engineering, and mathematics that could be helpful during the construction of Hinkley Point C (HPC) power station, and its future operations.

Nature of the Study

Researchers use a quantitative method to examine the relationship between cost, schedule overruns, and project success. According to Yin (2018), three research methods are at the disposal of a researcher: (a) qualitative, (b) quantitative, and (c) mixed methods. A quantitative method was appropriate for this study as it addresses the relationship between independent and dependent variables (Yin, 2018). The quantitative methodology necessitated numerical and statistical analysis to gather information to examine the relationship between cost overruns, schedule overruns, and project success. The quantitative method allows researchers to test hypotheses in which the empirical results variable fluctuates among study participants (Yin, 2018). A qualitative research method would be exploratory that researchers use to understand individual motivations and opinions (Houghton et al., 2013; McCusker & Gunaydin, 2014; Seitz, 2015). The qualitative methodology addresses participants' lived experiences and not the interpretation of the results from mathematical testing (Yin, 2018). A mixed-method study comprises qualitative and quantitative studies in the same research (Alavi et al., 2018). This study did not explore an individual's perception of an event or phenomenon or collect qualitative data. Therefore, qualitative or mixed methods were not suitable for this study.

According to Saunders et al. (2019), researchers could use various quantitative research designs, such as descriptive, experimental, correlational, or quasi-experimental. Correlational design was appropriate for this study because it helped to show the relationship between independent and dependent variables. Saunders et al. (2019) found that researchers used a descriptive design to examine a phenomenon's trend, sequence, or frequency. Similarly, researchers used an experimental design to determine an independent variable's causal effect over the dependent variable. Alternatively, researchers used a quasi-experimental design to decide the cause and effect between variables (Pattison et al., 2019). Because the objective was to examine the relationship between variables and not the sequence or cause-and-effect relationship, a correlational design was appropriate

Research Question

What is the relationship between cost, schedule overruns, and project success?

Hypotheses

Null Hypothesis (H_0): There is no statistically significant relationship between cost, schedule overruns, and project success.

Alternative Hypothesis (H_1): There is a statistically significant relationship between cost, schedule overruns, and project success.

Theoretical Framework

The theoretical framework relevant for this study was the triple constraint model, sometimes referred to as the iron triangle or project management triangle. Barnes (1988, 2007) developed the triple constraint of time, cost, and quality in 1969 as a catalyst to control project outcomes by managing and integrating time, money, and delivery. A change to any element of the iron triangle will trigger a resultant in the other two (Duarte et al., 2019; van Wyngaard et al., 2011). Projects are constrained based on cost, time, and quality requirements (Schwalbe, 2008). Pollack et al. (2018) affirmed that the project management triangle's quality, cost, and time variables are critical project success factors. The iron triangle helps the project manager manipulate variables in the projects that are flexible to allow for the constraint variable. As it applies to project quality improvement, the triple constraint could help guide the project manager with decision-making on project priorities and measure project success. The iron triangle served as the lens for project success. The independent variables of this study were two of the iron triangle constraints, cost and time.

Operational Definitions

The following are definitions of relevant terms used in the study:

Cost Overrun: Cost overruns are also known as budget overruns or cost increases and refer to the costs incurred over the budgeted project amount resulting from underestimating actual cost during the budgeting process (Vu et al., 2020).

Cost Performance Index: The cost performance index refers to a criterion for determining the success of construction projects (Johnson & Babu, 2018). It measures the project's financial effectiveness and efficiency, representing the amount of work completed for each unit of spent cost.

Mega Project: According to Laine et al. (2020), a mega project is one with intensive cost and time taking several years to complete, a minimum cost of 1 billion USD, and involves multiple stakeholders from both private and public sectors.

Project Complexity: Project complexity measures interfaces and elements or a comparative appraisal of the difficulty an entity has previously attained (Obeidat & Aldulaimi, 2016).

Project Control: Project controls are procedures for collecting and evaluating project information to keep schedules and costs consistent with projections (Laine et al., 2020).

Project Scope: In project management, scope involves the determination and documentation of project goals, features, deliverables, tasks, and functions, as well as deadlines and the ultimate cost of each task and deliverables (Johnson & Babu, 2018).

Project Success: Project success means meeting cost, schedule, and performance projections (Obeidat & Aldulaimi, 2016). It also means a project has not experienced schedule and cost overruns, has met health and safety requirements, and has met stakeholder success criteria such as time, cost, customer satisfaction, and profitability.

Schedule Overrun: Schedule overruns refer to delays in completing the project beyond the specified time due to changes in orders and project design, financial problems such as late payments for ongoing and completed work, and organizational changes (Vu et al., 2020). Schedule overruns are measured by the amount of time taken against time allocated to project completion.

Assumptions, Limitations, and Delimitations

Assumptions

Every study contains assumptions related to research methodology and design. Assumptions are facts researchers assert to be correct with a caveat that the assumptions need to be verified (Browning, 2018). The researcher assumed all participants would be available when needed to fill out questionnaires, and they would cooperate during data collection. Another assumption was that all participants would accurately respond to the survey questions and have all the necessary information for the study. The respondents were assumed to be accessible by the researcher within the study period to provide the needed information. The study sample represented the study population, and all participants consisted of experts involved in nuclear construction projects. I assumed that the quantitative option was best suited for this study.

Limitations

The intended study presented limitations. Limitations are possible shortcomings for which the researcher has control (Yin, 2018). A significant limitation in completing this research included the COVID-19 social distancing restrictions. It was not possible to have direct contact between the researcher and the participants. The researcher used online platforms such as email, LinkedIn, Zoom video calls, and Skype for Business to contact the respondents and administer questionnaires. Secondly, some participants could be reluctant to provide information to the researcher, thus adversely affecting the study's credibility (Yin, 2018). Given the limited number of nuclear projects, the researcher could have had challenges finding an adequate sample size needed for the study. Some prospective participants declined the request to participate in the study due to their busy schedules. This limitation required the recruitment of many project managers to ensure the minimum sample size was adequate. Using a G*power calculation helped determine an adequate sample size for data saturation.

Delimitations

Delimitations identify the study's threshold and highlight what the study did not cover (Gliner et al., 2016). The scope of this study was delimited to project managers involved in the construction of nuclear plants as the population of interest. Thus, project managers not involved in these projects did not meet the criteria for participation in this study. Although there was adequate literature on project implementation, few studies on critical success factors for nuclear construction projects were available (Subramani et al., 2014).

The research focused on cost and schedule overruns as independent variables and how they impact the success of nuclear projects as the dependent variable. Other factors not connected to schedule and cost overruns were outside the scope of this research. A correlational design and quantitative method were applied to determine the statistical relationships between variables of interest. The method and design were relevant in this study to gain objective results necessary to improve project success. The quantitative method allowed researchers to test hypotheses in which the empirical results variable fluctuates among study participants (Yin, 2018). Thus, other methods and research designs were not relevant for the current study. Finally, the study used structured survey questionnaires as data collection instruments to collect quantitative data and information needed to answer research questions and test research hypotheses.

Significance of the Study

The results of this study may benefit the construction industry by helping project managers understand how successful project cost and time management impact success. Construction project management teams focus on cost, time, and meeting client requirements to improve project success (Ghazal & Hammad, 2020). According to Alvarenga et al. (2019), cost, schedule, quality, and project manager decisions affect the organization's financial results and profits. Project success is dependent on the project manager's ability to control and balance project costs and schedules (Abdulla & Al-Hashimi, 2019; Daniel & Daniel, 2018). Project managers need to understand the relationship between cost, schedule overruns, and project success.

Contribution to Business Practice

Unlike other industries, innovation in the nuclear construction industry may result in lowered cost of energy (Berthélemy & Escobar Rangel, 2015). Globally, organizations in the construction industry have completed more than 500 nuclear power plant projects (Invernizzi et al., 2020). According to Portugal-Pereira et al. (2018), there is a need to construct more clean power plants worldwide. This study about the relationship between cost, schedule overruns, and project success in the nuclear industry could benchmark stakeholders, customer satisfaction, and profitability.

The expectation of crude oil price increase and projected improvement in the global economic growth could improve the nuclear power plants' construction time, which tends to improve a country's gross domestic product (Csereklyei et al., 2016). The need for the additional per capita income associated with successful projects necessitates timely, safer, and more cost-effective nuclear power plant construction (Morales Pedraza, 2017). Previous researchers have not examined the relationship between cost overruns, schedule overruns, and project success in the nuclear construction industry (Johnson & Babu, 2018; Moon et al., 2020; Plummer Braeckman et al., 2019). Nuclear construction characteristics include several uncertainties and challenges due to lack of standardization and skilled labour, design delays, safety hazards, project management experience, and poor project processes (Eash-Gates et al., 2020; Sovacool et al., 2014). The challenges come with high profitability for the construction organization (Portugal-Pereira et al., 2018).

Project managers can improve project success probability by managing construction project costs and schedules (Daniel & Daniel, 2018). Some project managers do not understand the relationship between cost, schedule overruns, and project success. According to Park et al. (2005), cost, schedule, quality, and project manager decisions affect the organization's financial results and profits. The findings of this study could help project managers understand cost and time management importance in nuclear construction projects and their implications for organization profitability.

Implications for Social Change

Nuclear construction projects contribute to economic growth worldwide (Nurdiana & Susanti, 2020; Wu & Lin, 2019). Nuclear power plant construction can be complex and risky. When successful, the outcomes are generally profitable (Portugal-Pereira et al., 2018; Wang et al., 2020a). The implication for positive social change included the potential of transferring the lessons learned on the HPC project to future power plant projects, which improves project process, profitability, and competitive advantage, while reducing complexity, scheduling, and cost overruns. The profits realized from completing the project in line with the baseline could facilitate education and healthcare programs for the local communities. Project cost reduction because of on-time project delivery implies a cheaper power production, which translates to a lower power cost and stable economic footing for 6 million homes in the United Kingdom population (Daniel & Daniel, 2019).

The successful completion of the HPC power plant could increase the employment opportunity and improve the project environment's social cohesion by contributing to cultural and recreational facilities and financing from the profit made on projects. The HPC power plant management's corporate social responsibilities duties could improve the community's quality of life due to growing and developing amenities, improving employee livelihood, increasing employee remuneration, and reducing poverty (Pogge, 2017). Organizations conforming to the strict health and safety culture of nuclear construction could mean the firms are fulfilling their ethical and corporate social responsibilities (Simončič, 2019; Soda et al., 2016).

A Review of the Professional and Academic Literature

The purpose of this quantitative correlational study was to examine the relationship between cost and schedule overruns and project success. Cost and schedule overruns were the independent variables for this study. Project success was the dependent variable. The target population was construction project managers in the nuclear construction industry in the United Kingdom who have successfully adopted project controls to reduce cost and schedule overruns, thereby improving project success. The null hypothesis of this study was as follows: there is no statistically significant relationship between project control, cost overruns, schedule overruns, and project success. The alternative hypothesis of this study was as follows: there is a statistically significant relationship between project control, cost overruns, schedule overruns, and project success.

In this section, the researcher reviewed the literature on the triple constraint theory, which was the theoretical framework for this study. The tenet of the triple constraint was that a project's productivity, efficiency, and success are measures based on cost, time, and quality performance (Kabirifar & Mojtahedi, 2019). A variation in the project cost or schedule could imply a change to the scope, control requirements, and quality of the project (Pollack et al., 2018). Previous studies on project controls, cost overruns, schedule overruns, and project success were a part of the preliminary data search. In previous studies, scholars agreed on the positive impacts of successful projects, but there was less agreement regarding the relationship between project controls, project cost overruns, project schedule, and project success. This literature review consists of ten sections: (a) the purpose of the study, (b) Barnes' iron triangle, (c) critique of Barnes' iron triangle, (d) project cost overruns, (e) project schedule overruns, (f) cost overruns and schedule overruns, (g) project control, (h) readiness in project control, (i) earned value management (EVM) and Gantt chart, (j) project success, and (k) nuclear construction projects. The effects of design, poor communication, and project complexity on cost overruns were discussed as subcategories of project cost overruns. The effects of weather, design changes, and funding were discussed as subcategories of project schedule overruns.

I searched for relevant literature on the following electronic databases: Walden University Library, ProQuest Library, SAGE Journals, Science Direct Journals, IEEE Xplore Journals, Emerald Insight Journals, Business Source Complete Journals, and Google Scholar. The primary search criteria were relevant peer-reviewed articles published within the last five years. The search keywords and associated Boolean parameters were (a) *project failure*, (b) *project success,* (c) *project controls,* (d) *project estimation,* (e) *project cost overruns,* (f) *project schedule overruns,* (g) *critical success factors,* (h) *triple constraint,* (i) *iron triangle,* (j) *project management triangle,* (k) *project schedule,* (l) *project duration*, (m) *earned value analysis,* (n) *project risk,* (o) *project uncertainties*, (p) *project manager,* (q) *key performance indicators,* and (r) *project changes.* Table 1 summarises the statistical sources used for this study.

Table 1

Summary Statistics for Research Articles Used in This Study

	Frequency	Percentage
Total references used are five years old or less	180	68%
Total references used are peer-reviewed	251	95%
References used in the literature review	123	46%
Total references	265	100%

Barnes' Iron Triangle Model

The iron triangle is also known as the project management triangle or the triple constraint (Pollack et al., 2018). Project managers use the iron triangle to measure the project success because it helps to measure whether the project team completed within the agreed time, budget, and quality standard. The project team uses the iron triangle to communicate the expected cost and time (Zid et al., 2020). The triangle depicts the project success criteria on the vertices, and any movement on one criterion can put pressure on the two other criteria. Albert et al. (2017) affirmed that Barnes' iron triangle model is one of the most common approaches adopted to measure the success of projects in terms of performance, cost, and time. This triangle contains three interdependent aspects: (a) performance, (b) cost, and (c) time, all of which are determinants of project success (Albert et al., 2017).

Project Success Measurement Evolution

Project success measurement approaches were extended between the 1970s and 1980s and now include a component that considers the satisfaction of different project stakeholders, quality. In the original model, Barnes portrayed the link between quality, time, and cost of construction ventures by drawing a triangle to stress the significance of regulating quality and cost and time (Barnes, 2007). Barnes aimed to illustrate the importance and necessity of assimilating all three components to enhance project control.

After the 1970s project team relied on the iron triangle when working on a complex and uncertain project, resulting in cost and time overruns (Pollack et al., 2018). In the 1980s, there was a focus on the importance of stakeholders' satisfaction (Padalkar & Gopinath, 2016). Project success is dependent on different stakeholders' requirements due to the differences in perception, interest, and power (Sarmiento Barletti et al., 2021). From the mid-1990 onward, project managers prioritized the client's autonomy on controlling the project's cost and time. The project team responds to clients' constraints by working longer hours to deliver the project's benefits (Legault, 2013).

According to Pollack et al. (2018), the iron triangle, commonly referred to as the triple constraint, is a significant notion in project control. The iron triangle represents the connection between primary project performance principles. Pollack et al. (2018) identified substantial correlations between quality, cost, and time through a comprehensive literature review. From these findings, it is plausible to affirm that these three factors should form the apexes of the iron triangle. In Pollack et al.'s study, the links between project quality, cost, and time were stronger than the connection between other elements such as requirements, performance, and scope. The findings, therefore, affirmed that quality, cost, and time are the essential factors that determine whether a project is a success or a failure. Ryan et al. (2021) rejected the principles of the iron triangle and recommended an alternative, effective measurement of the success of a project. After studying the effectiveness of various approaches to project control, Ryan et al. recommended that all approaches employed to assess project success consider short-term metrics such as period, specified need targets, and meeting price to comprise a broad range of indicators. These indicators include lessons learned, methodological concerns, team performance, process effectiveness and specification, stakeholder opinions, risk administration, and the realization of benefits.

Resource-Based Theory and Resource Dependence Theory

The resource-based theory and resource dependence theory (RDT) are relevant to project success. Both theories serve as a lens for understanding the relationship between cost, schedule overruns, and project success. The resource dependency theory helps to understand the relationship and the dependence of an organization on external cost and its impact on the project schedule (Wang et al., 2020b). The cost and schedule impacts are primarily raw material, inter-organization, and personnel costs. Organizations that can manage the external cost of the project can improve project success and competitive advantage (Wang et al., 2020b). Sherer et al. (2019) argued that an organization needs to understand and manage the sources of external resources and project duration to improve its competitive advantage. There is a relationship between cost, schedule overrun, and project success, which differs from one project to another. The resource dependency theory is not appropriate for this study because it focuses more on an external factor to the organization.

The RDT focuses on an organization's valuable resources to improve project profitability and success (Gupta et al., 2018). The resources can be in the form of labour or material. The cost of these resources fluctuates, leading to cost overruns, while the delay in the availability of these resources can lead to schedule overruns. Ng and Khodakarami (2021) argued that a strong relationship exists between organizational project success and the availability of essential resources. The RDT focuses more on the organization’s resources; it is not appropriate for this study.

Critique of Barnes' Iron Triangle

As noted previously, Pollack et al. (2018) found that the traditional vertices of the triple constraint of time, cost, and quality are significantly stronger measures than alternatives such as requirements, performance, and scope. Project managers consider adopting the triple constraint model when working on complex and expensive projects characterized by uncertainty (Krystallis et al., 2020). According to Armenia et al. (2019) and Tam et al. (2020), the traditional measurement of project success using cost, time, and quality adherence only worked in the 1970s because project management teams focused solely on project management success and the adoption of project management tools and techniques.

Project Measurement Criteria Recommendation

Modern-day project management should consider the iron triangle elements, project management team communication, stakeholders’ perceptions, and project team soft skills (Tam et al., 2020). According to Pollack et al. (2018), the schedule is the most significant element for the project management team, followed by cost, then quality at the start of a project. As the project team realizes deliverables, cost becomes more important, followed by the schedule, then quality. Upon project completion, the cost and schedule are no longer as important to the project management team as the quality of the product. Relying on the iron triangle components, such as on-time project delivery, cost adherence, and target quality, could create a false picture for project managers due to its oversimplification (van Wyngaard et al., 2012).

Boge et al. (2021) proposed that the use of the iron triangle helped to measure short-term success only because it cannot be used to measure long-term success factors such as project benefit realization. Badewi (2016) concluded that organizational effectiveness and creativity could be impacted if the project team is over-reliant on the triple constraint. Ahmadabadi and Heravi (2019) asserted that the iron triangle's components are superficial because project cost and time are not always accurately estimated, and project success is simply a phenomenon. Heravi asserted that a new set of project success criteria are needed to evaluate true project success. Gardiner and Stewart (2000) conducted a study to determine the percentage of projects with errors in estimations. Gardiner and Stewart found that over 70% of projects experience schedule cost overruns and that the initial estimate of cost and time is not enough to evaluate project success.

Fourth Element

One controversial issue relates to the three elements of the iron triangle: (a) time, (b) cost, and (c) quality. Badewi (2016) and Pollack et al. (2018) argued that the two most important elements of the iron triangle were cost and schedule. In contrast, researchers such as van

Wyngaard et al. (2013) contended that quality should be replaced with scope as a triple constraint. Pinto (2010) maintained that the third criterion of the triple constraint should be replaced with performance criteria, while Armenia et al. (2019) argued for replacing the third criterion to meet requirements. According to Ahmadabadi and Heravi (2019), the iron triangle should be transformed into an iron square by adding a fourth element, such as information system, or stakeholders' benefits. Pollack et al. affirmed that the fourth element that should be added is scope. Williams et al. (2015) concluded that client-relationship issues and customer satisfaction should be added to the iron triangle. Project success is thus characterized by many different criteria, with the iron triangle as the foundation.

Project Cost Overruns

Vu et al. (2020) defined project cost overruns as the excess of actual expenses over the approved budget. One of the critical criteria for an effectively completed project is accomplished within the contractually stipulated cost. Cost overruns in the construction sector are a significant issue for all stakeholders (Abusafiya & Suliman, 2017). International researchers and policymakers strive to determine the causes of project cost overruns (Durdyev, 2021; Herrera et al., 2020). For instance, Herrera et al. (2020) conducted a methodical assessment of stakeholders' views on the construction sector to determine the factors responsible for cost overruns in road construction. The findings indicated that cost overruns resulted from five key factors: (a) constant design modifications, (b) project scope alterations, (c) poor project planning, (d) changes in the price of building materials, and (e) failures in design (Herrera et al., 2020). The findings are consistent with the outcomes of a study conducted by Durdyev (2021) to explore the factors constraining on-site effectiveness in the construction sector. Durdyev and Herrera findings indicated that the most common causes of cost overruns in the construction sector were: (a) site conditions, (b) contract management concerns, (c) price fluctuations, (d) poor financial management, (e) competence and experience, (f) stakeholder's skills, (g) poor communication, (h) climatic conditions, (i) poor planning, (j) incorrect estimations, (k) incomplete designs, and (l) design problems (Durdyev, 2021). Based on these findings, the researchers concluded that cost overruns originate from various sources, particularly those connected to the project owner.

Because construction projects often experience cost overruns, project teams need to understand the causes of the overruns to deliver projects within the agreed cost. For instance, Subramani et al. (2014) undertook a study to determine the key causes of cost overruns in construction projects in the Indian building sector. The researchers examined the views of construction contractors and supervisors through a questionnaire survey and a desk study. The results indicated that the causes of project cost overruns in the construction sector included (a) long periods between design and the time of rendering or bidding, (b) an erroneous estimation approach, (c) challenges in land procurement, (d) rework because of faults, (e) interruption in delivering design, (f) poor design, (g) poor contract regulation, (h) increase in machine/material prices, (i) sub-standard plan management, and (j) slow decision making (Subramani et al., 2014). The findings are consistent with the results of studies conducted by Durdyev (2021) and Herrera et al. (2020). Based on these outcomes, Subramani et al. concluded that cost overruns in construction projects result from a combination of various factors.

Cost management performance has a significant influence on the overall success of a project (Abusafiya & Suliman, 2017). It is, therefore, a fundamental criterion for determining the success of construction projects (Johnson & Babu, 2018). Abusafiya and Suliman undertook a study to determine the key causes of cost overruns in the Bahraini construction industry and appraised the impact of the causes on overall project success. The researchers employed various research methodologies to collect the data, including expert opinions, historical building project records, and an extensive literature review. The study findings identified 45 broad causes of cost overruns in construction projects, including changes in project scope, poor project management practices, inadequate planning and scheduling, and fluctuations in the cost of construction materials.

Abusafiya and Suliman (2017) concluded that the most substantial causes of cost overruns in the construction industry included schedule delays, errors during building, and constant design alterations. The study findings conflicted with those of other studies. For instance, based on information from the Ghanaian construction sector, Asiedu and Ameyaw (2020) empirically tested a conceptual structure dynamics model to determine construction cost overruns in third-world countries. The findings indicated that the main causes of cost overruns in Ghana were limited construction management, knowledge of change orders, and poor contract planning and supervision. In Nigeria, Egila et al. (2020) conducted an in-depth literature review to identify the causes of project cost overruns; the result of the Relative Importance Index indicated that material and project delivery methods were the main causes of cost overruns.

Design and Cost Overruns

Project design changes predict cost overruns (Aslam et al., 2019; Yap et al., 2019). Aslam et al. (2019) explored the influence of design alterations on project cost and the actions that led to these modifications. The researchers conducted an extensive literature review of past studies. The findings indicated that design modification was a key cause of cost overruns. At times, changes in design could increase the cost overruns to between 5% and 40% of the overall project cost (Aslam et al., 2019; Gharaibeh et al., 2020). The findings affirmed that design modification, which is a key cause of cost overruns, is related to clients' needs to alter the project scope.

By contrast, technical advice from contractors and consultants resulted in minimal design modifications (Aslam et al., 2019). Yap et al. (2019) found that factors leading to cost overruns included unanticipated site conditions, errors in design documents, addition or omission of scope, alterations of specification or project requirements, and lack of coordination among professional consultants working on a project. Yap et al. concluded that design changes have a significant impact on cost overruns.

Design changes are considered primary contributors to the disruption of cost and time performance in building projects (Liu et al., 2017; Muhamad & Mohammad, 2018). Liu et al. (2017) interviewed five knowledgeable construction professionals to determine the design risk factors of design-built projects and the impact on project success. The findings indicated the causes of design changes leading to project cost overruns included (a) incorrect design project, (b) risk of delay or inaccuracy of third-party details, (c) risk of inadequate experience among designers, (d) risk of lack of responsibility among designers, and (e) risk of an inappropriate design team (Liu et al., 2017). Such risks adversely impacted project costs and delivery periods. The results were similar to a study conducted by Muhamad and Mohammad (2018) to explore the effects of design modifications in building projects. The researchers demonstrated that design changes were primary contributors to the disruption of cost and time performance in building projects. The researchers concluded that design modifications are significant cost and schedule performance inhibitors in construction projects. Design changes affect the project cost, time, and quality. A change in the design of a project may add more duration to the project and increase the cost because more resources result in more cost.

Poor Communication and Cost Overruns

Evidence from the available literature suggests poor communication is one of the factors leading to cost and schedule overruns in construction projects (Gamil et al., 2019; Othman et al., 2018). For instance, Gamil et al. (2019) conducted a correlational study to investigate the impact of poor communication on schedule and cost overruns in the construction sector. The researchers achieved the goal by eliciting information from different stakeholders in the construction industry in developed nations. The results indicated that developed nations had adopted advanced communication systems and information communication technology, which substantially reduced the severity of cost and schedule overruns. The findings also suggested that poor communication had a considerable impact on schedule and cost overruns in the construction sector (Gamil et al., 2019).

Othman et al. (2018) extended this work by evaluating the causes of poor communication on cost and schedule overruns. The study findings showed that poor communication in construction projects occurred because construction stakeholders came from diverse professions and varied in values, cultures, skills, and objectives (Othman et al., 2018). Poor communication thus resulted from language barriers or a lack of respect for diversity (Othman et al., 2018). The researchers concluded that poor communication among stakeholders in the construction sector contributed strongly to cost and schedule overruns.

Project Complexity and Cost Overruns

Project complexity is the measurement of project interfaces or a comparative appraisal of difficulty to what a construction firm has previously attained (Dao et al., 2020). Researchers suggested that different types of complexities linked with diverse kinds and sizes of projects have substantial effects on project cost overruns (Bohórquez-Castellanos & Mejía, 2019; Ma & Fu, 2020). For instance, Ma and Fu (2020) evaluated the effect of project complexity on the success of mega construction projects for project administration. The researchers defined a megaproject as a time-intensive undertaking that takes several years to complete, costs a minimum of $1 billion, and involves multiple private and public stakeholders. The researchers interviewed and scored 21 complexity cases concerning five project complexities and five components of project success. The outcomes indicated high organizational complications resulted in critical schedule delays in mega-building initiatives (Ma & Fu, 2020). The findings were consistent with the outcomes of research conducted by Bohórquez-Castellanos and Mejía (2019) to explore the association between cost overruns and complexity in engineering developments. The researchers concluded that the highly complex projects resulted in greater cost overruns while projects with low complexities exhibited relatively low-cost overruns. The researchers concluded that the mechanisms of project difficulty affecting the success of large building projects could assist project administrators in comprehending and evaluating the complexity of large building initiatives and correctly estimating their adverse effects.

Past literature has indicated that the type and nature of a project are predictors of cost overruns (Nguyen et al., 2019). For instance, Locatelli et al. (2014) undertook a study to determine the correlation between different characteristics of megaprojects. The researchers focused on various megaprojects, including cultural events, construction projects, and power plants. The findings indicated that for complex megaprojects, especially nuclear power plants, cost overruns positively and significantly correlated with delays by relevant authorities (Locatelli et al., 2014). To affirm this, Locatelli et al. referred to the case of the Moorburg power plant project. In this project, concerns over ecological requirements, particularly the discharge of warm water into the local river, led to massive conversations and disagreements in German politics that delayed the project's approval (Locatelli et al., 2014).

In another study conducted to determine the causes of project overruns in megaprojects, Nguyen et al. (2019) evaluated the correlation between the complexity of construction projects, project performance, and resource apportionment. The findings highlighted a significant and positive correlation between project complexity and schedule overruns but no significant association between project complexity and cost overruns. There was also a positive relationship between resource allocation and schedule overruns, but no significant link between resource allocation and cost overruns. Resource allocation exhibited a buffering impact as increasing resources decreased the influence of project complexity on schedule overrun. Nguyen et al. concluded that highly complex projects might correlate with more cost overruns than less complex projects. Project dynamism and complexity can affect project duration because it involves different scope changes and valuable resources. The project management team needs to manage projects in phases to manage the project complexity. Project complexity influences the management approaches, and the project team should select an appropriate process and procedures to deliver complex projects. The project management team could use the iron triangle elements to control the project cost and time.

Project Schedule Overruns

A project schedule overrun refers to the late delivery or accomplishment from the agreed-upon period specified by all stakeholders in an initiative (Mukuka et al., 2015). The primary role of project scheduling is to achieve the project objectives within a stipulated period (Choi et al., 2016). The existing literature revealed that different factors account for project schedule overruns and require critical attention to ensure the project lifecycle is fully implemented (Memon et al., 2011; Rachid et al., 2018; Sanni-Anibire et al., 2020). For instance, Memon et al. (2011) explored the factors responsible for time overruns in construction projects. The researchers conducted a statistical analysis of data gathered from 30 construction projects facing time overruns challenges to determine the causes of a mean rank of time overrun. The findings indicated that the main causes of project schedule overruns included inefficient scheduling and planning, inadequate site operations, insufficient contractor experience, inadequate site control by contractors, and monetary and cash flows experienced by contractors (Memon et al., 2011). The findings were consistent with the outcomes of a study conducted by Sanni-Anibire et al. (2020) to explore the causes of schedule overruns in the construction sector. The outcomes of the study indicated that the main causes of project schedule overruns included inadequate planning of resources, incorrect completion projection, poor site administration and coordination between different stakeholders, delays in the approval of accomplished work, and monetary problems among contractors. Sanni-Anibire et al. concluded that most project schedule overruns might result from factors related to the contractors.

Researchers have revealed the effects of schedule overruns on the performance of construction projects (Chen et al., 2019; Choi et al., 2016). For instance, Mukuka et al. (2015)

explored the impacts of construction project schedule overruns. The researchers surveyed 200 construction stakeholders, including project managers, construction administrators, civil engineers, quantity surveyors, and architects. A statistical analysis of the data by researchers revealed that delayed customer compensation, reputation interaction with the contracting team, accelerated losses, poor work quality, disputes, loss of profit, cost overruns, and extension of project completion were the key effects of schedule overruns in construction projects (Mukuka et al., 2015). The findings were consistent with Chen et al.'s (2019) study to evaluate the causes and effects of grain bin projects in China. The findings demonstrated that schedule overruns resulted in challenges with subcontractors, cost overruns, and project failure. Chen et al. (2019) concluded that schedule overruns are undesirable for construction projects.

Similar difficulties related to diverse project types and sizes also considerably impacted project schedule overruns (Gbahabo & Ajuwon, 2017; Ma & Fu, 2020). For example, Ma and Fu (2020) evaluated the effect of project complexity on the success of mega construction projects for project administration. The findings demonstrated that high organizational difficulty or a blend of goal complexity and environmental factors resulted in critical project schedule overruns, particularly in megaprojects. Ma and Fu affirmed that project schedule overruns and cost overruns might be significant and widespread challenges in construction ventures. The results were consistent with Gbahabo and Ajuwon's (2017) study, which provided insights into the economic effect of project cost overruns and schedule delays. The findings identified project collapse, contractual disagreements, further delays, and complete abandonment of a project as the primary sources of schedule delays and cost overruns. Gbahabo and Ajuwon also found that the causes of cost overruns had detrimental economic impacts that adversely affected construction industry revenue. The researchers concluded that complexities in projects lead to schedule overruns. While most researchers have investigated the overall causes of project schedule overruns, some have focused more precisely on distinct reasons.

Weather and Schedule Overrun

Inclement weather is synonymous with project delays. According to researchers, weather is one of the most significant causes of project schedule overruns (Ballesteros-Pérez et al., 2018; Mentis, 2015). For instance, Ballesteros-Pérez et al. (2018) conducted a case study to determine the impact of weather on the completion dates of construction projects in the United Kingdom. The outcomes revealed that the United Kingdom climate extends construction project periods by an average of 21% (Ballesteros-Pérez et al., 2018). The findings were consistent with those of Gunduz & Maki (2018) to explore whether climate impacted project costs and completion dates. The findings indicated that undesirable weather negatively influenced construction projects' cost and completion periods because it reduced labour productivity and led to a work stoppage, resulting in schedule overruns (Gunduz & Maki, 2018). The researchers concluded that bad weather causes schedule overruns in construction projects.

Some researchers have focused on specific aspects of weather to explore how they affect schedule overruns in construction projects (Durdyev & Ismail, 2016; Santoso & Soeng, 2016). For example, Santoso and Soeng (2016) examined the impact of rain and floods on schedule overruns in the Cambodian construction sector. The researchers conducted a qualitative study to explore the lived experiences of various construction stakeholders. The findings indicated that the two most significant external factors that caused schedule overruns in the Cambodian construction sector were rain and floods. Santoso and Soeng also identified minor factors leading to schedule overruns, such as low labour productivity, late progress compensations, low-quality workforces, unforeseen site conditions and terrain, poor site management, equipment breakdown, and land acquisition. The findings were consistent with Durdyev and Ismail (2016), who found that rain and floods caused schedule overruns and on-site construction productivity losses in Malaysian infrastructure projects. Durdyev and Ismail concluded that unforeseen climatic conditions, specifically rain and floods, slow down work and adversely impact completion time.

Design Changes and Schedule Overrun

The complexity and uncertainties associated with construction projects cause a significant delay when making design changes. Researchers have shown that design flaws resulting in design modifications and reworks are key factors leading to schedule overruns in the construction sector (Han et al., 2013; Johnson & Babu, 2018; Yap et al., 2019). For instance, Han et al. (2013) used a dynamic system model to assess experts' perceptions of the effects of design flaws on building projects in the construction sector. The findings indicated that design faults substantially delayed project completion irrespective of the constant schedule recovery measures taken by project managers (Han et al., 2013). The researchers also found that schedule pressure amplified the adverse impact of design faults on many construction activities directly linked to those flaws. The findings were consistent with Yap et al. (2019), who found that design errors caused by design modifications resulted in schedule overruns in construction projects. The researchers concluded that design errors significantly delay construction work.

Funding and Schedule Overrun

Projects require constant funding to ensure success. Project parties, such as individuals, corporations, and governments, fund projects based on nature, scope, and magnitude (Martin &

Benson, 2021). Financial and other associated factors significantly impact the completion dates of projects (Amri & Marey-Pérez, 2020; Martin & Benson, 2021). For instance, Amri and Marey-Pérez (2020) explored the financial-related causes of construction project delays by evaluating stakeholders.

Financial literacy was the most critical factor leading to schedule overruns, followed by late payment, inadequate monetary resources, and, finally, instability in the financial market (Amri & Marey-Pérez, 2020). Other significant causes of project delays included inflation, problems in acquiring a loan from financiers, the poor business and financial management of clients, and the fluctuating financial background of contractors. The findings were identical to those of Martin and Benson (2021), who evaluated the effect of funding on schedule overruns. The timely compensation of contractors was significant in ensuring continuity of operations and accomplishing infrastructural projects within the stipulated quality, budget, and time (Martin & Benson, 2021). Researchers concluded that adequate financing and funding ensure the timely completion of construction projects.

Cost Overruns and Schedule Overruns

The project team needs to manage the project cost and schedule to ensure the project does not run out of funding before project completion and does not extend beyond the agreed delivery date. Several researchers have focused on cost and schedule overruns rather than studying the two variables separately (Johnson & Babu, 2018; Tshidavhu & Khatleli, 2020). According to Plummer Braeckman et al. (2019), the impact of cost overrun is always higher than schedule overruns. The project team should concentrate more on cost overruns when compared to time overruns.

Causes of Poor Cost and Time Performance

Cost and time measurement is important in evaluating the performance of construction projects. Project complexity makes it difficult to accurately measure performance due to internal and external causes. Johnson and Babu (2018) examined the primary causes of poor cost and time performance in the United Arab Emirates construction sector by employing a concurrent mixed-methods technique to analyze the experiences of experts. The outcomes revealed that the causes of cost and schedule overruns include change orders from customers, incorrect time estimation dates projected by customers, delays in acquiring government approvals and permits, illogical schedules and completion dates estimated by customers, and design variation between the consultant and client (Johnson & Babu, 2018). The results were consistent with those of Tshidavhu and Khatleli (2020), who sought to determine the causes of schedule and cost overruns and the resulting challenges in mega construction projects. They found that the main causes of project schedule and cost overruns comprised multiple factors (e.g., variation orders, poor site management, contractual claims, changes in the scope of work on-site, poor material planning, unforeseen ground conditions, inaccurate material projections, unskilled labour, and poor site administration). The researchers concluded that the causes of both cost and schedule overruns could be categorized into five distinct groups: (a) design modifications, (b) delayed decision making, (c) inaccurate cost estimation, (d) poor procurement procedure, and (e) financial challenges, especially among clients (Tshidavhu & Khatleli, 2020).

Several studies have identified a relationship between cost performance and the construction period (Belay & Torp, 2017; Callegari et al., 2018). For instance, Belay and Torp (2017) determined whether projects with a longer turnaround time exhibit more cost deviation than projects with a short delivery timeline. The researchers employed correlation analyses to examine different-sized public road construction projects with diverse completion periods. The findings indicated no association between longer projects and higher cost overruns (Belay & Torp, 2017). Nonetheless, a few lengthy projects were associated with a moderately higher cost deviation than smaller ventures (Belay & Torp, 2017). The outcomes are consistent with Callegari et al.'s (2018), who estimated the probability distribution function of delays and cost overruns in building power generation projects. The findings suggested that megaprojects, which are more time-consuming, were linked with higher cost overruns than smaller projects (Callegari et al., 2018). Therefore, the researchers concluded that lengthy projects have more cost overruns than shorter ones.

Project Size and Duration

The size of the project is as important as the duration. While Callegari et al. (2018) concluded that the length of projects leads to cost and schedule overruns, Shalwani and Lines (2021) concluded that the size of the project causes cost and schedule overruns. Some researchers have revealed that schedule and cost overruns depend significantly on the size of the project (Heravi & Mohammadian, 2019; Shrestha et al., 2013; Vaardini et al., 2016). For example, Heravi and Mohammadian (2019) explored the performance of small, medium, and large projects regarding the ability to be implemented within the projected time and cost. The researchers evaluated 72 urban building projects by appraising their documents and actual performance in meeting the designed purpose. The findings showed that large urban building initiatives experienced more delays and higher cost overruns than other types of projects. They further determined that new construction projects led to higher cost and time performance than renovation projects (Heravi & Mohammadian, 2019). The results are consistent with those of Shrestha et al. (2013), who found that mega and lengthy projects had substantially more schedule overruns and higher costs than smaller, short-period ventures. Vaardini et al. (2016) found similar outcomes when exploring cost overruns in construction projects. For instance, they found cost overruns occur in most construction projects, and the magnitude of these varies substantially based on the type and size of the project. The researchers, therefore, concluded that project size might significantly influence both cost and schedule overruns. While most scholars have explored the overall causes of project cost overruns, some have focused more precisely on distinct reasons.

Project Control

Project controls are procedures for collecting and evaluating project information to ensure schedules and costs remain on track (Laine et al., 2020). The key functions comprise communicating, controlling, monitoring, planning, and closing out project schedules and costs (Laine et al., 2020). The extant literature shows that generic project management is among the key components of project control and a determinant of project success (Badewi, 2016; Barbalho et al., 2016; Larsson et al., 2018). Badewi (2016) examined the importance of project management on project control through a survey that elicited project managers' perceptions. The findings indicated that project management practices significantly and positively impact project investment success (Badewi, 2016). The findings were consistent with Yap et al.’s (2021) study that identified a positive correlation between project on-time delivery and project management determinations for training and the development of abilities.

Project Management Hard Skills

Project management hard skills play a vital role in project success. Hard skills are the knowledge transferred from the project leader to the employee. Hard skills can be documented, formed, and easily articulated as a basis of the organization's knowledge base (Borrego et al., 2019). According to Ribeiro et al. (2021), organization leaders use cultural adoption to improve project success by transferring hard skills within one organization unit. Larsson et al. (2018) examined the significance of complex project management and team inspiration for process performance in building projects. The findings indicated that hard project management improves the process performance of project teams and is part of project success. Leadership plays a vital role in guiding the project to a successful path. A project leader should understand the qualities of the project team and harness those attributes to deliver the project on time and within the agreed budget. The flexibility and visibility of the project facilitate the implementation of a transformational leadership style to improve project success (Zaman et al., 2019).

Performance Measurement

Construction projects are risky and need appropriate corporate strategies such as project controls. These risks significantly impact projects' quality, time, and cost performance. Charan and Krishnamoorthi (2019) examined the perceptions of construction experts on the role of project control in time and cost overruns. The findings indicated the necessity for enhanced standardization that addresses payment, dispute resolution, and the allotment of risks, functions, roles, fairness, and clarity in construction projects. These factors significantly influence projects' quality, time, and cost performance. Based on Charan and Krishnamoorthi’s (2019) findings, project managers should strive to adopt appropriate risk control and management in the building sector. A lack of objective, dependable, and consistent indicators and measurements of project controls poses significant problems for efficiently determining project performance and progress in the construction sector (Orgut et al., 2020). Project managers often have divergent views concerning project performance and progress until such progress completely fails. The lack of precise controls for measuring project performance and progress is a key concern in the construction sector as it leads to resource shortfalls and performance shortcomings (Orgut et al., 2020). Thus, it is evident that project control measures directly correlate with project success.

Efficient Controls

According to Laine et al. (2020), one significant technique for mitigating project risks is to adopt efficient controls. Project controls include account reviews, budget, schedule, and performance measurement for informal and formal elements. In an in-depth, qualitative study, Laine et al. (2020) found that informal project controls ensure effective project outcomes. The researchers found that project managers primarily employ formal controls on project aspects characterized by unclear and typically associated workforces (Laine et al., 2020). Formal controls dominated the start of a project but became less significant later (Laine et al., 2020). Dubey and Shrivastava (2013) employed a survey research methodology to evaluate the significance of project control methods applied in project administration activities to reduce schedule and cost overruns. The findings suggested that project controls consisted of seven dimensions: (a) risk evaluation and mitigation, (b) resource competency, (c) schedule, (d) monitoring adequacy, (e) highlighting concerns, (f) project health appraisals, and (g) accountability. The researchers concluded that project control is directly and positively related to project success and that project managers employ different measurements to control projects.

Project managers can use the iron triangle model to control project cost and time by monitoring the actual cost and time against the agreed baseline. Understanding the project status throughout the life cycle implies that the project teams control the project and avoid cost and schedule overruns.

Readiness in Project Control

Project control is essential in ensuring project success. Project controls involve managing resources and applying procedures, tools, and techniques throughout the project life cycle to deliver the project to the requirements (Perrier et al., 2018). Hence, project managers need to adopt different project control techniques to ensure that the project finishes on time and within budget. The project management team is expected to monitor the project's performance and implement corrective actions that could help ensure the project achieves the expected benefit (Vanhoucke, 2019).

Readiness-Based Framework

Previous research indicated that readiness is another significant component of the project control process (Grau & Abbaszadegan, 2015; Shenoy & Mahanty, 2021). For instance, Shenoy and Mahanty (2021) developed a mechanism to help stakeholders identify megaprojects likely to experience time overruns challenges. The researchers determined that the readiness-based framework offers stakeholders significant insights into the strengths and weaknesses of megaprojects. The findings suggested that the readiness-based framework enabled stakeholders to prioritize and eradicate the weak points identified and systematically enhance project readiness. Shenoy and Mahanty concluded that one of the approaches to guaranteeing project readiness was adopting effective information systems. In a similar study, Grau and

Abbaszadegan (2015) employed both external and internal information integration and automated analytics as surrogates of real-time controls of projects in terms of cost and schedule for statistical evaluation. The outcomes indicated that a sophisticated level of information assimilation and automated data analytics regulated projects with more dependable information proactively and informed decision making, thereby enhancing performance.

Schedule Mitigation

Based on the existing literature, project controls are significant as they mitigate schedule overruns that are typically extremely expensive and disruptive (Hsu et al., 2020; Silvianita et al., 2015). Hsu et al. (2020) undertook a case study via the Fault Tree Analysis (FTA) tree structure to explore the causes of schedule deviations in construction projects. The findings indicated that the FTA framework offered richer data and a better picture of the network of delay influences than other approaches employed. The FTA model also identified the causal relationship between occasions resulting in unwanted interruptions of a project schedule and understanding their importance in actual building projects (Hsu et al., 2020). The findings were consistent with Silvianita et al.'s (2015) study to evaluate the significance of FTA on project control. The researchers effectively determined the primary causes of project delays as bad project management, production delays, procurement delays, and insufficient project designs. Silvianita et al. concluded that the FTA is an effective project control tool for tracking the sources of cost and schedule overruns.

Earned Value Management (EVM) and Gantt Chart

Other project control techniques recommended by project management experts for appropriate project scheduling include the earned value management (EVM), Gantt chart (Khesal et al., 2019; Nizam & Elshannaway, 2019), critical path method (CPM), and project evaluation review technique (PERT; Kim, 2020). CPM helps the project team identify the activities required for the whole project to finish. The CPM reveals the longest time to complete the project. The PERT is another method the project team uses to schedule and coordinate all project activities throughout the project life cycle. Earned Value Management Software is an Enterprise EVM software program that assists project managers in determining performance and success. According to Khesal et al. (2019), EVM is a methodological project management procedure adopted to determine project variances by evaluating and comparing planned and performed work. EVM is normally employed for schedule and cost management and sometimes for project prediction (Khesal et al., 2019). The software is further beneficial in project control as it (a) provides project managers with a foundation on which to examine work progress against a baseline; (b) provides information for pro-active administration measures; and (c) gives managers a summary of efficient decision-making as it relates to cost, time, and technical performance (Khesal et al., 2019).

Nizam and Elshannaway (2019) acknowledged that although EVM was employed widely on numerous projects, it presents some noteworthy drawbacks that hinder its capacity to be universally accepted as a viable project control metric. The drawbacks comprise measurement challenges, incorrect projections, omission of benefits, quality omission, confusing terms, and a lack of commitment (Nizam & Elshannaway, 2019). Based on these limitations, Khesal et al. (2019) concluded that EVM is not an ideal project management and control technique.

The Gantt chart was developed in 1893 by Gantt (Hazarika et al., 2019). A Gantt chart uses plots to mark the progress of activities required for project completion (Wilson, 2003).

According to Wilson (2003), a Gantt chart consists of horizontal bars that represent the start date, finish date, and duration of each activity. A Gantt chart is also a significant tool in project control and management, particularly in scheduling and planning projects (Nurre & Weir, 2017). According to Robles (2018), a Gantt chart is a project management measure employed in scheduling and planning projects of all scopes and sizes. It is primarily adopted to simplify complex projects. Such tools are employed to determine the period a project should last, arrange the order of tasks, monitor project progress, and determine the resources required to accomplish the goals. Nurre and Weir (2017) stated that most scheduling dispatching processes are spontaneous procedures used in routine tasks, and the Gantt chart is an effective tool for this type of schedule. Specifically, the Excel-based Gantt chart schedule is an intuitive tool that allows learners to evaluate building schedules for diverse single and parallel machine problems (Nurre & Weir, 2017). The Excel-based Gantt chart further enables learners to acquire intuition regarding common scheduling rules rather than explicitly being told these rules (Nurre & Weir, 2017). The Gantt chart is a scheduling tool employed by a wide range of individuals in project control and management, including students because it helps draw up a work plan and enables a visual representation of the project progress compared with the agreed baseline (Brčić & Mlinarić, 2018). EVM is a monitoring and control technique that project managers use to monitor financial performance throughout the project life cycle. The project team can use the EVM to report the actual cost and time against the budget. A Gantt chart can help project supervisors visualize the variance in the project planned and the actuals, which can help in decision making to determine ways to realign the project to the baseline.

Project Success

Achieving project success is a dimension of increasing importance in the project control literature (Osei-Kyei & Chan, 2017). A project is successful if it attains an attempted, planned, or desired initiative (Gemino et al., 2021). A major concern in the existing literature is determining project success (Müller & Turner, 2007; Santos et al., 2020). For instance, Santos et al. (2020) conducted a systematic and extensive literature review of previous studies to explore general success criteria and success factors in construction projects. The researchers' findings indicated that general project success criteria included standards adopted by all stakeholders to determine such success. The findings were consistent with Müller and Turner's (2007) study. The researchers found that the significance attached to project success rates and project success criteria varied according to the nationality and age of the project manager, the project complexity, and the sector (Müller & Turner, 2007). The researchers concluded that the adopted success criteria are based on both type and significance.

Project Success Factors

There are elements in projects that are important to project success. Adequate communication, organization support, team technical capacity, and the understanding of the project environments mediate in improving renewable energy projects (Rasool et al., 2021). According to He et al. (2021), organsarions shoud enhance poorly controlled megaprojects to gain competitive advantage. The researchers examined key success factors of three megaprojects, namely the Hong Kong-Zhuhai-Macao Bridge, the Three Gorges Dam, and the Beijing-Shanghai High-Speed Railway. The findings revealed eleven success factors comprising achievement of social roles, corporate reputation, project citizenship behavior, project culture, top administration support, organizational structure and mode, application and invention of management programs, adoption of technology, stakeholders' experience, public support, and government support (He et al., 2021). The researchers categorized these project success factors into groups: the need for sustainable growth, positive behavior and culture, organization, construction abilities, and project administration (He et al., 2021). The outcomes enabled the researchers to conclude that project control is among the key factors driving project success.

Cost and time are the two primary determinants of project success in the building sector as they exert the same positive and adverse influences upon all stakeholders (Johnson & Babu, 2018). Researchers indicated that cost and scheduling are closely linked concepts that act together as the basis for project control (Nady et al., 2016; Sanchez & Terlizzi, 2017). For instance, Sanchez and Terlizzi (2017) conducted a correlational study to elicit stakeholders' views and evaluate the control practices a project can adopt to improve schedule and time performance in information technology development projects. The findings indicated that the formal authority of project managers, postponement, project period, and magnitude have statistically significant impacts on schedule, time performance, and project success. The results are consistent with those of Nady et al. (2016). The researchers identified a positive and statistically significant correlation between communication management, cost management, and time management on performance management success and project success (Nady et al., 2016). Thus, scheduling, project control, and project success are positively and significantly correlated.

Project Evaluation and Review Technique and Critical Path Method

The project schedule needs adequate planning to ensure project success. Project managers use the PERT and the CPM to plan the project scope of work by creating a network of associated activities in a sequential order to complete the project (Orumie Ukamaka, 2020). The activities on the critical path need to be closely monitored and coordinated to avoid cost and schedule overruns. The CPM helps evaluate the duration of each task to complete the project, while PERT is a probabilistic technique that considers the optimistic, pessimistic, and the most likely time to complete an activity. The critical path has a float value of zero. PERT helps calculate the float value between an activity and the next (free float) and between an activity and the last activity (total float). A float value of zero or less will indicate the critical path in the schedule (Guida & Sacco, 2019).

Project managers in an organization should monitor the float path throughout the project lifecycle within and outside the organization. An organization needs to engage contractors that understand the importance of the CPM. The existing literature suggested that choosing a suitable and qualified project contractor substantially influences a project's success (Iyer et al., 2020; Tripathi & Jha, 2019). For example, Tripathi and Jha (2019) undertook an empirical study to explore different determinants of project success in the construction sector in India. The researchers identified eight determinants of project success: the availability of qualified workforces; a desirable market and marketing team; efficient cost control measures; the availability of information and resource flow; leadership; the supply chain; a project factor; and the qualifications, experience, and performance of top management (Tripathi & Jha, 2019). The findings were consistent with Iyer et al.'s (2020) study to explore factors leading to project success. The findings indicated that the ability of contractors examined during the prequalification phase was an important attribute for an entity. The ability to alleviate risks and perform work are elements of project success. The researchers concluded that a contractor plays a significant role in the success of a project, and therefore organizations should only hire qualified contractors.

Government Projects

Megaprojects require organizations to hire qualified contractors. A megaproject attribute includes complexity, high risk, a duration of at least one year, and cost of at least $1 billion (Denicol et al., 2020; Qiu et al., 2019). Historical data indicated the poor performance of megaprojects regarding their benefits, meeting scheduled deadlines, and costs (Locatelli et al., 2014). Locatelli et al. (2014) conducted a correlational multiple-case study that found that megaprojects undergo a timely and effective planning stage where the government owns half the shares. A positive and significant correlation was also found between government-controlled megaprojects and an on-time planning stage, as large projects must pass numerous approval phases. When the government is the main project owner, the plans are more likely to meet regional and local administration needs. Locatelli et al. identified Électricité de France as an example of a megaproject that was successfully planned as the French government controls 85% of its shares.

Project Methodologies

The existing literature also included the impact that project methodologies have on project success (Joslin & Müller, 2016; Müller & Martinsuo, 2015). For instance, Joslin and Müller (2016) explored various project methodologies employed in the construction industry. The researchers identified a statistically significant and positive correlation between project methodology aspects and the features of project success. The findings were consistent with Joslin and Müller's (2016) study, which found that project performance and success were based on a systematic project methodology. The researchers concluded that project methodologies are vital for project success. The project management methodologies are the organizations' processes and procedures to constantly deliver successful projects, such as Project Management Institute, International Project Management Association, Association of Project Management, and Projects in Controlled Environments methodologies (Jovanovic & Beric, 2018). The project management team can use the triple constrain model to identify and concentrate on factors contributing to project success. The stakeholders measure the project's success by comparing the baseline cost, time, and quality with the agreed baselines. Organization project culture, client support, good communication, project team experience, project complexity, government support, adoption of technology, baseline management, and float path measurement can improve project success.

Nuclear Construction Projects

Construction and commissioning are commonly used in nuclear-related studies to refer to nuclear facilities built or renovated and whose components, structures, and systems are in certain working conditions (Grimston et al., 2014). Grimston et al. (2014) noted that the building phase of a new nuclear facility is critical for the safe operation of the plant throughout its stipulated lifespan. Various factors impact the successful construction of a nuclear plant, including the personnel, materials used, government approvals, facility design, and effective planning (Lovering et al., 2016). Only nine nations worldwide possess nuclear plants and weapons: the United Kingdom, North Korea, Israel, Pakistan, India, China, France, Russia, and the United States (Khattak et al., 2017). In the United Kingdom, Électricité de France is currently constructing the Hinkley Point C nuclear facility in Somerset and Essex, London. UK authorities in the regions monitor projects closely as nuclear power plants can be extremely dangerous to human lives and the environment.

Nuclear Plant's Decommissioning

Planning for decommissioning is a typical and necessary process in a nuclear plant's lifetime and is required in the initial phases of project development (Wealer et al., 2019). Mulholland et al. (2019) noted that decommissioning involves substantial material management, dismantling, facility decontamination, radiological characterization, physical characterization, and planning. The existing literature indicated that the characteristics of nuclear-decommissioning projects and programmes have significantly influenced the success of nuclear projects. For instance, Invernizzi et al. (2020) reported that the success of megaprojects depends on diverse NDP features that influence the success of (a) nuclear projects, (b) ensuring stable funding, (c) obtaining storage facilities, and (d) forging an appropriate connection with the relevant governing bodies and acquiring detailed knowledge concerning the site conditions. The storage of nuclear waste and the decommissioning of nuclear power facilities present various challenges (Wealer et al., 2019). These two procedures are financially and technologically problematic and significant determinants of a nuclear project's success. Nuclear nations have adopted various nuclear-decommissioning programs and processes to reduce these procedures' technological and monetary challenges. Wealer et al. (2019) noted that in the United Kingdom, the decommissioning of the legacy fleet is financed by taxpayers while an external segregated financing source meets operational expenses. Germany shifted to an exterior segregated fund from interior non-segregated funds for nuclear waste control (Wealer et al., 2019). In France, an interior segregated fund supports nuclear decommissioning and nuclear waste management

(Wealer et al., 2019). The findings all indicated that finance and control are key determinants of the success of nuclear projects.

Researchers have strived to explore some of the factors that impact the construction of nuclear plants (Grimston et al., 2014; Khattak et al., 2017). For instance, Khattak et al. (2017) reviewed the siting processes that nuclear countries employ in constructing nuclear power facilities. The findings indicated that the site selection processes for nuclear projects had two primary goals: ensuring the facility's economic and technical viability and reducing possible negative effects of the plant on the environment and community (Khattak et al., 2017). Khattak et al. found that geographical location plays a vital role in the siting of a nuclear power facility as the locality should have an abundant water supply. The findings were consistent with Grimston et al. (2014), who concluded that an appropriate site for a nuclear power facility required the deliberation and balancing of different factors. Geographical features such as the possibility of seismic activity and the local climate were universal to all nuclear plant designs. Other features such as the size of land needed, the availability of cooling water, and geographical states that can sustain the weight of the nuclear reactor and other facilities are dependent on the type of nuclear reactor selected. The researchers concluded that nuclear power construction projects are the most difficult to site due to the conditions involved.

Sensitivity, Quality, and Safety Requirements of Nuclear Projects

Researchers have identified various factors influencing the construction of nuclear plants (Madyaningarum et al., 2019; van Niekerk & Steyn, 2011). For instance, Madyaningarum et al. (2019) explored the main factors impacting project quality in construction projects involving radioactive minerals. The researchers focused on the rare earth metals thorium and uranium pilot plants and employed multiple linear regressions to analyze the data. The findings indicated that safety culture, project planning, leadership, and commitment impacted the quality of the construction projects. The results were consistent with van Niekerk and Steyn's (2011) study to examine a nuclear engineering project and determine the significant criteria for the success of complicated, high-tech programs. The researchers revealed that project effectiveness factors, including cost and timely delivery, were less significant for super high-technology projects. The researchers concluded that, unlike other projects, nuclear construction projects involve numerous factors due to their sensitivity and intense safety requirements. The safety requirements of the nuclear construction project during the planning phase make it sensitive. The decommissioning process needs to be incorporated into the planning phase to reduce reworks and remove complexity. Stable funding, availability of storage facilities, and communication with the governing bodies such as the Office for Nuclear Regulation can help reduce cost and schedule overruns in nuclear construction and decommissioning projects. The nuclear construction project location is important for its installation and operation as the site context should have an adequate supply of water to cool the reactors.

Transition

Section 1 included the problems and issues prevalent in the construction sector regarding the control and management of costs and schedules and other factors affecting project success. The main areas covered in this section include the background to the problem, the problem statement, the nature of the research, research questions and hypotheses, theoretical framework, operational definitions, the significance of the study, and the literature review. This section contained the literature review and a detailed appraisal of the theoretical framework employed for this study, which was the triple constraint model (sometimes referred to as the iron triangle or the project management triangle). Studies that have adopted the triple constraint model were critically evaluated and related to the current research.

The literature review also contained the key constructs of the current study, including cost overruns, schedule overruns, project control, and project success. Various correlational studies have focused on these constructs. A background evaluation of nuclear construction projects was also included.

Although scholars have agreed on the positive impacts of project controls on project success, there is less accord regarding the relationship between project controls, project cost overruns, a project schedule, and project success. Therefore, this correlational study aims to determine the connection between cost and schedule overruns and the success of nuclear construction projects. Cost and schedule overruns are the predictor variables, while nuclear construction project success is the response variable. Section 2 explains the data collection process and describes the steps taken to ensure the validity of the data and the research. The main areas covered in Section 2 are the role of the research, study participants, research method and design, research population and sampling, ethical considerations, data collection and analysis, and the validity and reliability of the study.

Section 2: The Project

Section 2 outlines the details of the methodology I employed in this research. I began by presenting the purpose statement before discussing the role of the researcher and the target participants. The rationale for the chosen research method (quantitative) and research design (correlational) was then explained. This rationale was followed by a discussion on population and sampling, ethical considerations, data collection instruments, data collection procedures, data analysis plan, and the study's validity.

Purpose Statement

The purpose of this quantitative correlational study was to examine the relationship between cost, schedule overruns, and project success. Cost and schedule overruns were the independent variables for this study, and project success was the dependent variable. The target population was nuclear construction project managers in the United Kingdom who had successfully adapted processes for projects to reduce cost and schedule overruns, thereby improving project success. The implication for positive social change included the socio-economic benefits from the savings on timely project delivery for an education program to motivate young people to develop their skills in science, technology, engineering, and mathematics that could be helpful during the construction of Hinkley Point C (HPC) power station, and its future operations.

Role of the Researcher

For this quantitative correlational study, I was the primary data collection instrument. According to Six (2020), the researcher is the primary instrument for data collection in a quantitative study. I am a project management professional with nine years of experience in the construction industry and four years in the nuclear construction industry. I have undertaken various roles as a project associate, project manager, planning consultant, delay analyst, project control manager, an extension of time analyst, and project planner on various nuclear construction projects. The study's goal was strictly professional and addressed through the quantitative methodology. I exerted no undue influence over research participants, even though some were work colleagues. I have a professional relationship with the study site and a keen personal interest in the topic. Therefore, although I had biases regarding the topic, I conducted the study solely as a researcher and analyzed the data according to established protocols, with no preconceived notions about what the data should contain. The survey protocol provided a structured approach throughout the data collection phase (Yin, 2018).

According to the U.S. Department of Health and Human Services (1979), A researcher must avoid ethical issues. I adhered to the recommendations of the U.S. Department of Health and Human Services regarding participant confidentiality by protecting vulnerable participants and ensuring their contribution was voluntary. The Belmont Report provided a framework to protect participants' rights (Kimmelman, 2020). I ensured the participants understood that their participation in completing the survey was voluntary and could withdraw themselves from the process at any time, as stated in The Belmont Report.

Participants

The participants for this study were project managers, project directors, project control managers, delivery integration managers, construction managers, and project planners within the nuclear construction industry in the United Kingdom. The eligibility criteria for the participants were as follows: (a) must currently be a project manager, project director, project control manager, delivery integration manager, construction manager, or project planner for the HPC power station construction project; (b) must have at least 1 year of experience or exposure to nuclear construction projects; (c) must be currently employed in the civil nuclear industry in the United Kingdom; and (d) must be 18 years old and above. I was directly involved in the HPC power station construction project and had access to 150 employees working on the project. I used purposeful sampling to select the participants for this study. Researchers use purposeful sampling to select the most appropriate participants for the study (Ames et al., 2019). I recruited participants by sending emails directly to the employees and reaching out to professional colleagues on LinkedIn. The established relationships with the participants over the years ensured their credibility. The study participants were interested in understanding the causes of project delays and cost overruns in construction projects. The participants were motivated to know whether there is any relationship between cost, schedule overruns, and project success. The participants understood the usefulness of this research and its importance to the nuclear construction industry. According to Patel et al. (2003), participants need to be motivated to participate in the study (Patel et al., 2003). There was no compensation for the participants, but the researcher offered a two-to-three-page summary of the completed study.

Research Method and Design

Researchers use a quantitative method to examine the relationship between cost, schedule overruns, and project success. According to Yin (2018), three research methods are at the disposal of a researcher: (a) qualitative, (b) quantitative, and (c) mixed methods. A qualitative research method would be exploratory that researchers use to understand individual motivations and opinions (Houghton et al., 2013; McCusker & Gunaydin, 2014; Seitz, 2015). A mixed-method study comprises qualitative and quantitative studies in the same research (Alavi et al., 2018). This study used a quantitative methodology with a correlational research design. The research method and design were based on the purpose of the study, the type of data collected, and the statistical analysis. The justification for choosing a quantitative method with a correlational research design is presented in the following sections.

Research Method

This study employed a quantitative method. The quantitative method involves applying mathematical techniques to yield statistical inferences about the relationships or differences between numerically measured variables (Anderson et al., 2012; Hancock & Mueller, 2010; Wisniewski, 2016). A quantitative methodology addresses research questions by asking “who," "what," and "how many" (Jarosławski et al., 2017; Yin, 2018). Researchers use quantitative methods to test relationships among dependent and independent variables (Morgan, 2018; Potter et al., 2017; Yin, 2018). I numerically measured all variables using a valid, reliable Likert five-point scale via SurveyMonkey. Researchers use the Likert scale to express a degree of agreement or disagreement with a statement (Lee et al., 2019). Therefore, based on all the above considerations, a quantitative method was appropriate for the study.

Conversely, qualitative and mixed-method approaches are deemed inappropriate. Qualitative studies employ observations, interviews, and case studies to collect information about a specific phenomenon from selected individuals or groups of individuals (Yin, 2018). They employ inductive reasoning to make sense of the insights and explanations gathered from various sources of information such as personal observations, interview transcripts, documents, and recordings (Park & Park, 2016). Qualitative studies strive to answer the “how” and “why” questions in research (Yin, 2018). Mixed-methods research combines quantitative and qualitative methods (Halcomb & Hickman, 2015; Saunders et al., 2019; Yin, 2018). A mixed-method study typically uses qualitative techniques to expound and give context to the quantitative results. For this study, I collected data from a survey requiring numeric responses. For qualitative data collection, interviews, observations, or recordings of interviews are performed (Johnson & Christensen, 2012). Therefore, qualitative and mixed-method approaches were inappropriate for the study's objectives.

Research Design

This study employed a correlational research design. A correlational approach determines the degree to which a relationship exists between the set of paired variables (Curtis et al., 2016; Gaskin & Chapman, 2014; Hoe & Hoare, 2012). A correlational research design facilitated an evaluation of both the magnitude and behaviour of the relationships between variables (Leedy & Ormrod, 2010). Regression analysis is the best technique to determine the strength and direction of the variables and the best statistical technique to answer this study's research questions. Therefore, a correlational design was the most appropriate for this study.

Other research designs, such as causal-comparative and experimental designs, were inappropriate. Causal comparative studies investigate differences between two or more categorical groups based on a dependent variable (Babones, 2014). This approach was inappropriate because this study did not compare groups to determine the causes or consequences of existing differences in groups of individuals. An experimental approach involves testing hypotheses that affirm whether a treatment or experiment affects a variable or variables (Babbie, 2013; Hoe & Hoare, 2012). There was no intent to experiment on the selected participants as the study focused on existing characteristics. Thus, an experimental research design was inappropriate for the objectives of this study.

Population and Sampling

Population refers to the collection of individuals that are the research team's main focus (Marandel et al., 2020; Martínez-Mesa et al., 2016). The population of interest in this study was employees in the nuclear construction industry in the United Kingdom. The target population was project managers, project directors, project control managers, and project planners working on various nuclear construction projects in the United Kingdom. The Nuclear Industry Association (2019) reported that approximately 60,000 were employed in the civil nuclear sector in the United Kingdom. Employees in the civil nuclear industry are highly skilled people employed in power station construction and operations, manufacturing, decommissioning, research and development, waste management, and nuclear fuel (Nuclear Industry Association, 2019).

The researcher used purposive and snowball sampling to recruit the participants. Purposive sampling is a sampling technique that involves the deliberate selection of participants such that only those who satisfy the inclusion criteria for the study are included (Campbell et al., 2020; Duan et al., 2015; Haas, 2012). The snowball sampling technique uses participant referrals and recommendations from the existing sample. Researchers typically employ this method when studying participants with unique attributes and beliefs who do not come from sites or pre-existing environments (Chambers et al., 2020). Thus, referrals from individuals in the same situations with similar characteristics are beneficial (O' Dwyer & Bernauer, 2014). The inclusion criteria for this study were as follows: participants (a) must currently be a project manager, project director, project control manager, or project planner of the HPC power station construction project; (b) must have at least 1 year of experience or exposure to nuclear construction projects; (c) must be currently employed in the civil nuclear industry in the United Kingdom; and (d) must be 18 years old and above. The exclusion criteria were as follows: participants must not be (a) associate employees with less than one year of working experience in the civil nuclear industry, (b) non-English-speaking individuals, and (c) individuals younger than 18 years old.

Researchers use G*Power software power analysis to help select the required sample size (Faul et al., 2013). The four considered factors in the analysis are the significance level, effect size, power of the test, and statistical test employed. The significance level refers to the probability of rejecting a true null hypothesis, commonly called a Type I error (Haas, 2012). The power of the test refers to the probability of rejecting a false null hypothesis (Haas, 2012). In most quantitative studies, the significance level is 95%, and the power of the test is 80% (Koran, 2016). Therefore, the researcher employed the same factors for this study. Effect size indicates the estimated degree of relationship between predictor and criterion variables (Cohen, 1988). Effect sizes for quantitative studies are categorized into small, medium, and large. The relationship between the variables requires striking a balance between being too strict or too lenient while estimating (Berger et al., 2013). Finally, multiple linear regression analysis was employed. Cost and schedule overruns were the two variables to test the hypotheses and answer the research questions. The researcher risked not gathering the required data to validate the study if the sample size was inadequate. The sample size needs to represent the population and should not be too many or too few (Andrade, 2020). Tabachnick and Fidell (2018) suggested that the sample size formula is 50 + 8(m) when m indicates the number of the independent variables. The minimum required sample size for this analysis is 50 + 8(2) = 66. An additional 20% was added to account for missing data and incomplete surveys during data collection; therefore, the final sample consisted of 80 participants.

Ethical Considerations

After obtaining the Institutional ReviewBoard's (IRB) approval, the researcher sent an invitation to participate to the respondents. This included giving them information about their rights to refuse to participate or withdraw once the research has begun (Fernandez Lynch, 2020). Informed consent is the procedure whereby individuals choose whether to participate in an investigation after being informed of facts that are likely to influence their decision (Cooper & Schindler, 2014). It ensured that the study was ethically sound and that the quantitative principles were applicable for data collection. The collected data remained uncompromised throughout the writing of the results. Participants' permission was required when the researcher planned to review the authorizations needed from the concerned authorities. The IRB application approval number for this study is 03-21-22-0672514. Finally, participants were not required to inform the researcher whether they had completed the questionnaire. Personally-identifying information was not collected throughout the data collection process to ensure anonymity. Participants were able to accept or reject participating in the study by clicking the accept or reject button on the SurveyMonkey landing page.

The data will be kept in an encrypted format for five years and then destroyed. Data will be stored on a flash drive and placed in a secure location. The entire 5-year period will be observed, including electronic calendar reminders, to ensure these procedures comply fully.

After five years, all copies containing the data set will be deleted. The researcher completed the Belmont Report and its principle training to adhere to the ethical requirement of the study. The Belmont Report (U.S. Department of Health & Human Services, 1979), the principle for using human participants in a study, guides researchers to respect the participants, not do any harm to the participants, and maintain a fair distribution of justice across all participants (Parker et al., 2019).

Data Collection Instruments

I collected data via an administered survey. A self-developed survey was employed to obtain data consistent with quantitative research methodology (Cooper & Schindler, 2014). I used the survey (see Appendix) to measure the study variables (cost, schedule overruns, and project success) in two parts: a demographic section and a project details section. The demographic section was used to collect data on age, position, and years of working experience in the nuclear industry. The project details section gathered data on the cost, schedule overruns, and success of projects managed by the participants. The survey was validated by establishing the validity, pilot testing the survey, and collecting pilot data.

Conducting a pilot test helped ensure the reliability and validity of the self-developed survey. This pilot test consisted of two phases. The first phase involved showing the survey (see Appendix) to a panel of five experts to examine the feasibility and acceptability of the instrument for the study variables. Recommendations from the experts were meant to then facilitate appropriate revisions. All experts agreed that the survey instruments aligned with the research questions and hypothesis; hence there was no need to update the questionnaire. The second phase involved selecting a sample of 20 participants following the inclusion criteria previously described. The outcome of the pilot study showed no need for revisions to the survey (or any other documents). There were no revised materials to be submitted to the IRB for review or approval of the modifications before conducting the study.

Data Collection Technique

Once IRB approval from Walden University was secured, I developed the survey on the site hosted by SurveyMonkey and organized a list of potential participants from the professional network and sent them the invitation to participate in the study. I also sent emails to my professional colleagues at HPC. According to Bashir (2017), a researcher can use an email-based survey as an instrument to collect effective data. The majority of the participants came from my place of work. Fritz and Vandermause (2018) concluded that using email to contact participants improves the data collection experience for both the researcher and participant.

All potential participants then receive an email or message with a link to the study survey in SurveyMonkey. SurveyMonkey was the survey host of choice because it enables importing data to Microsoft Excel and the Statistical Package for the Social Sciences (SPSS), the platforms for data pre-processing and analysis. SurveyMonkey was founded in 1999 by Ryan Finley to create sophisticated but straightforward surveys online that allow users to gather and provide feedback on a topic (Abd Halim et al., 2018). The email invitation also included a description of the study and the active link, which was only valid for one survey submission. The participants had the choice to click on accept or reject button on the survey landing page. A Likert-type questionnaire containing 36 questions was used to collect data. A Likert rating is a five-point scale system ranging from strongly agree (1) to strongly disagree (5) to test the different degrees of agreement and disagreement (Dourado et al., 2021).

The email content introduced the study and informed participants that their involvement would be strictly voluntary. No loss of privileges occurred by not participating or withdrawing from the study. The email also contained a confidentiality clause for the participants. It was made clear to participants that their participation or lack thereof would not impact their employment in their respective organizations. The researcher's contact information was provided in case participants had any questions regarding the survey. Once the researcher had obtained the required number of participants, the data was exported from SurveyMonkey to Microsoft Excel for data pre-processing and SPSS for data analysis. The researcher ensured the questionnaire was as straightforward as possible and noted any pattern in participants' submissions to avoid central tendency bias, which is common in the Likert scale data collection system (Douven, 2017).

Data Analysis

Data analysis in this quantitative study involved systematically applying a statistical test to answer research questions and test the null and alternative hypotheses. Researchers use data analysis to clean, transform and model collected data to help make decisions (Anda et al., 2017). The data analysis was conducted using SPSS for Windows to provide a range of descriptive and inferential statistics, including statistical correlations. Researchers in the educational, social, and behavioural sciences use SPSS software extensively (Hinton et al., 2014). The advantage of SPSS is that it is user-friendly and enables the researcher to import data from Microsoft Excel. Therefore, SPSS was used to analyze all the collected data.

Microsoft Excel facilitated all data processing and ensured a clean data set by excluding outliers and missing data. Only those surveys with complete information were included in the data analysis. Once a completed, clean data set was prepared, the researcher imported the data to SPSS for analysis.

A descriptive analysis was used to characterize the participants' demographic information and their responses to the survey. Descriptive statistics such as frequency, percentage, mean, and standard deviation were computed. Charts (i.e., pie charts and histograms) accompanied and illustrated the descriptive analysis.

The central part of the data analysis consisted of inferential analyses, specifically multiple linear regression analysis, to examine the relationship between cost, schedule overruns, and project success. Multiple regression analysis is a statistical technique that predicts the value of a dependent variable based on the value of two or more independent variables (Creswell, 2013). A multivariate correlation design was suitable for this study because there were two independent variables (cost and schedule overruns) and one dependent variable (project success). According to McQuitty (2017), researchers could predict the result of response variables from other multiple variables.

The researcher considered other statistical correlational analyses such as path analysis, analysis of variance (ANOVA), and canonical analysis. Researchers use Path analysis to evaluate the causal relationship between two or more independent variables and one dependent variable (Dai et al., 2020), while canonical analysis identifies and measures the relationship between sets of variables with multiple intercorrelated outcomes (Saini & Singh, 2020). The ANOVA is used to determine the effects of the independent variables on the dependent variable (Clayton-Soh, 2016). The researcher used this study to determine the relationship between two independent variables and a dependent variable; the multiple linear regression analysis was appropriate for this study. I used multicollinearity to check if the variables were related. Researchers use multicollinearity to determine a high correlation between two independent variables (Holbrook et al., 2016). I used the variance inflation factor (VIF) to check for multicollinearity. The variance result of VIF using SPSS software revealed no issue of multicollinearity. The result can skew the outcome since data sets are sensitive to minor changes, multiple linear regression model instability, and inaccurate estimate coefficients (Frost, 2020).

Multiple regression analyses are considered parametric tests; hence the investigation of four assumptions is required: (a) normality, (b) homogeneity of variance, (c) linearity, and (d) independence (Sedgwick, 2015). Researchers use a probability plot (p-p) diagram to detect whether all study variables comply with the normality assumption (Siddiqi, 2014). Second, researchers test for homogeneity of variance, investigating a constant variance of error for the independent variable by plotting residuals versus predicted values and residuals versus independent variables (Parra-Frutos, 2013). If there is no obvious pattern to the scatterplot of the variables, the assumption will be met if the error is consistent across the range of predicted values. Third, the linearity test will test for a linear relationship between the two variables (Sedgwick, 2015). This involved producing scatterplots to ensure that the mean of the outcome variable for increment resembled a straight line. Finally, researchers test for outliers through visual inspection of histograms and box plots to meet the assumption of independence (Huber & Melly, 2015).

Researchers use hypothesis testing at a .05 level of significance (Weakliem, 2016). A p-value of less than .05 indicated a statistically significant relationship between the variables. The hypothesis is null when a value greater than .05 indicates no statistically significant relationship between the variables. The hierarchical regression and logistic regression are not appropriate for this study. Researchers use hierarchical regression to explore the relationship between one independent variable and more than two dependent variables (Yang et al., 2021). According to Chen et al. (2018), researchers use the logistic regression, also known as the sigmoid function, to model the statistical probability of an event existing, such as win/lose, boy/girl, and cat/dog. This study did not test for a category of variable (logistic regression) and did not have more than one dependent variable; thus, hierarchical regression and logistic regression were not appropriate for this study.

Study Validity

Researchers are often required to show that a study is valid and reliable (Yin, 2018). It is essential to show that the data collection and analysis processes are reliable. There are two approaches to determining the validity of a study, internal and external (Khorsan & Crawford, 2014). Internal validity measures how the research design allows the researcher to draw accurate conclusions about relationships within the data (Leedy & Ormrod, 2010). The internal validity test is relevant to causal relationships in quasi-experimental designs (Flannelly et al., 2018; Peters & Pereira, 2017). Internal validity was not relevant in this study as this was a correlational study and a nonexperimental design. The lower the effect of confounding and experimental bias in a study, the more confidence in the outcome and the higher the internal validity (Grimes & Schulz, 2002). Confounding is the effect of a third variable related to the independent variables on the study's outcome (Flannelly et al., 2018).

Threats to Statistical Validity and Mitigation Strategies

According to Roe and Just (2009), there should not be dangers to internal validity involving history, statistical regression, instrumentation, and mortality should exist. These dangers to validity are only relevant to experimental studies and other studies that use pretest and posttest data or longitudinal studies. The study was not longitudinal and did not involve pretest and posttest data. Pilot testing was conducted to ensure its validity before using the pilot method as the data collection tool. External validity denotes the extent to which research results can be applied to specific situations beyond the research (Leedy & Ormrod, 2010). In the present study, the results could be applied to the civil nuclear industry in the United Kingdom; therefore, the outcomes may not be generalized to other study population groups. According to Cone et al. (2020), a Type I error (false positive) can occur in hypothesis testing. Type I is when a researcher rejects the true null hypothesis. A type I is a more severe error when compared to a Type II error (false negative) (Cone et al., 2020). The probability of making a Type I error is alpha (α) (significance level) and relies solely on the researcher (Rios, 2021).

Assumptions

There were two or more independent variables in multiple linear regression, and the researchers determined their contribution to a dependent variable (Chen & Bien, 2019). The first assumption of multiple linear regression was a linear relationship between the predictor variables and the outcome variables. I created a scatter plot diagram to check for linearity visually. A point closer to the probability plot lines represents the distribution of the normal variation (Schmidt & Finan, 2018). According to AlMomani et al. (2020), multiple linear regression is sensitive to outlier effects. Researchers can perform a visual inspection on a scatter plot to determine outliers. I used the normal probability plot (P-P) to identify outliers or unusual values.

Reliability

Reliability indicates the consistency and stability of the quantitative data (Mohamad et al., 2015). This means that another researcher who applied the same methodology should have the same result. The reliability of this study was validated using the test-retest principle to check the consistency of the test results over time. I applied the same methodology for the pilot and main studies. Another way researchers test for reliability is by using Cronbach's Coefficient Alpha. The Cronbach alpha is a psychometric statistical to estimate the consistency and reliability of a study (Tavakol & Dennick, 2011). The Cronbach's coefficient alpha coefficient ranges from .00 and 1.0, where .00 shows there is no consistency, and the value of 1.0 indicates perfect consistency in measurement. I considered a reliability coefficient of more than .60 acceptable for this research. Jovanović and Lazić (2018) used .6 as an acceptable value for the reliability coefficient.

Sample Size

The sample size is the number of participants included in a study. A population is the collection of participants that is the main focus of the study (Fernández-Castilla et al., 2019). Researcher bias is a significant threat to study validity (Wohlin, 2021). According to Fernández-Castilla et al. (2019), the sample size should represent the target population to improve confidence in the study outcome. Tabachnick and Fidell (2018) suggested that the sample size formula is 50 + 8(m) when m indicates the number of the independent variables. The minimum required sample size for this analysis was 50 + 8(2) = 66. To account for missing data, outliers, and incomplete surveys during data collection, an additional 20% was added; therefore, the final sample consisted of 80 participants. The result of this study was reliable since the sample size is a good representation of the population of project managers, project planners, construction managers, and delivery integration managers.

Transition and Summary

The purpose of this quantitative correlational study was to examine the relationship between cost, schedule overruns, and project success. The target population consisted of project managers, project directors, project control managers, and project planners on HPC construction projects in the United Kingdom. The researcher needed 80 participants consisting of project managers, project directors, project control managers, delivery integration managers, construction managers, or project planners to participate in the study. As a requirement, participants had to complete a survey hosted in SurveyMonkey. Data gathered from the participants was analyzed using multiple regression analysis in SPSS. Cost and schedule overruns were the independent variables for this study, and project success was the dependent variable. The results of the data analysis are presented in Section 3.

Section 3: Application to Professional Practice and Implications for Change

Introduction

The purpose of this quantitative correlational study was to examine the relationship between cost, schedule overruns, and project success in the nuclear construction industry in the United Kingdom. The cost and schedule overruns were the independent variables, and project success was the dependent variable. The target population was nuclear construction project managers in the United Kingdom who have successfully adapted processes for projects to reduce the cost and schedule overrun, thereby improving project success. The research question was: What is the relationship between costs, schedule overruns, and project success? The null hypothesis (H_0) indicated no statistically significant relationship between cost, schedule overrun, and project success. The alternative hypothesis (H_1) indicated a statistically significant relationship between cost, schedule overrun, and project success.

To conduct an online survey, I applied the Likert five-point rating scale (from strongly agree [1] to strongly disagree [5]) to collect the data for the purpose of testing the different degrees of opinion. First, a total of five experts completed Phase 1 of the pilot study survey (see Appendix 1) hosted on SurveyMonkey. Their function was to examine the feasibility and acceptability of the instrument for the study variables. The participants for the first phase of the pilot study were academics, scholars, and peer review authors who have published in peer-reviewed journals and had previously conducted quantitative studies and had at least 5 years' experience in research and publication. All of these experts accepted the survey instruments. To avoid conflict of interest, the current chair was excluded. The second phase of the pilot study comprised of 20 participants, and its purpose was to check for ease of completion and understanding. The participant sample size was calculated using G*power software, and the result indicated a minimum of *N*=66 data sets. An additional 20% were added to account for missing data and incomplete surveys during data collection. The final sample consisted of 80 participants. I obtained data from project managers, project directors, project control managers, and project planners of the HPC power station construction project. Through LinkedIn and email, I invited participants by using purposive sampling and mindful selections and encouraging referrals. I received 163 responses after seven days and subsequently exported the results into Excel for analysis and cleaning. Two participants declined to participate, while 20 did not answer all the questions. Consequently, I excluded 22 participants from further analysis. I exported the initial 20 results for the pilot study phase 2 analysis and the next 66 for the main study's descriptive and inferential statistical analysis.

Presentation of the Findings

Descriptive Statistics

I sent the online survey invitation to 160 potential participants by email, and a further 50 were sent through LinkedIn messenger. The survey was hosted on SurveyMonkey. The participants had the option to accept or reject participation in the study by clicking either the "accept" or "reject" button on the SurveyMonkey landing page. I used a self-developed questionnaire which was validated by the participant of the first phase of the pilot study by testing the adequacy of the research instrument and testing the protocol for the main study. The participant for the second phase of the pilot study and the main study anonymously answered an online survey (5-10 minutes) containing 36 questions by agreeing or disagreeing with a series of Likert scale statements. The questionnaire was grouped by variables. Cost overruns have 12 questions, schedule overruns have 10 questions, and project success has 12 questions. The G*Power can be used to calculate the sample size of quantitative analysis (Tabachnick & Fidell, 2018). The sample size N was 66, and although I received 165 responses, only 66 responses were used for the regression analysis. The data were cleaned in Excel by excluding outliers, duplicates, and missing data, the initial 20 responses were used to test for reliability (Phase 2 of the pilot study), and the next 66, after the data had been cleaned, were used for the detailed analysis.

Pilot Study

Five experts completed Phase 1 of the pilot study survey (see Appendix) hosted on SurveyMonkey. Their role was to examine the feasibility and acceptability of the instrument for the study variables. The participants in Phase 1 of the pilot study were academics, scholars, and peer reviewed authors who had conducted quantitative studies. They all accepted the survey instruments. Phase 2 of the pilot study comprised 20 participants to ascertain the ease of completion, understanding, and reliability. Each participant spent an average of 3 minutes completing the questionnaire, which implies ease of completion and understanding of the details of the survey. The data for Phase 2 of the pilot study were analyzed using Cronbach's alpha, where a score of .60 was considered acceptable for this research (Jovanović & Lazić, 2018). The variable scores of cost, schedule overruns, and project success were .69, .62, and .76, respectively. According to the data, all variable scores are strongly consistent and reliable. Figure 2 shows the Cronbach alpha result of the pilot study.

Table 2

Cronbach Alpha to Test the Reliability of Scales

Main Scale	No. of Items	Cronbach's Alpha
Schedule Overrun	11	.62
Cost Overrun	12	.69
Project Success	13	.76

Note. N = 36 (total survey questions).

Main Study

A total of 66 participants were used for the analysis of the main study. Table 3 presents the descriptive statistics for the variables in which the sample size was 66, and the observation for the cost overrun independent variable had a mean value of 3.99 (SD = .64, Min. = 2.33, Max.= 5.00). The observation for the schedule overrun independent variable had a mean value of 3.72 (SD = .69, Min. = 2.27, Max.= 5.00). Finally, the mean value of the observation for the project success dependent variable was 3.42 (SD = .64, Min. = 2.00, Max. = 4.54). These standard deviations (SD) values indicate a minimal variance of the data from the mean, which implies the reliability of the data sets.

Table 3

Descriptive Statistics for the Independent and Dependent Variables

Variable	*N*	Min.	Max.	*M*	*SD*
Cost Overrun	66	2.33	5.00	3.9962	.64424
Schedule Overrun	66	2.27	5.00	3.7176	.69365
Project Success	66	2.00	4.54	3.4184	.63806

Note. N = 66

Outliers

Outliers in regression are values that are more than three standard deviations from the mean (Rakotosaona et al., 2019; Sullivan et al., 2021). According to Walker et al. (2018), researchers use the boxplot technique to detect the existence of outliers in a linear regression analysis. I generated boxplot diagrams for the cost, schedule overruns, and project success. The boxplot diagram (Figure 1) for cost overrun shows outliers because this diagram exhibits three circles next to the numbers 2, 17, and 64. Tabachnick and Fidell (2018) claimed that the outliers can result from computed syntax errors, poor data entry, and missing codes for empty data. To reduce the impact of such outliers, I deleted three values. Figure 1 shows the regenerated boxplot for the independent variable – cost overrun. The boxplot diagram of the schedule overrun (Figure 2) indicates no outliers, nor does it show a circle next to the values in the boxplot diagram. Similarly, the boxplot of project success (Figure 3) indicates no outliers or circle next to the values in the boxplot diagram.

Figure 1

Boxplot Diagram for Outliers of the Independent Variable (Cost Overrun)

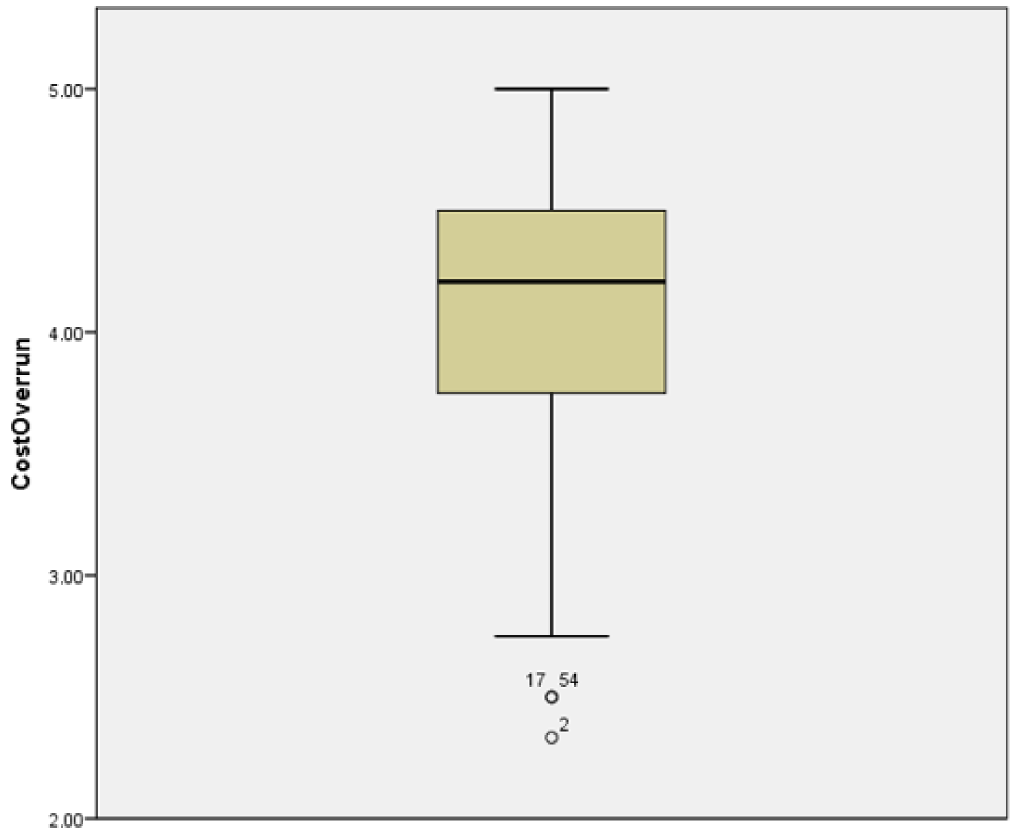


Figure 2

Boxplot Diagram for Outliers of the Independent Variable (Schedule Overrun)

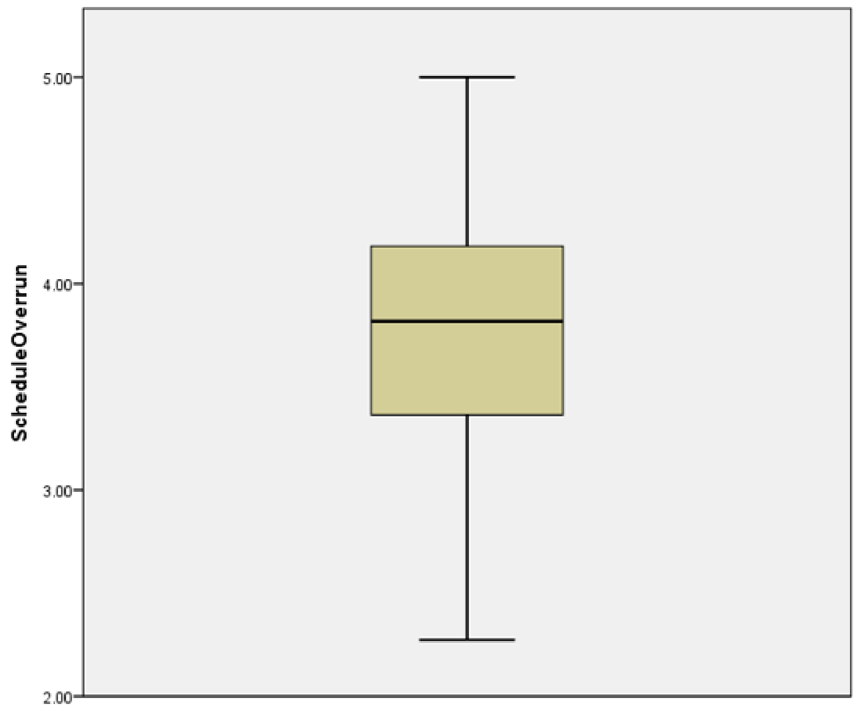
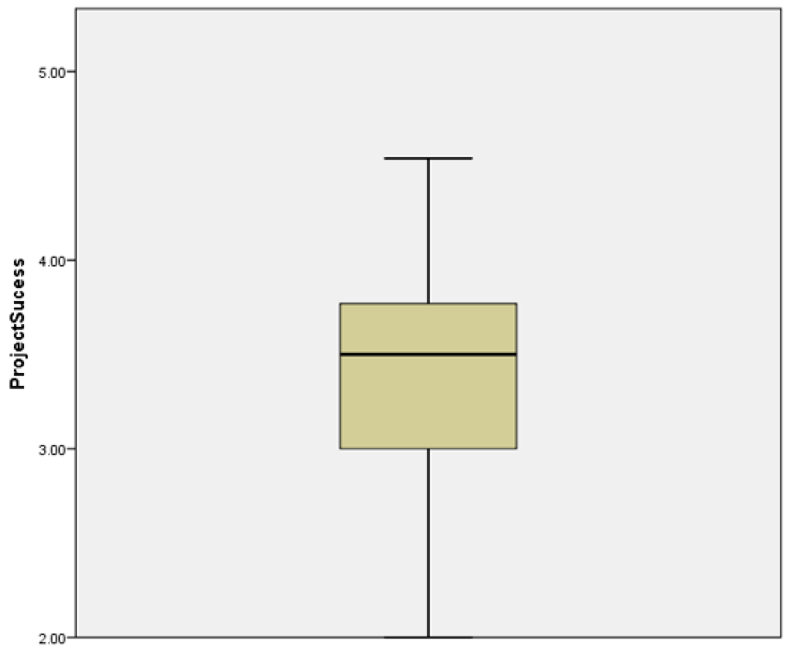


Figure 3

Boxplot Diagram for Outliers of the Independent Variable (Project Success)



Test of Assumptions

According to Yang et al. (2021), researchers can use the probability plots (P-P) diagram to test linearity, normality, and homoscedasticity assumptions, and I employed this diagram to test these assumptions. Shrestha (2020) used the Pearson correlation to test for multicollinearity, while I utilized this correlation to test for multicollinearity. The result indicated no violation of these assumptions.

Linearity

Linearity is the linear property of independent and dependent variables of a regression analysis. According to Saunders et al. (2019), when variables exhibit a linear relationship, a change in the dependent variable will lead to a proportional change in the independent variable. Researchers can use the predicted probability (p-p) plot to check for linearity (Fraza et al., 2021;

Saunders et al., 2019). Additionally, a plot of the data on a straight diagonal line from the bottom left of the plot to the top right will indicate a degree of evidence of linearity. Figure 4 illustrates that the linearity assumption has not been violated for the dependent variable project success. The result for the predicted probability plot for the independent variables indicates no violation of the assumptions. The p-p for cost overrun is depicted in Figure 5, and the p-p diagram for schedule overrun is presented in Figure 6.

Figure 4

Probability Plot Diagram for the Linearity of the Dependent Variable (Project Success)

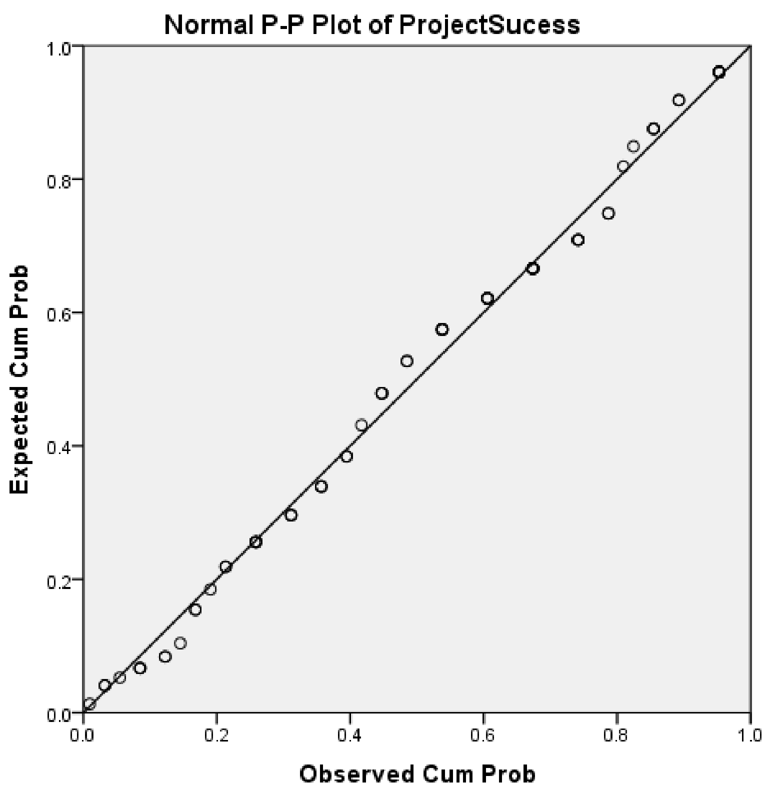


Figure 5

Probability Plot Diagram for the Linearity of the Independent Variable (Cost Overrun)

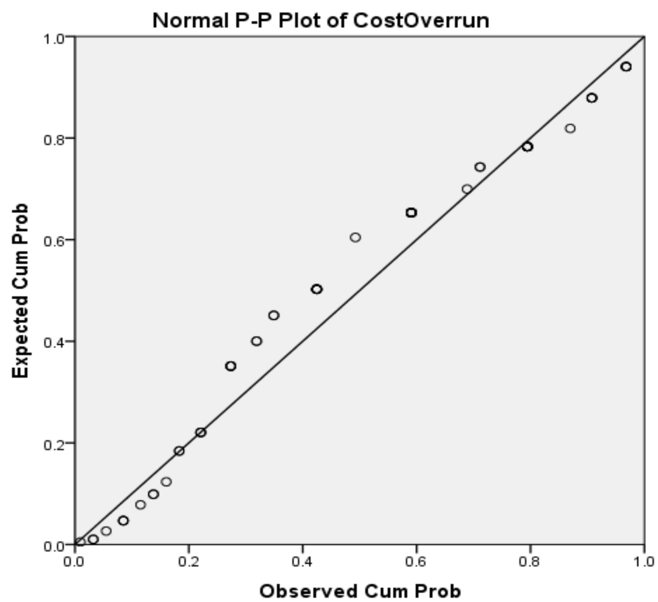
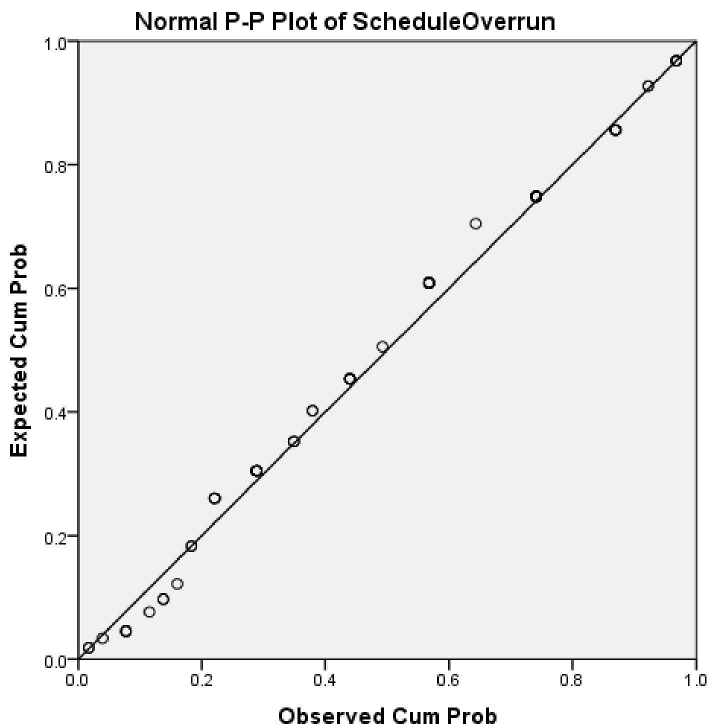


Figure 6

Probability Plot Diagram for the Linearity of the Independent Variable (Schedule Overrun)



Normality

The assumption of normality between the independent and dependent variables is significant in any regression analysis (Hopkins & Ferguson, 2014). Normality can be described as a statistical distribution defined by the mean and standard deviation of the variable data. Normality is also known as the bell-shaped curve (normal distribution) in statistical analysis. Gupta et al. (2019) used a curved histogram to ascertain normality between the independent and dependent variables, and I generated the statistical distribution for the dependent variable. The result of the bell-shaped curve shown in Figure 7 shows no violation of normality. I generated the normal quantile-quantile (Q-Q) plot for the dependent variable (project success), while all of the plot values tend towards the centre, indicating a normal distribution. Gupta et al. (2019)

concluded that researchers could use the Q-Q plot to check normality assumption. The result of the Q-Q plot is indicated in Figure 8.

Figure 7

Histogram for Normality of the Dependent Variable (Project Success)

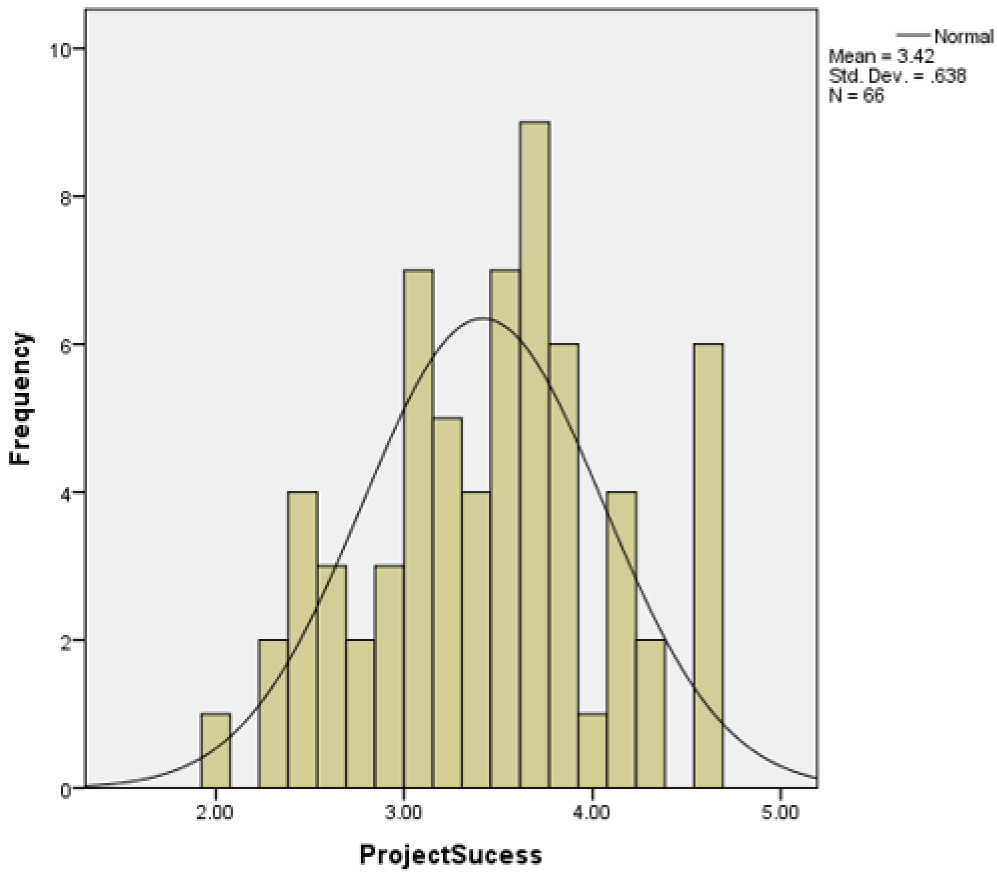
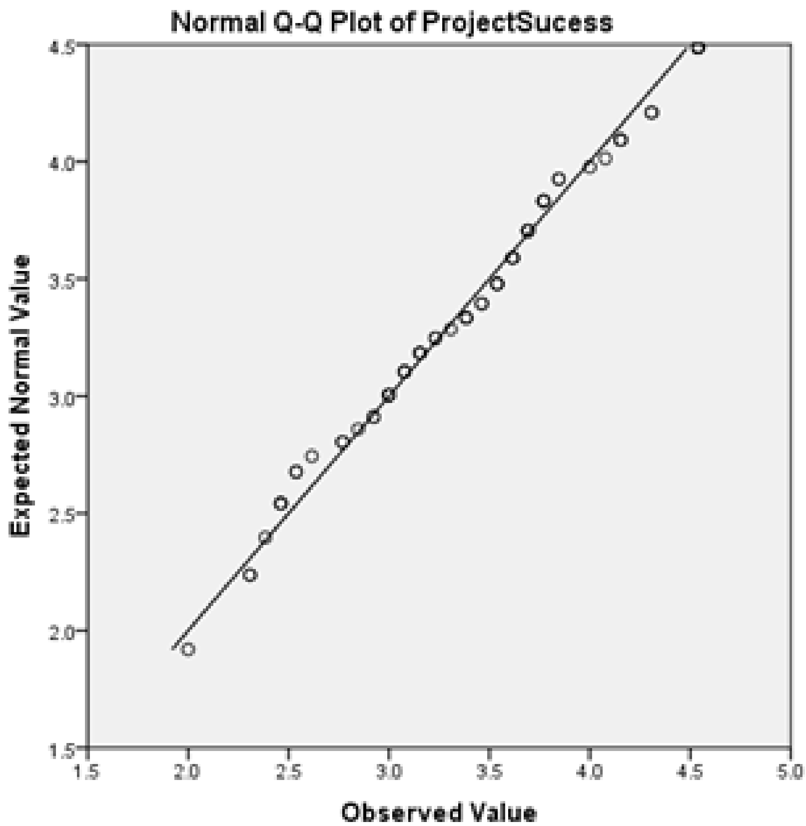


Figure 8

QQ Plot for the Dependent Variable Project Success

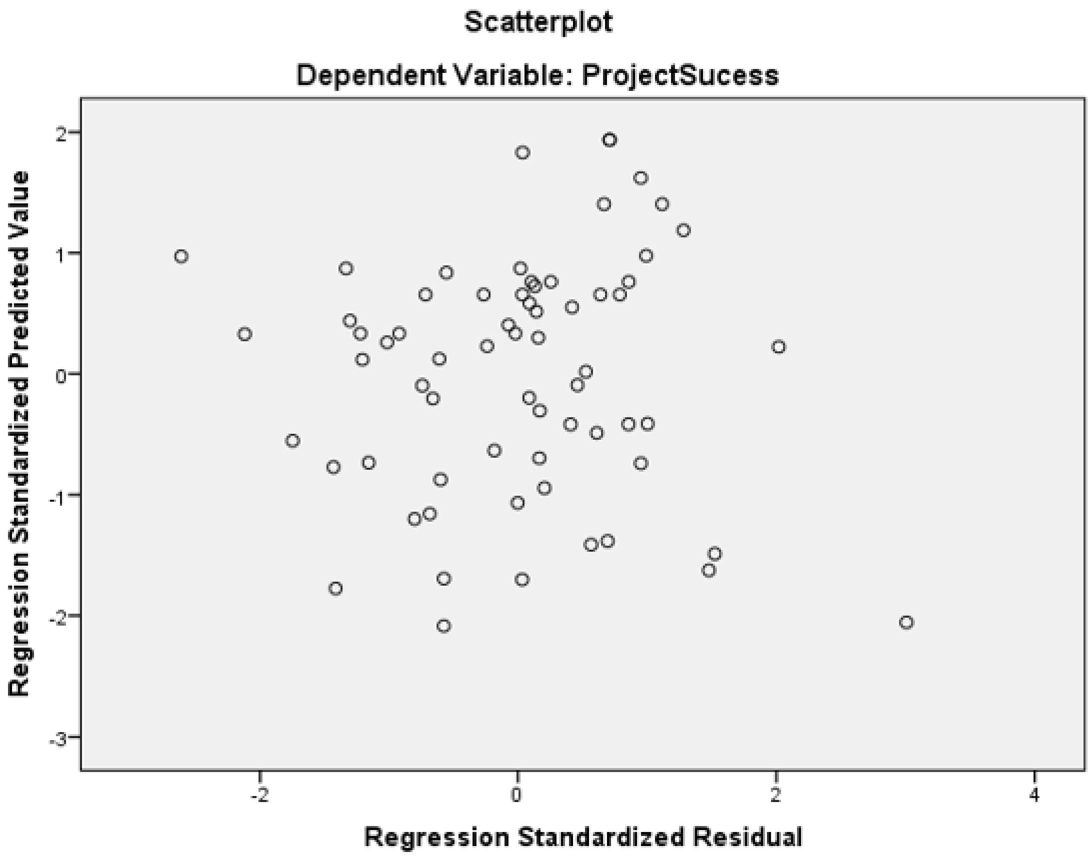


Homoscedasticity

The test for homoscedasticity is based on an assumption in a regression analysis to test for similar or equal variance in the independent and dependent variables (Abdullah et al., 2019). Saunders et al. (2019) claimed that the scatter plot diagram is used to test for homoscedasticity, such a test being salient because an uneven relationship between the variables has the potential to distort the result. A scattered number of rectangular plots of values indicate that the assumption of homoscedasticity was not violated (Flatt & Jacobs, 2019). The result in figure 9 shows a scattered rectangular plot indicating adherence to homoscedasticity.

Figure 9

Scatter Plot Diagram for the Homoscedasticity of Standardized Residual



Multicollinearity

Pambreni et al. (2019), researchers employ a multicollinearity test to find the degree of correlation between two or more independent variables. The two independent variables relevant to this study, namely cost and schedule overrun, would have been collinear if the correlation coefficient exceeded .80 (Khan, 2017; Saunders et al., 2019). Researchers may use the VIF to ascertain multicollinearity (Lavery et al., 2017). The assumption is satisfied if the VIF value is in the range of 1 to 10 (Kwan et al., 2016). I used Pearson's correlation to test for multicollinearity, but Runge (2014) claimed that a Pearson value of less than .80 implies no multicollinearity.

Table 4 shows a *p*-value of .1 and a correlation of .66; hence, the assumption of multicollinearity was not violated.

Table 4

Pearson Correlations for Independent Variables (Cost Overrun, Schedule Overrun)

		Cost Overrun	Schedule Overrun
Cost Overrun	Pearson Correlation	1	.573**
	Sig. (2-tailed)		.000
	N	66	66
Schedule Overrun	Pearson Correlation	.573**	1
	Sig. (2-tailed)	.000	
	N	66	66

Note. ** Denotes correlation is significant at the .01 level (2-tailed). N=66

Although there was generally no violation of any assumption, three cases of outliers in the dependent variable were observed. In order to overcome this issue of outliers, Hoxha (2017) suggested using bootstrap sampling with iteration=1000 for the purpose of eliminating the effect of outliers, and I used the bootstrap method (iteration=1000) to minimize this impact.

Inferential Results

For the current study, I conducted a multiple regression analysis by using IBM SPSS 24. This was undertaken at $\alpha = .05$ (one-tailed) and bootstrapping of 1,000 samples at 95% bootstrap confidence intervals in order to examine the correlation between cost, schedule overruns (independent variables), and the project success (dependent variable). The null hypothesis (H_0) exhibited no statistically significant relationship between cost overrun, schedule overrun, and project success. The alternative hypothesis (H_1) indicated a statistically significant relationship between cost overrun, schedule overrun, and project success. The research question involved how cost and schedule overrun affect project success.

The multiple regression results exhibited a linear combination significant relationship between cost, schedule overruns, and project success (see Table 5), F (2,63) = 19.002, $p < .05$. The sample multiple correlation coefficient (see Table 6) $R = .613$, the $R^2 = .376$ and the adj. R^2=.356 implied that approximately 36% of the variance of the dependent variable, and project success in the sample, could be predicted by the linear combination of the independent variables, cost, and schedule overruns. The null hypothesis of no statistically significant connection between cost overrun, schedule overrun, and project success was rejected. The alternative hypothesis of a statistically significant relationship between the above factors was accepted.

Table 5

Analysis of Variance Table (ANOVA)

Model	Sum of Squares	*df*	Mean Square	*F*	*Sig. (p)*
Regression	9.957	2	4.978	19.002	.000[b]
Residual	16.506	63	.262		
Total	26.463	65			

Note. Dependent variable (project success): Independent variables (cost and schedule overruns)

Table 6

Model Summary

Model	R	R^2	Adjusted R^2	Std. Error of the Estimate	F Change	df1	df2	Sig. F Change*(p)*
1	.613[a]	.376	.356	.51186	.376	19.002	2	63

Note. Dependent variable (project success). Independent variables (cost and schedule overruns)

Table 7

Regression Analysis Summary for Predictors Cost Overrun and Schedule Overrun

	Unstandardized Coefficients β	Bias	Std. Error	Sig. (2-tailed) *p*	95% Confidence Interval 95% Confidence Interval	
Variable					Lower	Upper
(Constant)	1.040	.014	.531	.054	.106	2.231
Cost Overrun	.165	.002	.145	.256	-.130	.459
Schedule Overrun	.462	-.006	.131	.002	.202	.726

Note. (N = 66) Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples and a dependent variable (project success).

As indicated in the coefficients in Table 7, no statistically significant relationship was apparent between the first independent variable (cost overruns) and the dependent variable (project success) because p = .256 exceeds .05. Nevertheless, a statistically significant relationship exists between the second independent variable (schedule overruns) and the dependent variable (project success) because $p = .002$ (being less than .05). Tabachnick and Fidell (2018) claimed that a single unit change in the independent variable would result in a change in the corresponding value of β in the dependent variable. Therefore, the unstandardized coefficients β=.462 show that a unit change in the value of schedule overrun will lead to .462 units of project success. The unstandardized coefficients β=.165 value of the cost overruns indicates that a unit change in the value of cost overrun will result in .165 units of project success. Alternatively, it may be deduced that the schedule overrun has 2.8 additional impacts on project success than on cost overrun. Schedule overruns have a greater effect on project success, while cost overruns have little or no impact.

Analysis Summary

The study's objective was to examine the relationship between cost, schedule overruns, and project success. I employed multiple linear regressions to analyze the data for the purpose of examining the correlation between the two independent variables and one dependent variable. I searched for violations of linearity, normality, outliers, multicollinearity, homoscedasticity, and outliers assumptions. No violations to these assumptions were found, with the exception of three outliers in the cost overrun, which were subsequently deleted.

The result of the multiple linear regression model was significant, where F (2,63) = 19.002, $p < .05$ the $R^2 = .376$, and the adj. $R^2 = .356$, thereby indicating approximately 36% of the variance of the dependent variable can be predicted by the linear combination of the independent variables (cost and schedule overruns). Therefore, I rejected the null hypothesis that there is no statistically significant relationship between cost, schedule overruns, and project success. I then accepted the alternative hypothesis that there is a significant statistical relationship between cost, schedule overruns, and project success. The statistical value of schedule overruns was β=.462, and p = .002, and cost overruns values was β=.165 and *p* = .256. Consequently, it may be deduced that the magnitude of the impact of schedule overruns on project success is greater than the impact of cost overruns on project success.

Theoretical Discussion of the Findings

The triple constraint model, or iron triangle, which Barnes developed in 1969, was the theoretical framework for this study. This constraint is a central concept of traditional project management practices representing the key project success factors: cost, schedule, and quality (Pollack et al., 2018). The management team can measure the project's success by aligning the final project variables, cost, schedule, and quality to the agreed criteria, while the movement of one criterion on the triangle vertices will influence the other two variables. If the team fails to complete the project on time, this could affect the cost and the quality criteria. Project success can be measured by other critical criteria such as stakeholder satisfaction, sustainability, client satisfaction, health and safety, and profitability; the criteria of the triple constraint are most relevant (Ike, 2022).

According to van Wyngaard et al. (2012), project managers are over-reliant on the progress measurement as they adhere to cost, time, and quality. This means that they create an illusion of the project progress because these criteria are insufficient to determine project success. Badewi (2016) argued that the triple constraint could limit the project management team in focusing on time, cost, and quality, while Ike (2002) concluded that ignoring other critical success criteria such as client satisfaction and benefits realization highlighted may lead to project failure. Some construction project managers do not understand the relationship between cost, schedule overruns, and project success, thereby causing a problem. The study confirmed a statistically significant relationship between cost, schedule overruns, and project success.

Some scholars agree that project progress monitoring regarding cost and schedule is the principal skill that a project management team needs (Annamalaisami & Kuppuswamy, 2019; Chadee et al., 2021). Other researchers contend that quality and resource optimization is the most critical factor in ensuring project success (Badewi, 2016; Geraldi et al., 2011; Jha & Iyer, 2007). Additionally, Pinto (2010) concluded that the three major elements for measuring project progress are scope, performance, and requirements.

I found that schedule overrun has a greater impact on project success when compared with cost overruns. This implies the possibility of a trade-off on the cost for the project schedule to achieve success. Lotfi et al. (2022) argued that project success requires scheduling, cost, resources, quality, and stakeholder management trade-offs to achieve project success in the construction industry. Also, Montenegro et al. (2021) argued that in addition to triple constraint components, project success criteria should include client satisfaction, benefits realization by the organizations, project management team, and stakeholders, end-user satisfaction, the strategic objective alignment, organizations and business success.

Moghadam et al. (2019) contended that project execution encounters various uncertainties. Therefore, the project team should implement strategic trade-off plans concerning cost, time, and quality to attain success. Luong et al. (2018) stated that project cost, schedule, and quality are crucial in achieving project success. The project management team needs to implement trade-off optimization to gain the intended benefit and deliver on time. Managers can plan project construction effectively and implement control measures by adopting trade-off project success criteria (Tran et al., 2019).

Applications to Professional Practice

Project success improves knowledge, process, and resources management while improving an organization's competitive advantage (Irfan et al., 2019). Project failure leads to a waste of expenditure and a loss of competitive edge for an organization (Einhorn et al., 2019). According to Berggren (2019), traditional project management considered innovation and project management as uninteresting topics in the same way as the project's cost and schedule, as long as good quality is obtained. Innovation helps an organization benefit from external expertise and knowledge, enhancing project success (Guertler & Sick, 2021). Poor data and schedule management practices can reduce the profit margins and the changes in the success of a project (Bilal et al., 2019). Khraiche and Alakshendra (2021) claimed that cost overruns are caused by poor cost estimation, and contractors rely on the outdated traditional bid process, favouring cost over efficiency and innovation.

A successful project must satisfy the agreed cost, time, and detailed contract specifications (Roumeissa, 2019). Nevertheless, Goldsmith and Boeuf (2019) concluded that risk analysis, stakeholder involvement, and project finance repayment are also critical factors in achieving project success. Factors such as project uncertainties regarding clear scope, complexity, opportunistic contractors, poor communications, and innovation by the project team could influence the project's successful completion concerning cost and schedule (Odusanya et al., 2021). The project management teams should attempt to identify the early signs of these factors to ensure that appropriate cost and time estimations are applied. The policymakers in a nuclear construction organization could use this study to train their project teams and improve their management, project controls, and stakeholder management. Project leaders can achieve successful commitments by adapting to the flexibility and visibilities required by changing leadership styles (Zaman et al., 2019).

Implications for Social Change

Business leaders should strive to reduce costs and schedule overruns to enhance project success. The implication of positive social change includes the potential for project managers to better understand the relevance of the relationship between cost, schedule overrun, and project success. By applying the findings of this study and understanding the importance of the relationship between the research variables, managers could improve the project's success not only by focusing on the triple constraint elements (cost, time, and quality) but also on other factors such as complexity, resource management, control, innovation, opportunistic contractors, and risk management.

Operation failure leads to notable financial setbacks for project shareholders. Poor project effectiveness may result in a financial catastrophe, having the potential to cause damage to business income. It could also reduce the sustainable development of economies and lead to a limitation on community growth. A rise in the construction's positive outcome might significantly influence operational efficiency, financial viability, the standard of living, business growth, and labour supply (Scheuchner, 2017). A successful increase in project percentages could enhance native societies' well-being and consequently lead to a favourable transformation.

In my organization, I would schedule a meeting with project managers, construction managers, and project planners to analyze the research outcome and to investigate new approaches to enhancing construction productivity. The latest results indicate the relationship between project cost, schedule overrun, and project success in the United Kingdom's nuclear construction industry. The report's validated observations will offer researchers micro-level data concerning construction variables that determine project success. Enhanced project success has the potential to improve company performance and competitive advantage (Shahzadi et al., 2021), as well as to boost the sustainable development of markets, improve care quality, expose commercial opportunities, and increase the number of jobs.

Recommendations for Action

Although the significance of projects for an organization's competitive advantage is growing, project failure is frequently experienced in most industry sectors. Incorporating nuclear construction project management techniques could provide managers with the necessary strategic initiatives to reduce project costs, reduce schedule overruns, enhance the potential of project success, and gain benefit from the realization of such projects. In this research, I focused on project cost and schedule overrun as two project success variables influencing project achievement in the UK nuclear construction industry.

Findings reveal that the participants agreed that cost overruns reduce project success and increase the possibility of project failures. Schedule overruns are similar since they cause delays in initiating and completing project work and, in certain cases, result in project failure as schedule overruns delay the completion of the project. Simushi and Wium's (2020) research aligns with these results in that the principal cause of cost overruns appears to be a lack of extensive planning. Consequently, organizations and management teams could use the research findings to improve their project management techniques. I am an engaged LinkedIn subscriber with over 500 connections, most of whom are project managers and planners. Therefore, I will post the research results on my LinkedIn profile to publicize the report's findings, thereby distributing the results to a larger audience. Additionally, I will submit the research to peer-reviewed journal articles for publication to add value to the project management book of knowledge.

Recommendations for Further Research

This research was conducted in the United Kingdom, whose wealth and accelerated development may have influenced the orientation of project factors in order to favor costs and schedule overrun. Therefore, it is recommended to conduct research among a larger population in numerous different nations to justify the findings of this research in comparison with that of other nations. For future analysis, it is recommended to investigate the correlation between different variables such as stakeholder management, communication, project location, and culture by using project implementation datasets.

Reflections

My experiences in project cost and schedule overruns in all projects I have worked on prompted me to pursue a master's degree in project management. I needed to understand the causes of these overruns in a project and how they affect project success, which involved a doctoral journey with its benefits and challenges. Working in the nuclear construction industry made me realize that certain project managers lack an understanding of the implication of cost and schedule overrun on project success. Research findings and literature reviews can help project managers improve their organizations' success by understanding the cause of cost and schedule overruns. Initially, I intended to explore the cause of cost and schedule overruns, but scholars have previously written about these topics. I found that the sensitive nature of nuclear projects will deter some participants from giving information without remaining anonymous.

I believe in the school of thought which argues that projects always experience cost and schedule overruns. Delivering the intended advantages is the main aspect of attaining project success. The result of this study has changed my professional bias, by which I have concluded that project cost and schedule overrun greatly affect delivering project success for an organization. Project managers need to control costs and schedules to ensure project success, and doctoral study completion requires dedication, consistency, and adherence to specific guidelines. Since this project is unique, it should be treated as such to ensure success. After scrutinizing my budget, I realized that my initial estimate for this doctoral study project was behind schedule; nevertheless, I believe this was a successful journey. There were times when I saw no progress and also times when family requirements took priority. There were times when financial constraints meant that I was unable to register for another semester, but the good end has justified the means. I continue to picture myself on the podiums and people calling me “Dr Osadare.” The entire process has been educative and rewarding.

As a competent project manager, my goal for this research was to identify the root causes of ineffective project success, and I presupposed a quantitative analysis method. I understood that time, cost, quality, and schedule overrun are important factors that influence project success. Otherwise, I realized the presence of other variables that impact the success of a project. Eventually, when I began the study, I had only a primitive understanding of project conceptual frameworks. During my investigation, I had the opportunity to investigate additional concepts and approaches which would help me in my professional and academic future. This research broadened and deepened my understanding of the nuclear construction industry in the United Kingdom.

Conclusion

The objective of this research was to examine the relationship between cost, schedule overrun, and project success. The multiple linear regression model result revealed a statistically significant relationship between cost, schedule overruns, and project success. Nevertheless, the effect of project schedule overruns on success is more perceptible than that of cost overruns. The result indicated that success could be increased when the project manages to provide further focus to the schedule than to the cost. The project management team in an organization needs to adopt trade-off strategies to improve project profitability, success, and organization to a competitive advantage.

This research could help organizations and managers improve their project management techniques, strategies, tools, techniques implementation, regulations, and leadership, thus enabling them to create a reasonable and efficient project execution methodology. The weaker relationship between cost and project success and the stronger connection between project schedule and project success presents a clear trade-off option for future project managers in nuclear construction in the United Kingdom.

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Appendix 1: Survey Questions

RELATIONSHIP BETWEEN COST, SCHEDULE OVERRUNS, AND PROJECT SUCCESS IN THE NUCLEAR CONSTRUCTION INDUSTRY IN THE UNITED KINGDOM - SURVEY QUESTIONS 2

DEMOGRAPHIC VARIABLES

Age

- ◯ 18-24 years
- ◯ 25-29 years
- ◯ 30-39 years
- ◯ 40-49 years
- ◯ 50 years and above

Position at HPC power stations

- ◯ Project manager
- ◯ Project director
- ◯ Project control manager
- ◯ Project planner
- ◯ Delivery Integration Managers
- ◯ Construction Managers

Experience or exposure to nuclear construction projects

- ◯ 1 year
- ◯ 2 to 4 years
- ◯ 5 to 9 years
- ◯ 10 to 14 years
- ◯ 15 years and above

COST OVERRUN

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1. Frequent design changes at any stage of the project life cycle are the cause of cost overrun	○	○	○	○	○
2. Project scope alterations are the cause of cost overrun	○	○	○	○	○
3. Lack of detailed planning is the cause of cost overrun	○	○	○	○	○
4. Design errors on an aspect of the project are the cause of cost overrun	○	○	○	○	○
5. Site conditions (such as quality of the cement being used, site surroundings) are the cause of cost overrun	○	○	○	○	○
6. Lack of client project knowledge causes cost overrun	○	○	○	○	○
7. Opportunistic contractors who take advantage of the client causes cost overrun	○	○	○	○	○
8. Price fluctuations of material resources are the cause of cost overrun	○	○	○	○	○
9. Poor financial management is the cause of cost overrun	○	○	○	○	○
10. Incompetence and inexperience of project managers are the causes of cost overrun	○	○	○	○	○
11. Lack of stakeholders'(subcontractors) skills are the cause of cost overrun i.e. The stakeholders are subcontractors that are executing some scope of work on the project	○	○	○	○	○
12. Poor estimating technique of material cost contributes to the changes in project cost.	○	○	○	○	○

SCHEDULE OVERRUN

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13. Lack of scheduling knowledge by the project team is the cause of schedule overrun	○	○	○	○	○
14. Lack of planning knowledge by the project team is the cause of schedule overrun	○	○	○	○	○
15. Lack of control of site operations are the causes of schedule overrun	○	○	○	○	○
16. Insufficient experience of the contractor is the cause of schedule overrun	○	○	○	○	○
17. Lack of cash flow management experience by subcontractors is the cause of schedule overrun	○	○	○	○	○
18. Lack of monetary experience by subcontractors is the cause of schedule overrun	○	○	○	○	○
19. Poor site administration between different stakeholders is the cause of schedule overrun NB Stakeholders are the ones who are affected positively or negatively by the project	○	○	○	○	○

20. Inadequate management of site scope configuration often leads to schedule overrun NB: Configuration management is a project scheduling process for establishing consistency of a product's attributes throughout scope sequence.	○	○	○	○	○
21. Poor site handover coordination between different stakeholders is the cause of schedule overrun	○	○	○	○	○
22. Poor cashflow management among contractors is the cause of schedule overrun	○	○	○	○	○
23. Disputes among stakeholders is the cause of schedule overrun i.e. Stakeholders are the ones who are affected positively or negatively by the project	○	○	○	○	○

PROJECT SUCCESS IN THE NUCLEAR CONSTRUCTION INDUSTRY

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
24. Poor estimating technique of the cost material impacts project success	○	○	○	○	○
25. Achieving tasks of social responsibilities such as building sports amenities, good roads, and student scholarships by the project owner leads to project success. NB. Project owners have to act in the best interests of the project environment, and society as a whole	○	○	○	○	○
26. Enhancing positive corporate reputation leads to project success	○	○	○	○	○
27. Project team behavior culture focused om health and safety leads to project success	○	○	○	○	○
28. Senior administration support leads to project success	○	○	○	○	○
29. Clear organisational structure of the project leads to project success	○	○	○	○	○
30. Clearly defined roles and responsibilities of project team lead to project success	○	○	○	○	○

31. The ability of the project team to adapt leads to project success	○	○	○	○	○
32. Application of management programs lead to project success NB Project management programmes includes but not limited to: budget forcasting, financial controls, risk management and contract management.	○	○	○	○	○
33. Active engagement on the project by regulatory body leads to project success NB Regulatory bodies includes: Office for Nuclear Regulation (ONR) and The Nuclear Regulatory Commission (NRC)	○	○	○	○	○
34. Use of qualified workforces lead to project success	○	○	○	○	○
35. Efficient control of financial resources by project managers lead to project success	○	○	○	○	○
36. Efficient control of schedulling measures lead to project success	○	○	○	○	○

Which of the question above (1 to 36) does not justify the research question?

Are there any questions that should be included to the questionnaire that would better align with the research questions?

Is there any of the questions that needs to be rewritten for clarity? If yes which one and what would be a better phrase?

Is the questionnaire completion process simple and clear? If no what can be done to make the process clearer and simpler for future participants?