Taxonomy of The Causes of Cost Overrun in Building Construction Projects

Maina Joseph Jatau

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Prof. Dr. Ali Hakan Ulusoy
Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science in Civil Engineering.

Prof. Dr. Umut Türker
Chair, Department of Civil Engineering

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Civil Engineering.

Assoc. Prof. Dr. Tolga Çelik
Supervisor

Examining Committee

1. Prof. Dr. Hüseyin Gökçekuş
2. Assoc. Prof. Dr. Tolga Çelik
3. Asst. Prof. Dr. Umut Yıldırım

ABSTRACT

In general, time and cost variations versus its objective represent the performance of the construction project. Most studies have spent much time finding and assessing potential causes that might overcome construction costs in the past and have linked their studies to the impact and cost overrun causes. A deeper knowledge of the factors that cause cost overrun is however necessary from the viewpoint of the parties concerned in the construction industry (client/owner, contractor and consultant), in this case in Iran and Nigeria as regions of concern. Cost overrun causation causes vary according to geography and political, economic, and cultural considerations. This study aims to check the level of agreement between the parties involved from their different point of view. Also, the level of agreement between Iran and Nigeria on the causes of cost overrun in building construction projects by applying the Mann Whitney U test, Kruskal-Wallis H test, and Post hoc test parametric tests. And finally, using the relative importance index and Pareto analysis, discover the most important factors causing cost overruns in building projects. A new parameter was introduced, Manageability, in the evaluation of risk assessment (i.e. the product of the probability of occurrence and impact) because of the capacity of people to cope with each risk factor. As a result, the goal of this study is to discover and categorize possible cost overrun causes from a new perspective by utilizing a systematic framework to extract the components from an extensive literature analysis and rating the most important cost overrun factors.

Keywords: Cost overrun, Factors, Risk, Iran, Nigeria, Clients, Contractor, Consultant, Parametric, Non-parametric, Quantitative Analysis.

ÖZ

Genel olarak, amacına göre zaman ve maliyet değişimleri, inşaat projesinin performansını temsil eder. Çoğu çalışma, geçmişte inşaat maliyetlerinin üstesinden gelebilecek potansiyel nedenleri bulmak ve değerlendirmek için çok zaman harcamış ve çalışmalarını etki ve maliyet aşımı nedenleriyle ilişkilendirmiştir. Bununla birlikte, inşaat sektöründeki ilgili tarafların (müşteri/mal sahibi, müteahhit ve danışman), bu durumda endişe duyulan bölgeler olarak İran ve Nijerya'da, maliyet aşımına neden olan faktörlerin daha derin bir bilgisi gereklidir. Maliyet aşımlarına neden olan nedenler, coğrafyaya ve siyasi, ekonomik ve kültürel hususlara göre değişir. Bu çalışma, taraflar arasındaki anlaşma düzeyini farklı bakış açılarından kontrol etmeyi amaçlamaktadır. Ayrıca, Mann Whitney U testi, Kruskal-Wallis H testi ve Post hoc test parametrik testleri uygulayarak bina inşaat projelerinde maliyet aşımlarının nedenleri konusunda İran ve Nijerya arasında anlaşma düzeyi. Ve son olarak, göreli önem indeksini ve Pareto analizini kullanarak, bina projelerinde maliyet aşımlarına neden olan en önemli faktörleri keşfedin. İnsanların her bir risk faktörü ile başa çıkma kapasitesi nedeniyle, risk değerlendirmesinin (yani meydana gelme olasılığının ve etkinin ürünü) değerlendirilmesinde yeni bir parametre olan Yönetilebilirlik tanıtıldı. Bu nedenle, bu çalışma, kapsamlı bir literatür taraması yoluyla faktörleri çıkarmak için sistematik bir çerçeve uygulayarak ve maliyet aşımına neden olan en etkili faktörleri sıralayarak, olası maliyet aşım faktörlerini farklı bir bakış açısına göre tanımlamaya ve sınıflandırmaya odaklanmaktadır.

Anahtar Kelimeler: Maliyet aşımı, Faktörler, Risk, İran, Nijerya, Müşteriler, Yüklenici, Danışman, Parametrik, Parametrik Olmayan, Kantitatif Analiz.

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INTRODUCTION

1.1 Background

Clients are becoming increasingly concerned about the construction industry's incapacity to complete projects on time and within budget. Cost overruns are a typical occurrence throughout the world, but they are especially problematic in developing countries. In both developed and developing countries, the construction industry plays an important role in economic and social growth (Niazi & Painting, 2017). To comprehend the project performance and hence to understand the financial risks involved in project execution, it is vital to measure the cost variation in construction. The cost variance, resulting in the overrun of project costs, is shown to have a negative economic impact and profitability. In the existing literature, various perspectives on cost overrun are available and demonstrated to be relevant. However, why the cost overrun continues, while the appropriate information of overruns is extensively shared, is not adequately explained (Cindrela Devi & Ananthanarayanan, 2017).

It is not rare to see that a construction project does not reach its objective within the given cost despite its proven importance. Cost overrun is a highly common event and is almost linked to all building industry projects. The overrun of the costs can only be determined by exceeding the original cost of the project (Cindrela Devi & Ananthanarayanan, 2017).

Most studies have put a lot of effort into finding and assessing probable explanations for current building cost overruns, and have linked their research on the effect and source of cost overruns (Karunakaran et al., 2018). However, a better knowledge of the reasons that cause cost overruns from the standpoint of the stakeholders (client/owner, contractor, and consultant) in the construction sector, particularly in Iran and Nigeria, is required. As a result, the goal of this study is to discover and categorize possible cost overrun causes from a new perspective by utilizing a systematic framework to extract the components from an extensive literature analysis and rating the most important cost overrun factors.

1.2 Statement of Problem

Most researchers in their work on this topic fail to distinguish between parametric and non-parametric tests. If in any case any of the criteria of assumption of the parametric test is violated, the results from the test will become inconsistent and unreliable. Therefore it is recommended that before these statistical tests are carried out that the criteria be checked. In the case of this study, there were violations in the assumption of parametric test thereby leading to the adoption of non-parametric tests. Also, in the evaluation of risk, researchers usually factor in only impact and probability of occurrence. Because people have the tendency and capacity to respond to risk, it is important to also consider the coping capacity (manageability) of the risk together with the impact and probability of occurrence. It is important to note that the coping capacity has an inverse relationship with impact and probability of occurrence. This means that the higher the coping capacity, the lower the risk.

1.3 Research Questions

The following are the research questions that aimed to be addressed in this study:

- How could the factors that cause cost overruns in construction projects be determined?
- How would the interrelationships between the factors from the perspective of the client, contractor, and consultant be explored?
- How the factors causing cost overrun would be ranked in terms of frequency, impact, manageability, and total risk?
- How would the causal factors be analyzed using qualitative risk analysis to determine the most influential factors causing cost overrun?

1.4 Scope and Objectives

The execution of projects on budget, on schedule, and with the satisfaction of the client's needs is one of the most essential elements for project success. The completion of projects within the budget is even more crucial in the construction sector, as enterprises are working on small margins. A project is a difficult undertaking, even with various cost management software and technologies, cost overruns are not rare globally in construction projects (Ramabhadran, 2018). In the construction sector and among the key players, cost overrun is common. Cost overruns could lead to the abandonment of projects and a drop in the industry's building activity. They can earn a poor reputation, which leads to the non-obtainment or higher cost of project funding due to greater risk. Cost overruns suggest that more money is spent above what was agreed initially and results in lower investment returns for the client (Ahady et al., 2017). Poor cost performance has been a serious worry for all stakeholders involved in the building project. Cost overrun causation causes vary according to geography and political, economic, and cultural considerations. This study aims to check the level of agreement between the client, contractor, and consultant on their point of view on the causes of cost overrun. And also, the level of agreement between Iran and Nigeria on the causes of cost overrun in construction projects. And finally, determine the most influential factors causing cost overrun in construction projects. The regions of concern in this study are Nigerian and Iran. The research objectives below address the research questions:

- To determine the factors that cause cost overruns in construction projects.
- To analyse the interrelationships between the factors from the standpoint of the client, contractor, and consultant.
- To rank the factors in terms of frequency, impact, manageability, and total risk.
- To analyze the causal factors using Pareto analysis to determine the most influential factors causing cost overrun.

1.5 Research Contribution and Novelty

The approach adopted in this research was the best possible way of collecting data for a non-structured complex problem. The data used in this research was collected through a quantitative survey conducted and distributed to building construction stakeholders from Iran and Nigeria. It is evident that in most researches, researchers rank the most influential factors causing cost overrun by factoring only the probability of occurrence and impact to determine the risk level. In this study, another parameter, the Manageability of risk (coping capacity) is taken into consideration in the evaluation of the risk value of each factor. Since people may react to risks actively, their coping capacity, C, should thus be included in risk assessment (Boudreau, 2009). This way, the risk value will simulate a more accurate representation. Also, this study examined the assumptions of parametric statistical tests and thus discovered that some assumptions were violated therefore leading to the adaptation of non-parametric statistical tests instead. This way the level of agreement between the two regions and between the building construction stakeholders involved in this study (client, contractor, and consultant) could be properly determined.

Although the outcomes of this case study are intriguing, there are opportunities for this work to be continued. The study deals only with the construction sector of two regions with similar conditions (i.e. Iran and Nigeria) and was greatly influenced by the factors that caused overrun in costs extracted through the systematic framework developed for this study from the relevant documents. Additional research shall verify if the results could be generalizable for the broader construction area and other regions. Moreover, future research could look at convergent solutions for alternative approaches for minimization of dimensionality to mitigate causes and perhaps the effect of costs in the construction industry.

1.6 Organization of Thesis

The structure of this study involved five chapters which are: Introduction, Literature review, Methodology, Result and discussions, and Conclusion. Chapter 1 is the introductory part of this study which emphasizes the background of the study, statement of the problem, research questions, scope and objectives, and the research contribution and novelty. Chapter 2 emphasizes a comprehensive and elaborate literature review that introduces cost overrun and its consequences, risk identification, assessment, and prioritization. Chapter 3 explains the systematic framework developed for this study and the statistical test adopted to synthesize and analyze the data collected. The developed framework is shown in figure 1. Chapter 4 discusses the results obtained from all the statistical tests performed. Lastly, chapter 5 concludes the study and gives recommendations. It summarizes the results and observations from the study and provides an area for further research.

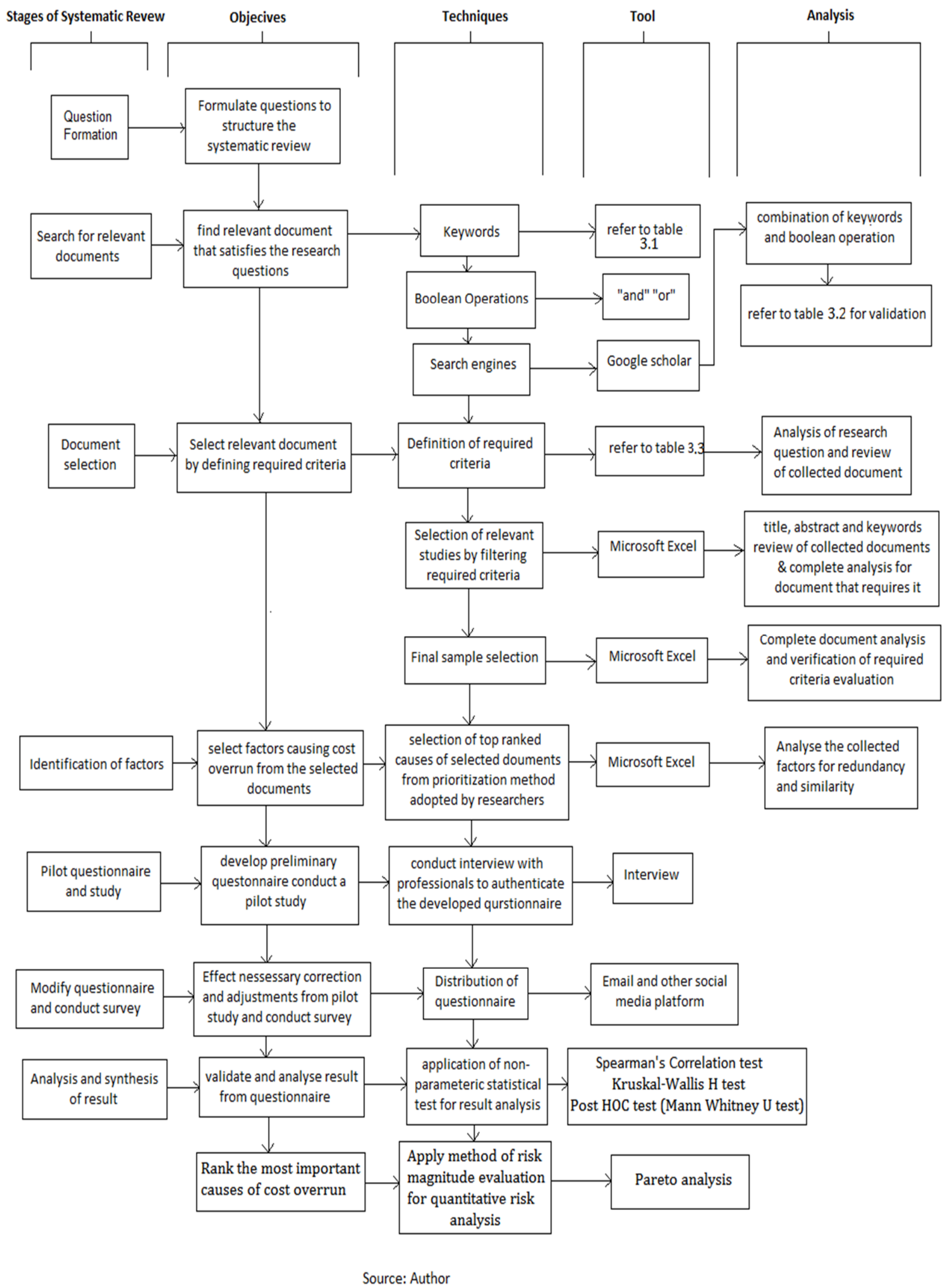

Figure 1. 1: Methodology systematic framework

Chapter 2

LITERATURE REVIEW

2.1 Cost Overrun

Cost overruns in construction are common across the world, however the situation varies by nation. The variance is influenced by a variety of elements such as a country's economics, geographical location, and building conditions. The existence of many interest groups such as consultants, contractors, project owners, end-users, financiers, project money, materials, equipment, economic, climatic, and political settings, and so on are all examples of such elements. The ratio of the change in the initial contract amount to the original contract award amount is known as cost overrun (Ahady et al., 2017). The cost overrun can be translated into a percentage figure for ease of comparison. It can be stated mathematically as:

$$\text{Cost overrun} = (\text{Final Amount} - \text{Original Amount}) / \text{Original Amount}$$

Cost overrun refers to the difference between the final cost of a construction project and the contract amount agreed upon by the contractor and the owner when the contract was signed. Cost escalation, cost increase, and budget overrun are all terms used to describe cost overrun (Ahady et al., 2017).

Cost overrun is defined as the amount by which actual costs exceed projected costs when measured in local currency, with constant pricing, and against a consistent baseline. Overrun is often represented as a percentage of the projected cost, with a positive number indicating overrun and a negative number indicating underrun. The amount, frequency, and distribution of cost overrun should all be considered when determining cost overrun for a given investment type (Ahady et al., 2017).

According to (Ramabhadran, 2018), comprehensive study of the elements that cause cost overruns in building projects throughout the globe (like Vietnam, Nigeria, Ghana, Kuwait, Turkey, Malaysia, Libya, Pakistan, and Indonesia). Cost overrun is a typical occurrence in building projects all around the world, according to their research.

Throughout the lifecycle of a project, the cost is one of the most important factors to consider. Unfortunately, the majority of the projects did not finish on time or within budget. Cost overrun, in addition to time overrun, is a critical issue in the construction business. In Nigeria, the trend is more pronounced, with cost overruns often exceeding 100% of the project's original budget (Bamitale et al., 2019).

Project cost overrun is defined as the positive difference between the actual cost upon project completion and the agreed estimation of the project budget (Derakhshanalavijeh & Teixeira, 2017).

One of the most crucial markers of project success is cost variance. It is not only a measure of the company's profitability but also of the organization's productivity at any point during the construction process. Despite its obvious importance, it is uncommon to see a project completed on time and on a budget (Gunduz & Maki, 2018).

When it comes to project cost variance, cost overruns are a global issue, particularly in the construction industry, and its consequences are generally a source of dispute among clients, consultants, and contractors. Clients are exposed to a significant financial risk due to project cost overruns. Regardless of the danger, the construction industry's history is replete with projects that were completed with significant cost overruns (NEGA, 2008).

The term "cost overrun" refers to when the project's true or actual costs surpass the budgeted amount. The entire money spent for the project's construction by the spending agency is known as the project's real costs. The project's budget shows the estimated costs that were assigned to the project before its start and served as the basis for its evaluation. Cost overrun is one of the most common financial manifestations of these risks (Berechman & Chen, 2011). This discrepancy, it may be claimed, simply reflects changes in the project's scope, engineering design, or quantities required during construction, and hence should not be considered a cost overrun. To this reasoning, there are two main answers. First, why are these cost considerations unaccounted for in the project's intended budget, given the regularity of cost overruns and their magnitude? Is it because doing so diminishes the chances of the project being implemented? Second, any additional expenditures incurred as a result of a cost overrun must be covered; given the total budget constraint, this inevitably means that some other projects will be cancelled (Berechman & Chen, 2011).

2.2 Consequences of Cost Overrun on Projecst and Consideration as a Potential Risk to Projects

Cost overrun has clear implications for construction and major stakeholders. Cost overruns could lead to the cancellation of projects and a decline in construction works. These may generate a poor reputation and therefore make it unable to seek or secure project finance due to additional concerns. Cost exceeds signify greater costs to the client/owner, which exceeds the initially negotiated cost, which leads to lower investment returns. For the contractor, it signifies loss of earnings because of incompleteness and defamation which could imperil the contractor's prospects of gaining more work if it's the contractor's fault. The extra costs are transferred to the end-user as higher costs or rental fees or rates. It suggests for professionals the failure to provide the worth of the money and could damage their reputation and lead to the loss of the value of the client/owner (Ahady et al., 2017).

In construction projects, poor cost performance was a key issue for the client/owner, contractor, and client. Despite many reports of poor performance, the cost overrun of all project activities, ranging from the simplest to the more complicated, including nuclear power plants, transport systems, and oil-and-gas platforms, appears to have become progressively high for construction projects. As a result, many construction companies, particularly in the private construction sector, encountered successive financial constraints, which sometimes led to insolvencies and bankruptcy (Annamalaisami & Kuppuswamy, 2019).

The increased capital-output ratio in the sector, which has a consequently negative influence on the global economy, will have a negative impact on infrastructure procurement. For example, cost and schedule overruns were highlighted as major drivers for project abandonment and a high incidence of contract failure (Gbahabo & Ajuwon, 2017).

2.3 Categorization of Cost Overrun Causes Based on Different Literature Perspectives

2.3.1 Construction Project Life Cycle

Projects follow a predetermined life cycle or pattern. There are many stages in a project life cycle in which the results are developed and the deliverables are approved. The simplest way for us to understand it is that somehow the project needs to start – so the starting phase begins with the seed of a project concept and concludes in a decision to carry out the project (or at least the decision to plan it in further detail and decide whether to carry it out.) In the middle period, a combination of project planning and execution is carried out in most projects. Before starting any project work, the most methodical strategy would have completed all planning. The final step in a project life cycle, completed, begins with project clients formally accepting project results and ends with the completion of all deliverables, comprehensive documentation, resource assignments, etc. (Assudani, 2008).

The processes involved in Project management are grouped into five categories known as project management groups/process groups (APM, 2008);

- The Initiating process group: Processes that are completed by obtaining authorization for a project or phase start to specify a new project or phase of an existing project.

- The Planning process group: Processes for defining the project's scope, improving objectives, and determining the actions required to achieve the project's goals.
- The Executing process group: methods must comply with project specifications established in the project management strategy.
- The Monitoring and controlling process group: the processes necessary to monitor, review and regulate project progress and performance; determine any areas where changes to the plan are necessary and initiate commensurate changes.
- The Closure process group: steps carried out to complete all activities in all process groups to finish the project or phase formally.

2.3.2 Construction Project Stakeholders

Stakeholders in the project are individuals who can influence and affect the project. The project stakeholders in the context of the project literature, the main stakeholders for the project success must be identified. Project managers must identify all stakeholders, establish which stakeholders are most important, establish ties with at least key stakeholders and communicate effectively with all stakeholders. One technique to identify stakeholders is to find out who can influence the project and who can influence it. These effects can be beneficial to assist the project to succeed or negative to make it harder for the project to succeed. These consequences can be either for the project process or the outcomes. To further provide or withhold resources, define project needs, people, and communication questions some researchers break down the impact on the project process (Assudani, 2008). Most researchers in the literature group the factors affecting cost overrun into the contractor, project manager, client, supplier, and consultant.

2.3.3 Other Categories

Cost overrun factors can be categorized into several categories. A set of cost overrun variables, for example, can be included in the group of cost overrun factors (Karunakaran et al., 2018);

- External or environmental issues are unavoidable for the project parties.
- Factors that can be compensated (Instances where parties can minimize cost overruns by avoiding certain conditions).

Another research split the factors into two categories, but the groups were distinguished as follows:

- Construction stakeholders (client, contractor and consultant) it is also referred to as an Internal factor.
- As a result of an external factor (an event that is beyond the control of the parties to a deal).

A group of academics improved and classified the components that lead to cost overruns, as indicated in Table 2.1 below. (Karunakaran et al., 2018).

Table 2. 1: Group categorization of causative factors of cost overrun

Sources	Categories	Number of categories
Ameh et al (2010)	Estimation of costs and funding in the areas of environmental, construction, construction goods, and construction items	5
Zewdu & Aregaw (2015)	Construction item estimation, project participant estimation, environmental estimation, and funding	5

2.4 Risk Identification

Risk identification in a process of risk management entails the definition of risks that may influence the project before documenting the characteristic (Razi et al., 2018).

It is crucial to ensure that the widest range is identified in the risk identification process since the risks missing in this step cannot be analyzed and discussed in the following steps. It is a good idea to collect all information sources at the start of the risk identification process. These sources are the process inputs. A "risk list" includes the risks highlighted by the information sources. A complete "risk list" is the fundamental output of the risk identification procedure (Kasap & Kaymak, 2007).

Risk Identification identifies and records the risks that can harm the project. The following stakeholders may be involved in the risk identification: project managers, project team members, risk management teams (if assigned), non-project experts, clients, end-users, and risk management professionals. Risk identification is an iterative process because the project moves through its life cycle and new risks can be known (Mojtahedi et al., 2010).

2.4.1 Method of Risk Identification

- **Documentation reviews**: To identify areas of inconsistency or lack of clarity, include the thorough analysis of project documentation and assumptions from the project overview and a detailed perspective. Indicators of a hidden danger are lack of information and inconsistency (Kasap & Kaymak, 2007). Depending on what is included and what is not included in the early project scope declaration, the project charter and following papers may help detect hazards. Learning, articles, and other materials may also serve to disclose dangers. The document review shall be carried out from an overall project perspective as well as from a single project or activity level, to assess project plans, hypotheses, and historical data. This examination assists the project team to identify risks related to project goals. Planning quality and coherence should be considered. (Eldash, 2015).

- **Brainstorming:** A practice of collaborative creativity aiming at producing a wide range of problem-solving ideas. As a popular group practice, brainstorming has not been proven to increase the quantity or quality of ideas. In spite of the fact that traditional brainstorming does not increase the productivity of groups, it can still be beneficial. Changes to the underlying approach have been made as a result. There are four key rules to follow when brainstorming (Eldash, 2015).. These aim to decrease social inhibitions among group members, encourage the development of ideas and boost the group's overall creativity:
    i. Quantity Focus: This rule is intended to increase divergent output to facilitate the resolution of problems by maximizing the quality of quantities. The concept is that the more ideas are created, the higher the opportunity for a radical and effective solution.
    ii. Withhold criticism: During brainstorming, critics of developing ideas should be put "on hold." Rather of criticizing each other, the participants should focus on extending or adding ideas to a later "critical" stage of the process. By postponing their judgment, participants can discover novel ideas.

iii. Unusual thoughts welcome: For a nice, long list of ideas, unusual ideas are encouraged and entertained. New viewpoints and a suspension of preconceptions can help you create new ideas and new ways of looking at things. This unique approach can provide better results than the traditional approach.

iv. Combine and improve ideas: There are good ideas that can be combined into a superior one, as suggested by the phrase "1+1=3". The development of ideas is supposed to be facilitated by a process of association (Eldash, 2015).

- **Delphi technique:** Delphi is a method of forecasting that involves a panel of experts. The questionnaires are answered by the experts in two or more rounds. Each round, the facilitator delivers a summary of the predictions made by the experts in the previous round and the reasoning behind their decisions. This is done anonymously. Please evaluate your earlier responses in light of the answers of other panelists, if you have not already done so. the assumption is that during this process, the range of possible responses is narrowed to the desired answer. Finally, a pre-defined end criterion (e.g. number of rounds or consensus reached) pauses the operation and outcomes are determined by the mean or medium scores in the final round. A formal Delphi group is used in this strategy, which aims at bringing together the expertise of many specialists in order to obtain access to their knowledge and technical talents, while removing the influence of elderly people, hierarchies, and personalities on the forecasts that are made. The ancient Greek Oracle of Delphi inspired the method (Eldash, 2015).

- **Interviewing**: In addition to question and answer sessions with other project managers and subject matter experts, interviews with customers, managerial teams, members of the project team, and users also include discussions with stakeholders. These professionals, based on their experience with similar projects, identify potential dangers. Expertise with prior experience in projects similar to that or experts in the field are interviewed. Any risks they have had or think your project could take place, ask them about those risks. Get their attention by presenting them with the work breakdown structure (WBS) and your list of assumptions. (Eldash, 2015).

- **Root cause analysis (RCA)**: In order to uncover the root causes of problems or events, a group of problem-solving strategies is employed. To solve a problem, first try to eliminate the underlying causes, rather than focusing only on the symptoms that are immediately apparent. Recurrence of the issue is likely to be minimized by addressing the underlying causes. In spite of this, a single procedure is not always enough to prevent recurrence. As an iterative process, RCA is often used for continuous improvement (Eldash, 2015).

- **Checklists**: Especially in typical or routine projects, they can be used quickly and provide valuable guidance in areas where the company has a deep level of expertise. They have the same effect as conventional procedures in some cases. So, many organizations create lists of inspections for frequent operations such as contracts or tenders, for example, in order to avoid or limit the risks connected with these activities. As part of the organization's quality assurance and documentation procedures, checklists are commonly incorporated. As part of the risk identification process, project team members employ checklists that are based on their historical knowledge and prior experience. On a single checklist, it is impossible to provide a complete source for all projects. You can improve your checklists at the conclusion of your project by adding more observed risks. (Eldash, 2015).

- **Diagramming techniques**: Systems flow chart diagrams, cause-and-effect diagrams, and diagrams of influence are used to identify dangers that are not easily seen in oral descriptions:
    i. Cause and effect diagrams: Cause-and-effect diagrams or fishbone diagrams are used to detect dangers. An important aspect of drawing a fishbone diagram is that its inner branches must intersect with a horizontal straight line, which is known as a "spine". A fish's head-shaped box contains the problem statement or effect. After completion, the entire map is like a fishbone.
    ii. System or process flow charts: There are several varieties of flowcharts, each of which represents a particular algorithm or process. Flowcharts are used in the analysis, design, documentation, and management of several domains.
    iii. Influence diagrams (ID): There are nodes of 3 types and one sub-type in this directed cyclic graph.
        - ✓ In each case, the decision node is shown as a rectangular shape (in correspondence to each decision to be made).
        - ✓ An oval shape is made to represent the uncertainty node (in correspondence to each ambiguity to be modeled).

- ✓ An elliptical shape is drawn for the deterministic node (the result is known deterministically when the outcome of certain other events is known), which relates to a particular form of uncertainty.
- ✓ Value node (in this case, it corresponds to each component of additively separable) is drawn as an octagon (or diamond).

2.5 Risk Assessment

Risk assessment is described as an evaluation of probability required as input data for the evaluation of different risk impact decisions. This approach includes an analysis of the risk causes and the potential repercussions of risk on a project. The three variables are assessed quantitatively according to the risk matrix; risk, R, probability, P, and impact, I. In the five-level rating system of very high, high, medium, low, and high, the project manager evaluated the chance of occurrence. The level of risk effect has also been implemented in the same way (Rahman et al., 2018).

$$R = P \times I$$

The risk assessment attempts to assess the impact on a project of the identified risks. The risk evaluation can be carried out qualitatively or quantitatively, or semi-quantitatively, depending on the available data. Many researchers have attempted to adapt risk assessment approaches to project planning, but many of the techniques available for project risk management are currently available to practitioners. Statistical tools can easily be adapted to a multidimensional technical risk. Risk management is mostly based on cost and time risk, whereas the technical assessment of risk has not yet attracted broad interest in non-quality risk (Mojtahedi et al., 2010). Risk assessment has several objectives:

- It provides an overview of the project's general level and risk pattern.
- It focuses on high-risk items in the list for management attention.
- It helps to decide instantly what action is needed and where action plans for future activities should be formed.
- It provides funding to support the choice of action by management (Mojtahedi et al., 2010)

2.5.1 Risk Assessment Methods

The process of assessing and integrating risk's probability of occurrence and impact in order to prioritize risking for further analysis or action is known as qualitative risk analysis. Organizations can improve project performance by focusing on high-priority risks. A qualitative risk analysis determines the priority of identified risks based on their relative probability, the impact of the risks on project goals, and other factors such as response timeframes and the organization's risk tolerance in relation to project cost, schedule, scope, and quality constraints. Such assessments are reflected in the project team's and other stakeholders' attitudes toward risk. As a result, effective assessment necessitates the explicit identification and management of key actors in the qualitative risk analysis process. If these attitudes lead to bias in the assessment of known risks, care should be taken to identify and correct biases (APM, 2008). The numerical examination of the impact of recognized risks on the overall project objectives is known as quantitative risk analysis. Through a quantitative risk analysis procedure, hazards that are prioritized as a possible and significant influence of the project's conflicting demands are analyzed quantitatively. The quantitative risk analysis approach assesses the consequences of these risk events. It can be used to assign numerical ratings to these hazards on an individual basis or to assess the overall impact of all project-related risks. It also provides a quantitative approach to decisions in the face of insecurity (APM, 2008).

2.6 Parameters for Determination of Risk Magnitude among Cost Overrun Causes in Qualitative Analysis

In ranking the factors affecting cost overruns in construction projects, there are different methods and are as follows;

- Relative importance index (RII) of each factor can be calculated.
- Important index is calculated as a function of frequency and severity indices
- Effectiveness index is calculated as an expression of the effectiveness of mitigation measures

2.6.1 Relative Importance Index Method

This method is used to determine the relative importance of numerous causes of overrun, and it is also used in this study among diverse stakeholders (i.e., Clients, Contractors, and Consultants). The Likert scale was used, with a scale ranging from 1 (least important) to 5 (most important) (Wilfred & Sharafudeen, 2015). Relative Importance Indices (RII) can be expressed as follows:

$$\mathrm{RII} = \frac{\sum W}{(A * N)}$$

Where:

RII = Relative Importance Index;

W = number weight of each factor by the respondents from 1, 2, 3, 4, and 5 (for very low, low, moderate, high, and very high, respectively);

A = the highest number weight (i.e., 5 in this case); and

N = the total number of respondents.

The RII rankings can be used to compare the relative importance of the factors perceived by the three stakeholder groups (i.e., Clients, Contractors, and Consultants). The perceived RII of each factor should be used to evaluate the general and overall rankings to provide an overview of the causes of construction delays in the construction industry (Wilfred & Sharafudeen, 2015).

2.6.2 Importance Index Technique

This is a technique in which for each factor two questions were asked: 1. what is the probability of occurrence (frequency) for this factor? 2. What is the degree of severity (impact) of this factor affecting construction cost? (Deepshikha Soni & Dr. Keerti. K. Choudhary, 2015). The Importance Index is calculated for each source of the delay according to the frequency and severity indexes in this technique. The incidence frequency and severity were divided into 5-point scales with values 5-1 in this case. The frequency is classified as always, often, sometimes, and seldom (on a 5 to 1 point scale). The gravity was also divided into extreme, high, moderate, and small (on a 5 to 1 point scale) (APM, 2008).

- **Frequency index**: to rank the causes of delay based on the frequency of occurrence as identified by the participants, the following formula is used:

  $$\text{Frequency Index (F.I) (\%)} = \sum a(n/N) \times 100/4$$

  Where, a = the constant expressing weighting given to each response (ranges from 1 for rarely up to 5 for always), n = the frequency of the responses, and N = the total number of responses.

- **Severity Index**: A formula is used to rank causes of delay based on severity as indicated by the participants:

  $$\text{Severity Index (S.I) (\%)} = \sum a(n/N) \times 100/4$$

Where, a = the constant expressing weighting given to each response (ranges from 1 for negligible up to 5 for extreme), n = the frequency of the responses, and N = the total number of responses.

- **Importance Index**: The importance index of each cause is calculated as a function of both frequency and severity indices as follows:

$$\text{Importance Index (IMP.I) (\%)} = [\text{F.I. (\%)} * \text{S.I. (\%)}]/100$$

2.6.3 Effectiveness Index Technique

It is computed as follows to express the effectiveness of the mitigation method in controlling the cost overrun:

$$\text{Effectiveness Index (E.I)} = \sum W_e / (H \times N)$$

W_e = Total of Effectiveness weight given to each factor

H = Highest Ranking Available which is 5 in this case

N = Total Number of Respondents who have answered the question (Ramabhadran, 2018).

2.7 Qualitative Risk Analysis for Cost Overrun

Several qualitative risk analysis types are needed for various project kinds. In determining how to estimate a project's risk, resources and personal experience are also available. The following are the five most common analytical types:

- Probability/Consequence Matrix
- Bow-Tie Analysis
- Delphi Technique
- SWIFT Analysis
- Pareto Principle

2.7.1 Probability/Consequence Matrix

This is the usual approach for evaluating the severity of risk for many. Risk matrices exist in various sizes, but they always perform the same function. They give a realistic technique of calculating the entire severity of risk by balancing the chance of hazard against the risk effect if it persists. It shows that the underlying driver of risk severity is a probability or consequence by isolating risk probability from risk effects. Based on the main variables, this information assists in the selection of appropriate risk management solutions. (AS, 2021).

2.7.2 Bow-Tie Analysis

One of the most helpful techniques for finding reduction in risk is the bow-tie analysis. The bow-tie method begins with a risk event and then projects it in two directions. You list all of the probable causes of an event on the left. You construct a list of all the possible repercussions of the incident on the right. Using this basic approach, remedies may be discovered and executed independently for each cause and impact. This allows you to reduce risk on both sides by lowering the probability on one side while reducing the consequences on the other (AS, 2021).

2.7.3 Delphi Technique

Experts in this area are asked to answer to a number of questionnaire rounds using the Delphi Technique. After each round, the responses are put together and divided into groups. This technique may be used to detect risk and then evaluate probability and impact when it comes to risk management. Experts are encouraged to weigh in on the possibility and ramifications of the threat. The experts gather and examine these replies until they reach a conclusion (AS, 2021).

2.7.4 Swift Analysis

SWIFT (structured what-if method) is a workshop-based risk analysis tool that's used by a group of people. Teams are looking at how a project can impact modifications to an approved plan through a number of considerations. What happens if something unexpected occurs? This technique is very effective for assessing the feasibility of opportunities and risks. (AS, 2021).

2.7.5 Pareto Principle

The Pareto principle is a statistical decision-making method for selecting a small number of actions that have a large overall impact. The Pareto Principle, often known as the '80/20 Rule,' is a tool for evaluating which risks are the most effective. Because the basic assumption asserts that just 20% of the work impacts 80% of the outcomes, it's known as the 80/20 rule. Pareto analysis is used by risk managers to quickly identify the most important 20% of risks and successfully mitigate the consequences of the other 80%. The challenge for risk managers is figuring out how to properly analyze each risk. Multi-attribute weights for large projects may be necessary for a variety of business purposes, such as security data, operational, or compliance requirements. However, if you know where to look and what to look at, the majority of the 20% will be informative. This is a critical step in addressing the most significant threats and weaknesses (AS, 2021).

2.8 Limitation of Qualitative Risk Method

2.8.1 Subjective Evaluation

A qualitative risk analysis produces no metrics; it all depends on the study researcher's point of view. To reduce subjectivity in a qualitative risk analysis, a significant amount of people must be included. The accuracy and detail of the analysis will be determined by previous team experience. Some risks may not be adequately assessed unless the risk team has prior expertise with a project type (AS, 2021).

2.8.2 Limited Scope

In qualitative risk analysis, each project risk is analyzed, but the total project risk exposure is not. The cost of risk diagnosis and management will also be excluded from the study (AS, 2021).

2.8.3 Lack Of Differentiation

When many risks are grouped together in the same category, such as high likelihood and medium impact, it's impossible to discern between their effects or decide which one should be handled first (AS, 2021).

2.9 Quantitative Risk Analysis for Cost Overrun

Quantitative risk analysis, in its most basic form, answers these three questions: What can go wrong? What is the probability of occurrence? And what are the ramifications? It's a top-down strategy that goes like this:

- In terms of public safety, personnel loss, and system failure, a set of undesirable end states (adverse consequences) is defined.
- For each end state, a list of disturbances to normal operation is compiled that, if not contained or managed, can lead to the end state in question. This is known as Initiating events (IEs).
- An event and fault tree, or other logic diagram, is often used to identify sequences of events that begin with an IE and conclude at an end state. A special attention is paid to accident situations involving system hardware failures and redundant components (common-cause failures). These examples address the first question.

- In assessing the likelihoods of various outcomes, all available evidence, principally past experiences and expert judgment, is considered. These probabilities are the answer to the second question.
- The mishap possibilities are graded according to the likelihood that they will occur.

A key part of the process is peer evaluation by independent experts. A national or international expert panel may be included in this evaluation, depending on the relevance of the topic, with aid from the staff on occasion. Until they have been peer-reviewed by independent specialists, the results of quantitative risk analysis should not be used in making decisions (Apostolakis, 2004).

2.10 Limitation of Quantitative Risk Analysis

Current Quantitative Risk Assessments don't address the following issues correctly or at all.

2.10.1 Errors Made By Human In Accident Conditions

The Human Reliability Handbook gives enough direction to prevent human mistake during typical activities, such as maintenance. In the event of an accident in progress, we can distinguish between mistakes of omission and errors of conduct (the crew does something that worsens the situation) (Apostolakis, 2004). Some of these errors have not been effectively addressed, and efforts to fix the problem have been made to correct the situation. Even when finances were low, the Nuclear Regulatory Commission spent a great deal of money on studies into commission errors. Error-theorists' contributions to this project have been invaluable. People are known to become innovative in the aftermath of a disaster and use unorthodox techniques of mitigation, it's also worth noting. Risk evaluations cannot take into account these human behaviors (Apostolakis, 2004).

2.10.2 Failure of Digital Software

This is a contentious issue. Rather than estimating failure probabilities, the idea is to understand the variety of failure modes that may be introduced. As a result, Quantitative Risk Assessment analysts did not use any of the many models that assume software to be black boxes and give failure rates based on dubious assumptions that are available in the literature. There are still ways to protect against digital software problems, such as extensive testing and the use of several different software systems (Apostolakis, 2004).

2.10.3 Safety Culture

Safety is a priority for managers of hazardous operations or facilities, they say. This is not always the case, as history has taught us. In spite of the ease of blaming an accident on a bad safety culture, predicting the symptoms of a good or bad safety culture remains a difficulty. A good case can be made that quantitative risk assessments will not address the impact of culture on crew conduct for a long time, if ever (Apostolakis, 2004).

2.10.4 Error of Designing and Manufacturing

Unforeseen scenarios, such as accident situations, may require the use of equipment that may require these features. The standard safety testing and equipment qualification procedures address these problems. NRC survey finds that only 1 percent of design basis breaches reported by nuclear power reactors in 1998 resulted in safety concerns. (Apostolakis, 2004).

2.11 Statistical Method Used For Evaluation Of Cost Overrun Causes

(Allahaim & Liu, 2015) conducted study on the **empirical classification** of cost overrun in infrastructure projects using the **cluster analysis** statistical approach. The cluster-level test was passed by four clusters. Each group is made up of things that are connected in some way. These groups include insufficient planning and control, scope change, site condition, and market and regularity unpredictability.

(Le-Hoai et al., 2008) used **factor analysis** to classify the causes of cost and time overrun in the construction industry in Vietnam, identifying seven groups: slowness and lack of constraint, incompetence, design, market and estimate, financial capability, government, and worker in their study on delay and cost overrun in large construction projects in Vietnam. They also used the **importance index** to rank the reasons in terms of frequency and severity, as well as **spearman's correlation** to determine the degree of agreement among the persons involved.

(Rahman, Memon, Azis, et al., 2013) in their research carried out a study about modeling causes of cost overrun in large construction projects using the **partial least square-Structural Equation Modeling** (PLS-SEM) approach statistical method. Based on the literature, the study divided cost overruns into seven groups, which were subsequently tested among contractors working on significant construction projects in Malaysia. Site management, design and documentation, financial management, information and communication, Human Resource, Non-human; and project management, and Contract Administration-related elements were also assessed. Based on a hierarchal model for identifying causative factors and cost overrun, they observed that the contractor's site management-related component has a significant impact on cost overrun.

(Pham et al., 2020) in their study on the assessment of the impact of cost overrun causes in transmissions lines construction projects employed the use of **factor analysis** with principal component analysis (PCA). **Kaiser Meyer Olkin and Bartlett's Test of Sphericity** were used to determining the sample adequacy and evaluate the identity matrix. Seven factors with a total of thirty-three causes are developed by factor analysis, and their influence level on cost escalation is investigated. **Regression analysis** was used to examine the effects of these seven elements. The regression model demonstrates that just four factors, namely risks, resources, party ineptitude, and components, transportation, and machinery costs, are relevant in cost overruns, whereas firm policies, project policies, and inadequate party collaboration are insignificant.

2.12 Parametric And Non-Parametric Tests

2.12.1 Qualitative And Quantitative Data

Data analysis is broad, exploratory, and downright complex. But when we take a step back and attempt to simplify data analysis, we can quickly see it boils down to two methodologies: Qualitative data and quantitative data. These two data types are quite different, yet, they make up most of the data that will ever be analyzed; Quantitative data is statistical and is typically structured in nature – meaning it is more rigid and defined. This data type is measured using numbers and values, making it a more suitable candidate for data analysis (Pickell, 2021). Whereas qualitative is open for exploration, quantitative data is much more concise and close-ended. It can be used to ask the questions "how much" or "how many" followed by conclusive information. While qualitative data is non-statistical and is typically unstructured or semi-structured. This data isn’t necessarily measured using hard numbers used to develop graphs and charts. Instead, it is categorized based on properties, attributes, labels, and other identifiers. Qualitative data can be used to ask the question “why”. It is investigative and is often open-ended until further research is conducted. Generating this data from qualitative research is used for theorizations, interpretations, and initial understandings (Pickell, 2021).

2.12.2 Parametric Vs. Non-Parametric

Parametric statistics is a branch of statistics that makes inferences about the parameters based on the assumption that the data came from a certain sort of probability distribution. It assumes that the data are on a quantitative (numerical) scale, with the underlying population having a normal distribution; samples have the same variance; samples are taken at random from the population, and observations within the group are independent of one another. Parametric methods, on average, make more assumptions than non-parametric methods. If the additional assumptions are right, the parametric technique can yield a more exact and accurate estimate. It is claimed that they have greater statistical power. The parametric method, on the other hand, might be quite deceptive if the assumptions are erroneous. As a result, they're frequently considered robust (Uchechi, 2020).

Non-parametric tests are sometimes known as assumption-free or distribution-free tests. They are not, however, assumption-free, and it has been suggested that the term "assumption freer" be used instead. A non-parametric statistic does not require any conditions regarding the parametric of the population from which the sample was taken to be met. On nominal or ordinal data, a non-parametric test can be applied. They're also used on scales that don't follow the normal distribution, such as interval or ratio scales. The non-parametric statistical analysis differs from parametric statistical analysis in that it only employs + or – signs, as well as the rank of data sizes, rather of the data's original values (Uchechi, 2020).

Table 2. 2: Showing some parametric and nonparametric tests (Uchechi, 2020)

Parametric Tests	**Non-parametric Tests**
Unpaired T-test	Mann-Whitney Tests
Paired T-test	Wilcoxon signed Rank Tests
One sample T-test	Signed-rank test
One-Way ANOVA	Kruskal Wallis Tests
Pearson's R	Spearman's R

2.12.3 Non-Parametric

A non-parametric test (also referred to as a distribution-free test) assumes nothing about the base distribution (for example, the data comes from a normal distribution). This is compared to a parametric test that prescribes parameters of a population (e.g. medium or standard deviation); it doesn't indicate that you know nothing about the population when the word "non-parametric" is used in stats. Usually that suggests you're unaware of the people. It usually signifies that you know that there is no normal distribution of population data (Spiegel, 1972). The main Non parametric tests are:

i. 1-sample sign test; Application this test to estimate a population's median and to compare it with a reference or target value.

ii. 1-sample Wilcoxon signed rank test; you also estimate the median population with this test and compare it with the reference/target value. But the test implies that your data is symmetrical (like the Cauchy or uniform distribution).

iii. Friedman test; this test is used to assess differences of ordinal dependent variables among groups. It may also be used for continuous data if the single way ANOVA is problematic with repeated measures (i.e. some assumptions has been violated).
iv. Goodman Kruska's Gamma; association test for ranked variables.
v. Kruskal-Wallis test; to see if two or more medians are different, use this test instead of a one-way ANOVA. Data points ranks rather than data points will be utilized for the calculations.
vi. Mann-Kendall Trend Test; finds trends in time-series data.
vii. Mann-Whitney test; when the dependent variables are either ordinal or continuous, use this test to compare differences between two independent groups.
viii. Mood's Median test; when you have two independent samples, this test should be used instead of the sign test.
ix. Spearman Rank Correlation; when you need to find a correlation between two sets of data, this test is used.

Non-parametric tests provide the following advantages over parametric tests: adaptability to all sample sizes and data kinds (includes nominal variables, interval variables, outliers, or data that has been measured imprecisely) (Spiegel, 1972).

2.13 Risk Prioritization

The complete collection of identified risk events, their effect assessments, and their likelihood of occurrence are "processed" in the risk prioritization process is to generate a most-to-least-critical rank-order of recognized risks. One of the major goals of risk prioritization is to set the stage for resource allocation (The MITRE Corporation, 2014).

For risk impact assessment and prioritization, a variety of qualitative and quantitative techniques have been developed. Qualitative methods include likelihood and impact analysis, the development of a probability and impact matrix, risk classification, risk frequency ranking (risks with many consequences), and risk urgency assessment. Weighting of cardinal risk evaluations of consequence, likelihood, and time frame; probability distributions; sensitivity analysis; anticipated monetary value analysis; and modeling and simulation are examples of quantitative approaches. All of these techniques rely on expert judgment to discover possible implications, specify inputs, and assess findings (The MITRE Corporation, 2014).

To measure and analyze project risk, many project managers opt for a matrix-based decision strategy. In these models, tasks are classified using a set of criteria, such as mission-critical vs. mission-support, and then prioritized using criticality or another measure of likelihood. The author was able to build a more accurate risk prioritization measure by integrating approaches from earlier matrix-based systems. Because risks are evaluated on three dimensions: effect, likelihood, and discrimination, combining these systems results in a cubic structure rather than a matrix (Eldash, 2015). This grading method has the same impact as more general business impact studies. The first component, impact, is based on Lansdowne's (1999) five-point risk impact scale:

- Critical risk (5): would result in the failure of the program.
- Serious risk (4): Costs or duration would escalate, and secondary objectives would not be met.

- Moderate risk (3): Significant criteria would still be satisfied despite minor increases in cost and schedule.
- Minor risk (2): would only result in minor increases in costs and schedules.
- Negligible risk (1): would not have a meaningful impact on cost or schedule.

Kendrick's (2003) rubric for probability is used for the second dimension:

- High probability (5): With a 50 percent or greater likelihood of occurring.
- Medium probability (3): 10 to 49% likelihood of occurrence.
- Low probability (1): 10 percent or less likelihood of occurrence.

Kendrick (2003) criteria define discrimination as the third dimension in basic decision-based models (Eldash, 2015). A new viewpoint is introduced, which tries to analyze each risk's influence on the overall structure of the project, rather than considering it as an isolated variable. The following are the levels of prejudice:

- High effect (1): the project's objectives are at risk, it will be necessary to alter its scope, timeline, or resources.
- Medium effect (3): project objectives will be achieved, but a substantial amount of re-planning is necessary to fulfill the project's goals.
- Low effect (5): A small inconvenience or minor overtime labor can handle the risk.

The formula below is used to provide a point value to each risk depending on its appraisal in the context of the three dimensions:

$$\text{Overall risk factor, R} = \frac{P * I}{D}$$

Where P = Probability, I = Impact, D = Discrimination. All of the project risk factors may then be rated according to the risk's severity, and the project's overall potential effect can be calculated (Eldash, 2015).

2.13.1 Methods used for Risk Prioritization

- Prioritizing risk by taking into consideration probability of occurrence and severity impact:
  - ✓ Probability-impact picture (PIP): Risks of independent events, variable risks, and ambiguity risks can be represented in a way that is customisable. A range of likelihood and impact can be specified when event risks are involved. Probability estimations are often highly subjective, as the former concedes. Last but not least, the latter acknowledges that the impact of an event is frequently unknown. In contrast to the probability and impact estimates for each risk, the PIP allows for a clearer relative sizing of event risks. Comparing variability and ambiguity risks is made more easier by the tool. (APM, 2008).
  - ✓ Probability-impact matrix: PIM provides a relative evaluation of risk events by combining probability and impact factors. Either way, threats and opportunities can be captured in the PIM. When the P-I score is calculated, the events can be prioritized and plotted in order to provide them a clear visual representation. Probability and impact for each risk event can be assessed to within the range of the PIM scale's bands. A single cause or a domino effect would result in different priorities if these elements are clear, making this strategy inefficient for prioritizing all causes of uncertainty, such as outcome variability.

On the other hand, a work on a project's non-critical path that has a relatively moderate time impact may be more important to the project's completion date and hence be given more priority. (APM, 2008).

- ✓ Summary statistics of probability distributions (expected values): Ranking distinct sources of risk by their expected impact size is one way to assess them. By multiplying each impact with its associated likelihood of occurrence, the expected impact may be determined. In this way, all conceivable outcomes are taken into account. When it comes to the assessment of different sources of risk, it is possible to use expected effect as a very basic technique. (APM, 2008).
- ✓ Variance/standard deviation: It is not taken into account when comparing the impact values of different risk sources. An alternative is to look at a risk's variance. Using variance (σ2) as a measure, any risks that can be mapped into a PIP can be compared, even those that straddle the opportunity/threat divide. Variance produces the same result, although standard deviation (σ) is a more generally known and preferred statistic. You can also compare it with the expected result (E) (APM, 2008).

- Prioritizing risk by the application multi-attribute technique:
  - ✓ Generalized multi-attribute risk prioritization: A similar approach can be used to assess qualitatively expressed strategic risks as well as extremely comprehensive quantitative risks. Probability can be substituted with variability. It is possible to address both risks and possibilities with this strategy (APM, 2008).

- ✓ Bubble chart: This permits three risk characteristics to be displayed in a single graphical format on an x/y plot with different-sized circles (APM, 2008).
- ✓ Risk Prioritization chart: A variety of factors can be employed to prioritize risks. Using the risk prioritization chart, three independent aspects can be displayed in a single graphical manner. Three dimensions can be used to express any number of variables. Examples of the third dimension for which this technique is particularly useful include urgency of the situation, impact window, reaction cost, manageability and proximity (APM, 2008).
- ✓ The Uncertainty-importance matrix (UIM): is in keeping with the notion of project risk as it is generally understood. In order to determine the highest priority risks, it must be determined which risks are most likely to affect the project's success. In this context, "uncertainty" should be understood to mean "lack of certainty." It is most effective in the early stages of a project when there is insufficient clarification of strategy and plans to do impact evaluations based on deviation from objectives. After this stage, other methodologies are likely to provide more objective criteria for ranking (APM, 2008).
- ✓ High-level risk models: The information on generic hazards is used by some firms as part of their strategic decision-making and portfolio management process. This technique may have as its primary purpose a first-pass evaluation of general risk, but it may also produce a project-specific, prioritized ranking of generic risk. In the early stages

of a project, and during the first pass of a risk management process, this approach is most useful as a prioritization technique (APM, 2008).

- Prioritizing risk by the application quantitative models:
  - ✓ Prioritizing techniques based on quantitative modeling: The risk prioritization approaches described in this part take into account the effects of risks, including all relevant dependents, up to and including an examination of the whole overall project risk, as well as all applicable dependencies and dependencies. In order to better project management, such modeling is done for two purposes: (i) gaining insights into the importance and relevance of risk and (ii) forecasting project outcomes (APM, 2008).
  - ✓ Simple quantitative models: As a starting point, this is a reasonable method to look at the whole project risk. Later in the project's life cycle, they may be useful for examining a specific risk or response to a specific risk or response. With the least amount of time and expenditure, the goal is to provide the most basic level of information possible. They are often significant enough to inspire the creation of more complex models (APM, 2008).
  - ✓ Increasing detail and complexity in quantitative risk models: As a means of illustrating risk prioritization ideas, simple quantitative models are quite effective. They are often a stepping stone to a model with more details and/or complexity (APM, 2008).
  - ✓ Schedule risk analysis (SRA): Asses the entire risk associated with a project's timeline. It can be used to aid in the formulation of project

plans by setting schedule objectives that reflect feasible targets, as well as determining the level of schedule contingencies required to ensure that obligations are met, according to the authors. The output of the analysis can also be utilized to prioritize activities and hazards (APM, 2008).

2.13.2 Prioritization

Prioritization is an essential element of any risk management approach since it helps to focus attention on the most significant issues. However, in the sense that it is context-dependent, ‘what matters most' is flexible. It differs from one stakeholder to the next, and it shifts as the project progresses from one stage to the next. It aids in the identification of risk that matters to significant stakeholders (i.e. the range of outcomes of a particular risk or the project as a whole), as well as decision-making, escalation, and consideration of viable responses to individual risks or specific outcomes (APM, 2008). The main goal of risk prioritization, according to MITRE's systems engineering guide on risk management, is to provide a foundation for resource allocation. For risk impact assessment and prioritization, a variety of qualitative and quantitative methodologies have been developed. Analysis of likelihood and impact, development of a probability and impact matrix, risk categorization, risk frequency ranking (risks with numerous effects), and risk urgency evaluation are all examples of qualitative procedures (The MITRE Corporation, 2014).

2.14 Previous Studies on Risk Prioritization

(Cindrela Devi & Ananthanarayanan, 2017) focused their research on identifying and categorizing cost overrun factors that affects construction cost performance. 68 cost overrun factors were identified. The parameter used for the assessment of these causes was the frequency of occurrence. The prioritization approached used in this study was Relative Importance Weight. The study categorized the factors based on the project life cycle and concluded that cost over-run occurs in the detailed design stage about 68% as often and always and about 37% at the execution stage of the project.

(Azhar et al., 2008) from literature, discovered 42 cost overrun causes, and a questionnaire was constructed to collect data that was used to rate the factors in terms of severity. The factors were categorized into macro-economic factors; management factors; business and regulatory environment. His study concluded that macro-economic factors affect the construction project the most severely and 88% of the factors lie in the medium severity impact range.

(Abusafiya & Suliman, 2017) through literature review, 41 factors were identified and group into the following categories: costing estimating; construction items; environmental & financing. The factors were prioritized using the Importance index based on frequency and severity. The study concluded with the top 26 factors as most critical.

(Mahamid & Dmaidi, 2013) identified 45 factors causing cost overrun in their research. Data was collected via a quantitative survey and ranked the factors using the Importance index based on the likelihood and impact of the risk factors. The researchers developed a risk map and showed that 16 out of then 45 factors were critical.

(NEGA, 2008) for the Ethiopian cause, he found 39 causes of cost overruns in his investigation. Based on the most common causes and impacts, the mean score technique was used to determine the relative relevance of the causes of cost overrun in public building development. The analysis found that the overall amount of cost overrun for the various types of public building construction projects studied in the study varies significantly.

(Rahman, Memon, & Karim, 2013b) adopted a quantitative survey approach. The collected data were assessed and ranked based on the Relative Importance Index value of each of the cost overrun factors identified. 35 factors were identified from the comprehensive literature review.

(Memon et al., 2011) through a comprehensive study of literature, 78 factors were identified. The quantitative result was analyzed using the Average index method which resulted in a ranking of 59 common factors causing construction cost overrun in Malaysia.

(Rahman, Memon, & Karim, 2013a) collected data for their research through a structured questionnaire consisting of 20 factors causing cost overrun extracted from a comprehensive literature review. The mean Rank approach was adopted to prioritize the factors causing cost overrun. It was discovered that the 3 most significant factors are: fluctuating prices of materials; cash flow; and financial difficulties faced by the contractors.

2.15 Risk Magnitude Determination

The data from the quantitative survey was analyzed in this study to determine the frequency, effect, and manageability index of each of the factors that cause cost overrun. Cost overrun causes were graded according to their frequency of occurrence, severity of impact, and manageability. Each of the parameter indices utilized in this study was thoroughly discussed in the literature review part on significance index approach.

The Relative Importance Index (RII) was adopted in this study to determine the relative importance of quality factors involved. The points of the Likert scale used are equal to the value of W, the weighting given to each factor by the respondent (Azman et al., 2019). According to (Kassem et al., 2020) the RII approach used to describe the relative importance of the specific factor based on the impact on the project and probability of occurrence using the Likert scale of 5 points. The expression of RII was illustrated in the importance index technique section in the literature review. The ranking of each factor was based on the RII consisting of the frequency, impact, and manageability index of each of the 38 factors. The evaluation of RII was carried out for each index separately in determining the unique index value. Also, the total risk was evaluated using the expression of importance index as earlier described in the importance index technique section in the literature review to compare the Index value and performance of the two methods.

However, in this study, another quantity was introduced in the expression of risk magnitude. Manageability i.e. coping capacity which is how people and organizations use existing resources to achieve various beneficial ends during unusual, abnormal, and adverse conditions of a disaster event or process (ADRC, ISDR, UN, 2002). This expression of risk magnitude is given as;

$$\text{Risk magnitude} = \frac{\text{Frequency} * \text{Impact}}{\text{Manageability}}$$

Because individuals have the active potential to respond to risks, when animate things, notable people, are the subject of risk assessment, considerable complexities develop. As a result, their ability to cope (manageability) must be considered in a risk assessment (Boudreau, 2009). This new expression adopted for this research was also compared with the RII and total risk determined.

2.16 Importance Index Ranking

The frequency of responses from the quantitative survey was categorized based on the position as stakeholders of the respondents in their respective projects (i.e. client, contractor, or consultant). Also, the responses were categorized based on the two regions in this study (Iran and Nigeria). The ranking of factors was based on the index value gotten from the RII evaluation.

2.17 Selection Of Most Effective Causes Of Cost Overrun

Most researchers in previous studies rank the most effective causes of overrun in their various researches simply by applying the parameter index as shown in table 3 (table 3: relevant documents on causes of cost overrun) which based on impact severity and frequency of occurrence. Because people have the active capacity to respond to hazards, it is only logical to consider the coping capacity of each causative factor as well as it is done in this study. Due to the nature of the data obtained from the quantitative survey, there is also bias in the use of parametric statistical tests compared to non-parametric statistical tests. Data gotten from the quantitative survey should be analyzed by non-parametric statistical tests.

Because the Pareto Principle states that 80% of success comes from 20% of the work, it aids in finding the most successful risks. In their study on improving cost estimation in building projects, Sayed et al 2020 used the Pareto principle to find the most important elements, reducing 29 components to 9 most influential factors, indicating that the 9 factors should be addressed during the cost estimating process (Sayed et al., 2020). The adoption of the Pareto principle in the subject of cost overrun is not popular.

Chapter 3

METHODOLOGY

This research aims to identify the causes of cost overruns in construction projects in Iran and Nigeria and prioritize risk levels. The study seeks to determine the factors which, influence cost overruns in construction projects, explore the interrelationships between the factors with the application of non-parametric tests, rank the factors in terms of frequency, impact, and manageability, and analyze the causal factors using Pareto analysis.

A comprehensive literature review was conducted on the common factors driving project cost overrun in the construction industry. To fully grasp the relevance of each causative element of cost overrun identified in the literature, it is necessary to relate them to construction project management activities throughout the construction project life cycle. Quantitative data will be gathered in order to statistically assess the major causes of building cost overruns. This will aid in gaining a better understanding of the study objectives and creating ways to reduce construction project cost overruns. The quantitative data will be acquired using a questionnaire survey that will be administered to random professionals within the construction sector which will include design consultants, contractors, and clients. The literature review essentially aims to achieve a better comprehension of cost overrun and the constraints affecting it in construction projects. The gathered data will be ranked by the Risk level using Severity Index, frequency (probability) index, and manageability to determine the main constraints leading to these overruns. The Pareto analysis will be adopted to deduce the most influencing factor from the thirty-eight factors prepared.

3.1 Design Strategy

As indicated in Figure 1, a combination of quantitative and qualitative approaches were employed to meet the study objectives and answer the research question, with a questionnaire survey acting as the major quantitative method. The combination of quantitative and qualitative approaches benefited this study significantly since both methods complimented each other, producing a comprehensive picture and providing a variety of viewpoints to deepen the research. Each category received a basic random sample as well. This guarantees that not only the entire population is represented, but also significant subsets of the population. It is statistically more efficient than simple random sampling (Ramabhadran, 2018).

A systematic literature review was used as the research strategy in this study. This is because systematic reviews differ from standard literature reviews in that they use an explicit approach that is replicable, scientific, and transparent, allowing the findings to be evaluated through an examination of the evidence collecting and analysis method (Herrera et al., 2020). The applied systematic review methodology was compound by seven principal stages: Question formulation; Searching of Relevant Studies; Document Selection; Identification of factors; Pilot Questionnaire and Study; Modify Questionnaire and Conduct Survey; and Analysis and Synthesis of Result.

3.2 Questionnaire Development

The systematic review process was structured by the following research questions;

- Research question 1: What are the recognized causes of cost overrun in non-infrastructural construction projects?
- Research question 2: What is the perception of respondents on determining the Impact and frequency level of each cause?
- Research question 3: What is the perception of respondents on determining the manageability level of each cause?
- Research question 4: which category as a project stakeholder best describes the position of the respondents?

3.3 Searching For Relevant Documents

Extensive research of relevant articles from the formulated research questions by applying "OR" and "AND" Boolean operation and some keywords gotten from literature reviews. Table 3.1 shows the keywords and Boolean operation that was used to research the relevant documents. The search engines in which the search process was performed are shown in table 3.2 below. A total of 97 documents were collected examined and classified using Microsoft Excel after defining and filtering the required criteria from the selected documents.

Table 3. 1: Keywords and Boolean operation applied in this study

Keyword	**Boolean Operation**	**Keyword**	**Boolean Operation**	**Keyword**
Construction project Non-infrastructure Building High-rise buildings	"And" "Or"	Cost overrun Cost extension	"And" "Or"	Reasons Causes Factors

3.4 Document Selection

The searched documents were gathered and organized using Microsoft Excel in order of; title, author, journal name, publication year, project type, and prioritization method used. Finally, a complete analysis of the documents and verification of the criteria evaluation was carried out. The documents were chosen based on the following criteria: it focuses on cost overrun causes; it analyzes the kind of project (non-infrastructure, high-rise building construction); and it presents the top ten cost overrun causes or more. The selection process of the documents involved filtering the documents with the aforementioned criteria. The process began with the initial sample, which consisted of 97 documents. The use of these three criteria resulted in the selection of 21 documents (21.6%) as the final sample and the elimination of the remaining 76 documents.

Table 3. 2: Validations used in this study

S/N	Findings validation
1	Organization, technology and management in construction
2	Journal of Applied Sciences
3	Int Journal of Real Estate Studies
4	Journal of Mgnt in Engineering
5	Int Journal of Sustainable Construction Engineering & Technology
6	Journal of Advanced College of Engineering and Mgnt
7	Int Journal of Advance Research in Computer Science and Mgnt Studies
8	Journal of Construction Engineering, Technology and Mgnt
9	Int Journal of Civil Engineering and Technology (IJCIET)
10	Int Journal of Project Mgnt
11	Modern Applied Science
12	Construction Mgnt and Economics
13	KSCE Journal of Civil Engineering
14	Journal of King Saud University
15	Int Journal of Science and Mgnt
16	Journal of Engineering, Design and Technology
17	ASCMCES-17
18	CCIDC–I
19	Modern Applied Science

Table 3. 3: Relevant documents on causes of cost overrun

ID	1	2	3	4	5	6	7	8	9	10	11
Title	Factors influencing cost over-run in Indian construction projects	Cost Overrun Factors In Construction Industry of Pakistan	Causes and effects of cost overrun on construction project in Bahrain: Part I (ranking of cost overrun factors and risk mapping)	Risks Leading to Cost Overrun in Building Construction from Consultants' Perspective	Significant factors causing cost overruns in Large construction projects in Malaysia	The cause factors of large project's cost overrun: a survey in the southern part of peninsular Malaysia	Cause and effect of cost overrun on public building construction projects in Ethiopia	Factors Affecting Schedule Delay, Cost Overrun, and Quality Level in Public Construction Projects	Preliminary Study on Causative Factors Leading to Construction Cost Overrun	An Exploration Of Causes For Delay And Cost Overrun In Construction Projects: A Case Study Of Australia, Malaysia & Ghana	Analysis of Construction Project Cost Overrun by Statistical Method
Journal	ASCMCES-17	CCIDC–I	Modern Applied Science	Organization, tech & mngt in construction	Journal of Applied Sciences	International Journal of Real Estate Studies	-	Journal of Management in Engineering	Int Journal of Sustainable Const Engineering & Tech	Journal of Advanced College of Engineering and Management	Int. Journal of Adv. Research in Computer Sc. & Mgmt. Studies
Year	2017	2008	2017	2013	2013	2012	2008	2015	2011	2016	2015
Type of Project	Construction	Construction	Construction	Construction	Construction	Construction	Building	Construction	Construction	Construction	Construction
Prioritization method	Relative Importance Weight	Impact (based on severity)	Importance index	Importance index	Relative Importance index	Relative Importance index	Mean Square (Frequency)	Relative Importance index	Average Index (based on significance)	Relative Importance weight	Relative Importance index
ID	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	
Title	Identifying Factors Leading to Cost Overrun in Construction Projects in Jordan	Causal attributes of cost overrun in construction projects of Pakistan	An exploration into cost-influencing factors on construction projects	Relationship Between Factors Of Construction Resources Affecting Project Cost	Cost and time control of construction projects: inhibiting factors & mitigating measures in practice	Delay and Cost Overruns in Vietnam Large Construction Projects	Micro and macro level of dispute causes in residential building projects: Studies of Saudi Arabia	Factors causing cost overruns in construction of residential projects; case study of turkey	Major causes of construction time and cost overruns	Cost overrun factors in construction industry: a case of Zimbabwe	
Journal	Journal of Const. Engineering, Tech. and Mngt	International Journal of Civil Engineering and Technology	International Journal of Project Management	Modern Applied Science	Construction Management and Economics	KSCE Journal of Civil Engineering	Journal of King Saud University	International Journal of Science and Management	Journal of Engineering, Design and Technology	-	
Year	2015	2017	2014	2012	2010	2008	2014	2012	2016	2019	
Type of Project	Construction	Construction	Construction	Construction	Construction	Construction	Building	Building	Construction	Construction	
Prioritization method	Importance index	Average Index	Severity Index	Mean Rank Score	Relative Importance index	Importance index	Severity Index	Relative Importance index	Relative Importance index	Relative Importance index	

3.5 Identification Of Factors

From the 21 documents selected through the selection process discussed earlier, the top 10 causative factors of cost overrun were collected from each document. A total of 210 factors were collected from the selected documents as shown in table 3.4. This selection was based on the following prioritization method; Relative importance index, Impact index, Importance index, Mean Square, Average Square, and Mean rank score. These factors were analyzed for redundancy, similarities, and repetition. From the 210 identified factors, a framework was developed using Microsoft Excel to eliminate repeated factors to fine-tune the factors, remove overlapping and also modify some at the same time. The inference yielded 45 factors which were then used in the formation of the preliminary questionnaire.

Table 3. 4: Top ten causes of cost overrun from selected documents

1	**2**	**3**	**4**	**5**
Factors influencing cost over-run in Indian construction projects	**Cost Overrun Factors In Construction Industry of Pakistan**	**Cause and effect of cost overrun on construction project in Bahrain: Part I (ranking of cost overrun factors and risk mapping)**	**Risks Leading to Cost Overrun in Building Construction from Consultants' Perspective**	**Significant factors causing cost overruns in Large construction projects in Malaysia**
Construction delays	Fluctuation in prices of raw materials	Frequent design changes	political situation	Fluctuation of prices of materials
Additional works	Unstable cost of manufactured materials	Mistakes during construction	fluctuation of prices of materials	Cash flow and financial difficulties faced by contractors
Design changes	High cost of machineries	schedule delay	economic instability	poor site management and supervision
Changes in the specifications	Lowest bidding procurement method	poor site management and supervision	currency exchange	lack of experience
Changes in the scope of the project	Poor project (site) management/ Poor cost control	inaccurate quantity take-off	level of competitors	schedule delay
Practice of assigning the contract to the lowest	Long period between design and time of bidding/tendering	inaccurate time and cost estimates	number of competitors	inadequate planning and scheduling
Rework	Wrong method of cost estimation	shortage of site workers	previous experience of contract	incompetent subcontractor
Cash flow and financial difficulties	Additional work	Delay preparation and approval of drawings	project financing	mistakes and errors in design
Incomplete drawings	Improper planning	Incomplete design at the time of tender	inflationary pressure	Frequent design changes
Unpredictable weather conditions	Inappropriate government policies	laborer productivity	contract management	poor financial control on site
6	**7**	**8**	**9**	**10**

The Cause Factors Of Large Project's Cost Overrun: A Survey In The Southern Part Of Peninsular Malaysia	Causes And Effects Of Cost Overrun On Public Building Construction Projects In Ethiopia	Factors Affecting Schedule Delay, Cost Overrun, and Quality Level in Public Construction Projects	Preliminary Study on Causative Factors Leading to Construction Cost Overrun	An Exploration Of Causes For Delay And Cost Overrun In Construction Projects: A Case Study Of Australia, Malaysia & Ghana
Fluctuation in prices of materials	Inflation or increase in the cost of construction materials	Errors or omissions in consultant material	Poor design and delays in Design	Contractor's improper planning
Cash-flow and financial difficulties faced by contractors	Lack of planning and coordination or less emphasis to planning	Errors or inconsistencies in project documents	Unrealistic contract duration and requirements imposed	Contractor's poor site management
Delay in progress payment by owner	Fluctuations in the cost of labor and/or material or any other matter affecting the cost of the execution of the works and subsequent legislation that affect the project	Late user changes affecting the project or function	Lack of experience	Inadequate contractor experience
Frequent design changes	Insufficient geotechnical investigation	Lack of preliminary examination before design or tendering	Late delivery of materials and equipment	Inadequate client's finance and payments for completed work
Shortage of materials	Additional costs due to variations works	Inexperienced or newly qualified consultants	Relationship between management	Problems with subcontractors
Poor financial control on site	Change in foreign exchange rate	Unsettled or lack of project planning	Delay Preparation and approval of drawings	Shortage in material
Schedule delay	Change orders and/or lack of control on excessive change orders	Lack of Identification of needs	Inadequate planning and scheduling	Labor supply
Financial difficulties of owner	Costs due to special risks which very often include out-break of war, projectile missile, hostilities, contamination and other such risks	Lack of Requirement specifications in tender documents	Poor site management and supervision	Equipment availability and failure
Incompetent subcontractors	Delay of drawings	Errors or omissions in construction work	Mistakes during construction	Lack of communication between parties
Incomplete design at the time of tender	Changes in Plans and drawings	Political focus on reduced project costs or time	Changes in Material Specification and type	Mistakes during the construction stage
11	**12**	**13**	**14**	**15**
Analysis of Construction Project Cost Overrun by Statistical Method	**Identifying Factors Leading to Cost Overrun in Construction Projects in Jordan**	**Causal Attributes Of Cost Overrun In Construction Projects Of Pakistan**	**An exploration into cost-influencing factors on construction projects**	**Relationship Between Factors Of Construction Resources Affecting Project Cost**
Material shortage	Schedule delay (time overrun)	delay in approval of drawings by the client	Clearly define the scope of project in the contract	fluctuation of prices of materials
Shortage of labor	Frequent design changes	poor site management and supervision	Cost control	cash flow and financial difficulties faced by contractors
Late delivery of materials and equipment	Changes and additional works at owner request	delay in design by the client	Contract dispute (unclear drawings or guidelines/regulations)	shortages of materials

Unavailability of competent staff	Mistakes and errors in design	Mistakes during construction	High fluctuation in commodity	financial difficulties of owner
Low productivity level of labors	Inadequate planning and scheduling	Inadequate constructor's experience	The gap between the construction plan and the reality is too great	mode of financing, bonds and payments
Quality of equipment and raw material	Inflation/ prices fluctuation	Improper construction methods	Material shortage or supply delay	Changes in Material Specification and type
Delay in progress payment	Change in the scope of work (by owner)	Incompetent subcontractors assigned by contractor	Time management	Delay in progress payment by owner
Financial difficulties by contractor	Incomplete drawings/ detailed design at the time of tender	design mistakes	Practical experience	poor financial control on site
Poor site management	Shortage of skilled site workers	shortage of skilled labor	Modifications to the scope of construction	labor productivity
Escalation and fluctuation of material prices	Construction mistakes and defective works	change in the scope of the project	The level of demand on quality	Late delivery of materials
16	**17**	**18**	**19**	**20**
Cost and time control of construction projects: inhibiting factors and mitigating measures in practice	**Delay and Cost Overruns in Vietnam Large Construction Projects: A Comparison with Other Selected Countries**	**Micro and macro level of dispute causes in residential building projects: Studies of Saudi Arabia**	**Factors Causing Cost Overruns In Construction Of Residential Projects; Case Study Of Turkey**	**Major causes of construction time and cost overruns**
Design changes	Poor site management and supervision	Inadequate contractor’s experience	Improper Planning;	Financial difficulty by client
Risk and uncertainty associated with projects	Poor project management assistance	Lack of communication between construction parties	Inaccurate Project Cost Estimation;	Material price fluctuations
Inaccurate evaluation of project’s time/ duration	Financial difficulties of owner	Delay in progress payment by owner	High cost of needed resources: money, men, materials and machinery;	Material price changes (inflation)
Non-performance of subcontractors and nominated suppliers	Financial difficulties of contractor	ineffective planning and scheduling of project by contractor	Lack of skilled workforce;	Financial difficulty by client
Complexity of works	Design changes	Cash problems during construction	Price of Construction Materials;	Financial difficulty by client
Conflict between project parties	Unforeseen site conditions	Unrealistic contract duration	High land prices;	Delay in payment of completed works
Discrepancies in contract documentation	Slow payment of completed works	Poor estimation practices	Lack of Coordination between parties;	Poor financial management on site
Contract and specification interpretation disagreement	Inaccurate estimates	Used unbalance contracts in Saudi Government projects	Cost of the Reworks;	Variations of clients
Inflation of prices	Shortages of materials	Incorrect planning	Inadequate duration of the contract period;	Shortage of materials
Financing and payment for completed works	Mistakes in design	Poor Saudi litigation system to settle the delay claim (Arbitration)	Lack of communication between parties;	Poor financial management on site

3.6 Pilot Questionnaire and Study

Construction project stakeholders from the Iranian and Nigerian construction industries including clients, consultants, and contractors participated in a pilot study. They defined some of the concerns that were more relevant, resulting in the identification of 45 factors that contribute to cost overruns. A pilot test was conducted through a series of interviews to ensure the highest relevance and affinity with both construction industries. These experts assisted in the evaluation of the questionnaire's design and structure. During the interviews, experts were consulted to assess each of the 45 factors on the list. The experts recommended that the list be enhanced and that some of the factors that were not significant or effective for cost overrun is removed. The questionnaire was ready to use by the end of this step. The questionnaire contained and organized a total of 38 unique factors. These factors are shown in table 3.5.

Table 3. 5: List of 38 factors causing cost overrun

S/N	Factors causing cost overrun
1	Variations of clients
2	Change in the foreign exchange rate
3	Change in project design
4	Change in the scope of the project
5	Contract related issues
6	Delay preparation and approval of drawings
7	Delays in the construction schedule
8	Errors or inconsistencies in project documents
9	Errors or omissions in construction work
10	Financial difficulties related to the contractor
11	Financial difficulties related to the owner
12	Improper construction methods
13	Inaccurate project cost Estimation and control
14	Inaccurate scheduling and planning
15	Inadequate contractor's experience
16	Incomplete design at the time of tender
17	Insufficient geotechnical investigation

18	Lack of Identification of needs
19	Lack of material, Equipment availability, or failure
20	Lack of Requirement specifications in tender documents
21	Lowest bidding procurement method
22	Material quality change
23	Number and level of competitors
24	Poor financial control on site
25	Poor site management and supervision
26	Project complexity
27	Subcontractor related issues
28	Reworks or additional works during the construction stage
29	Mistakes and defective works in design and construction stages
30	Lack of preliminary examination before design or tendering
31	The long period between design and time of bidding/tendering
32	Labor productivity-related issues (labor shortage, unskilled labor, etc.)
33	Lack of communication and coordination and agreement between project's parties
34	Inflation in prices of (labor, material, equipment, services, land, permissions, and so on)
35	Governmental policies related issues (corruption, legislation, political…)
36	Financial difficulties related to the cash flow (including mode of financing, bonds, and payments)
37	special issues related to Unforeseen site conditions, adverse weather condition, or other unpredicted condition in construction site
38	Force Majeure causes including outbreak of war, projectile missile, hostilities, contamination, and other such risks

3.7 Modified Questionnaire and Conduct Survey

The cost overrun factors at the end of the preceding process were 38. Purposive sampling was used since the goal was to select the respondents who had expertise or experience with the topic. Purposive sampling is very effective in this circumstance because it enables one to quickly obtain a specified sample size, and parallelism isn't the main concern. The questionnaire was distributed to personnel from the 3 main construction parties (client, contractor, and consultant), to assess the ranks of impact, frequency of occurrence, and manageability of each factor listed in table 5. The questionnaire consists of 3 sections; the first contained the demography and background of the respondents; the second section consists of the construction party of the respondent, years of experience, project budget, percentage of cost overrun, construction sector, and project type; the final section consists of the 38 factors causing cost overrun to be evaluated using Likert scale. A Likert scale is a type of ordered scale in which respondents select the option that best represents their point of view. It's frequently used to gauge people's views by asking how much they agree or disagree with a certain issue or statement. The adoption of this technique was due to the fact it reduces subjectivity by minimizing the bias of the respondents and it complies with conforms with the objective and established scaling procedures used by construction industry professionals (Assaad et al., 2020). The Likert scale of 1 - 5 was applied for assessing the effect of each factor. The respondents' rating are associated with these numerical values. The risk evaluation parameters are defined below:

3.7.1 Definition of Scale for Probability

1. Extremely unlikely and only occurs in rare situations (<10% chance).
2. In most cases, the likelihood of occurrence is low (10% < chance < 35%).
3. There is a moderate likelihood that this will happen in most cases (35% < chance < 65%).
4. There is a good likelihood that this will happen in most cases (65% < chance < 90%).
5. There is a very good possibility that it will happen, and it is virtually guaranteed that it will happen (90% or greater chance of occurrence).

3.7.2 Definition of Scale for Impact

1. The effect is negligible (5% < increase in cost).
2. The effect is minor (5% < increase in cost <10%).
3. The effect is moderate (10% < increase in cost <20%).
4. The effect is significant and could jeopardize the project's objectives (20% < increase in cost <50%).
5. The effect is severe and would prevent functional objectives from being met (50% or greater increase in cost).

3.7.3 Definition of Scale for Manageability

1. The influence of project stakeholders was negligible and risk reduction measures were unlikely to be cost-effective.
2. The influence of project stakeholders was minor and risk reduction measures were rarely to be cost-effective.
3. The influence of project stakeholders on the probability and/or impact of the causes were moderate and risk reduction measures were often to be cost-neutral.
4. The influence of project stakeholders on the probability and/or impact of the causes were significant and risk reduction measures were cost-effective.
5. The influence of project stakeholders on the probability and/or impact of the causes was extreme and risk reduction measures were highly cost-effective.

3. 8 Number of Respondents

The targeted population for this study was construction project stakeholders consisting of client/owner, consultant, and contractor who participated in projects in Iran and Nigeria. The contractor and consultants included; site engineers, cost estimators, quantity surveyors, cost control engineers, construction and project managers. In both Iran and Nigeria, the stakeholders' work scope included cost estimation. Moreover, the stakeholders involved in this study as the targeted population were based in both countries. The target population is determined by;

$$n = \frac{t^2 s^2}{e^2}$$

Where;

n = required sample size

t = Z-statistic corresponding to the chosen significant value α

s = Estimate of variance deviation for the data collecting scale, determined by dividing the scale's inclusive range by the number of standard deviations that encompass almost all possible values in the range.

e = multiplied by the allowable margin of error (number of points on the principal scale).

Typically in survey research, the features of a concept, event, or occurrence that poses questions are examined. Solutions to the questions raised were constructively answered by the targeted sample group to form the required data. This group is formed from a population that possesses experiences that influences this study. The entire set of cases from which the researcher's sample is drawn is called the population.

3.9 Method of Distribution

Traditional methods of data collection, such as face-to-face, postal, and telephone surveys, can be costly and time-consuming. A reasonably cost-effective survey option is the growing data gathering strategy based on internet/e-based technologies such as online platforms and emails. These unique data gathering methodologies enable researchers to acquire vast amounts of data from participants in less time.

They also appear to be viable and useful in gathering data on sensitive issues or in situations where respondents are difficult to reach. (Paramod R Regmi, 2016). Moreover, the ongoing pandemic is also a limiting factor, especially for physical contact.

In a variety of industries, questionnaire surveys are a common data collection approach for academic or marketing research. Traditional methods of completing questionnaire surveys include face-to-face, telephone interviews, and postal surveys. However, with more people around the world having access to the internet, data gathering via an online survey appears to have the potential to collect massive volumes of data efficiently, affordably, and in a short amount of time (Cobanoglu & Cobanoglu, 2003). The online survey approach is also very helpful when collecting data from a hard-to-reach population such as travelers and others. Moreover, people with certain conditions, which could be disabilities, for instance, may not be so reachable in face-to-face sessions.

The online survey approach provides convenience in several ways, for example, a) respondents can answer at a convenient time; b) respondents can take as much time as they need to respond to questions; c) respondents can complete a survey in multiple sessions (where needed). Similar to the paper-based survey; online questionnaire surveys are capable of question diversity. Also, the construction of the online questionnaire can be built to help better the response rate for each item; for example, respondents could be mandated to answer a question before advancing to the next question (Paramod R Regmi, 2016). The online survey adopted for this research is Google Forms because of its user-friendly interface and efficient data management features.

3.9.1 Targeted Regions

The two regions surveyed in this research were Nigeria and Iran. These two locations are bedeviled with similar characteristics. Though immensely oil-rich, both countries continue to grapple with cost overruns in projects, mainly infrastructure projects. In 2017, a report by the Chartered Institute of Project Management disclosed that abandoned projects with regards to existing structures alone amount to over 33 billion USD – at the time, this was equivalent to 10% of the country's economy. At nearly the same time, a Minister of Works placed the figure at over 40 billion USD (Ogunde, 2019). Iran has similar cases as well in its construction industry.

3.10 Analysis and Synthesis of Result

After the collection of responses from the participants of the qualitative survey, a validity test will be carried out to validate the credibility of the questionnaire. The data collected will then be analyzed using the following index analysis: frequency index; impact index; manageability index; and relative important index. Because the data collected from this survey disobey some of the requirements of the parametric test, therefore non-parametric statistical test will be employed for the synthesis of the result. Mann Whitney U test, Kruskal-Wallis H test, and Post HOC tests were adopted in this study for assessment as a non-parametric test. Spearman's correlation test was performed to analyze the dependencies between the parties (categorization of respondents as; Clients, Contractors, or Consultants) involved in this study. Pareto analysis was also adopted to optimize the causative factors and prioritize their risk level based on their performance from index analysis ranking.

3.10.1 Spearman's Rank Correlation Analysis

The Spearman rank correlation coefficient (S) was calculated to check the agreement on the ranking of the results between two groups, and this method has been adopted in this study to check the agreement between parties involved in construction projects (clients, contractors, and consultants).

3.10.1.1 Assumption

Tests of statistical significance are usually based on assumptions about the sampling technique used to get the sample data These tests are more 'robust' and do not involve stringent assumptions about population distributions, although they are often less strong than their parametric counterparts (Statkat, 2021). Violation of some assumptions (e.g. independence assumptions) is often more severe than violation of others (e.g. normality assumptions in combination with large samples). It is based on the following assumptions: This is a simple random sample from a population of pairings, based on a random number generator. It's important to note that pairings are independent of each other. As a result, the correlation coefficient is not affected by this assumption, which is solely relevant for the significance test. In other words, it measures the strength of the monotonic relationship between two variables, not the relationship itself. (Statkat, 2021).

3.10.1.2 Null Hypothesis

The assessment for Spearman's correlation tests the null hypothesis (H_0):

$$H_0: \rho_s=0$$

Where ρ_s = Spearman correlation in population.

When two variables of at least ordinal measurement level are compared, Spearman correlation is used to determine the strength and direction of their monotonic relationship. The null hypothesis would be;

H_0: No monotonic relationship exists between the two variables in the population.

3.10.1.3 Alternative Hypothesis

The assessment for Spearman's correlsation tests the null hypothesis $H_{0,}$ against the following alternative hypothesis (H_1 or H_a):

$$H_1 \text{ (two sided): } \rho_s \neq 0$$

$$H_1 \text{ (right sided): } \rho_s > 0$$

$$H_1 \text{ (left sided): } \rho_s < 0$$

Therefore in this study, the spearman's correlation coefficient was computed using SPSS. From the 'analyze' menu, 'correlate' option is selected and the 'Bivariate'. There two variables will be put in the box below and then under correlation coefficient, spearman will be selected. This will evaluate the correlation between the inputted variables and in the case: client-contactor; client-consultant; and contractor-consultant.

3.10.2 Mann Whitney U Test

First and foremost, the Mann-Whitney U test mandates the establishment of a U statistic for each group. These data have a known distribution under Mann and Whitney's null hypothesis (1947). For each group, the Mann-Whitney U statistics are defined mathematically as follows:

$$Ux = nxny + ((nx(nx + 1))/2) – Rx$$
$$Uy = nxny + ((ny(ny + 1))/2) – Ry$$

Where: nx = the number of participants in the 1st group; ny = the number of participants in the 2nd group; Rx = the total number of rankings given to the first group; and Ry = the total number of rankings given to the second group. In other words, both U equations can be read as the number of times observations in one sample precede or follow observations in the other sample when all the scores from one group are arranged in ascending order (Beaugrand, 1982; Nachar, 2008).

3.10.2.1 U Test Hypothesis

The Mann-Whitney U test's null hypothesis (H0) states that the two groups are from the same population. In other words, the two independent groups must have the same distribution and be homogeneous. The two variables that represent the two groups are stochastically identical since they are represented by two continuous cumulative distributions. The alternative hypothesis (H1) asserts that the variable of one group is stochastically greater than the variable of the other group. The null hypothesis is rejected without determining the direction of the difference if one group is significantly larger than the other (Beaugrand, 1982; Nachar, 2008).

3.10.2.2 U Test Assumptions

In order to test the hypothesis, the sample must meet certain conditions. These guidelines are simple to follow. These criteria’s are:

- The two study groups must be randomly selected from the target population. The phrase "random" implies that no measurement or sampling errors exist (Robert et al., 1988). It's important to note that these last types of mistakes can happen, but they must be minimal.
- Each measurement or observation should be linked to a specific person. There is independence inside groups and reciprocal independence between groups.

The data is measured on an ordinal or continuous scale. The observations' values are then scaled using an ordinal, relative, or absolute scale (Beaugrand, 1982; Nachar, 2008).

3.10.3 Kruskal Wallis H-Test

The Kruskal–Wallis test is discussed in this section. When determining if two or more samples are from the same distribution, the Kruskal-Wallis test is employed. The null hypothesis states that all of the samples are drawn from the same distribution. Assume that there are k samples, each with its own set of values. To run the Kruskal–Wallis test, first rank all of the values together, regardless of which sample they belong to, and then add up all of the values' rankings inside each sample to generate a unique total of ranks for each sample. If there is no tie in any of the variables, the test statistic is;

$$H = \frac{12}{N(N+1)} \sum_{i-1}^{k} \frac{R_i^2}{n_i} - 3(N+1)$$

Where: N = the total number of values in all samples; n_i = the number of values contained in the i^{th} sample; and R_i = the sum of ranks in the i^{th} sample. (Guo et al., 2013).

The non-parametric Kruskal Wallis H test is an alternative to the One Way ANOVA. As previously stated, a non-parametric test means that the test does not presume that data originates from a specific distribution. When the assumptions for ANOVA aren't met, the H test is employed (like the assumption of normality). It's also known as the one-way ANOVA on ranks because the test uses the ranks of the data values rather than the actual data points.

The test determines whether the medians of two or more groups are different. Like most statistical tests, calculate test statistics and compare them to a distribution cut-off point. The test statistics used are the H statistics. A major premise surrounding this test is the assumption of independence. In support of the Kruskal Wallis test for analysis, the Mann Whitney tests can accommodate more than two groups (Glen, 2021b).

3.10.4 Post Hoc Test

The Dunn's Test can be used to identify which means differ significantly from the others. It's one of the least powerful multiple comparisons tests, and it might be a very conservative test when there are a lot of them. The calculation provides an exceptionally low per-comparison error rate of.005 if 10 comparisons are conducted at an alpha level of.05 (Glen, 2021a):

- The **null hypothesis** for the test is that there is no disagreement among groups (groups can be either equal or unequal in terms of size).
- The **alternate hypothesis** for the test is that there is agreement among groups

3.10.5 Total Risk Index

As a function of frequency index (probability of occurrence), severity index (impact), and their inverse association with manageability, the total risk of each cause is computed. It is expressed as;

$$\text{Total risk} = \frac{P \times I}{M}$$

Where: P = Probability of occurrence (frequency/likelihood), I = Impact (severity of each cause), and M = Manageability (coping capacity of each cause).

Manageability: This is a function of controllability and response effectiveness. It can be expressed as;

$$\text{Manageability (\%)} = \sum a(n/N) \times 100/4$$

Where, a = the constant expressing weighting given to each response (ranges from 1 for the negligible influence of the stakeholders at risk reduction up to 5 for the extreme influence of the stakeholders at risk reduction), n = the frequency of the responses, and N = the total number of responses.

3.10.6 Pareto Analysis

According to (Powell & Sammut-Bonnici, 2015), operational outcomes and economic prosperity are not evenly distributed, and some inputs contribute more than others. The "80/20 rule" was coined by Vilfredo Pareto, an Italian economist in the 19th century, to explain a sophisticated economic concept he introduced. Keep in mind that the 80/20 rule should not be taken literally when using it. The fact that the majority of outcomes are generated from a limited number of inputs is suggestive.

Chapter 4

RESULTS AND DISCUSSION

4.1 Number of Responses Report

The estimated number of responses estimated to be sent out with a 95% significant level was 69. This means that the minimum number of responses with a very credible significance should be at least 69. The actual valid responses gotten from the survey in this study was 89, which satisfies the minimum requirement need for the desired significance level. A total of 260 questionnaires were sent out to the respondents from both Iran and Nigeria and with a response rate of 34.23%.

Required sample size (n);

$$n = \frac{t^2 s^2}{e^2}$$

Where for α=0.05; t=1.96; s could be either of 1.25 or 0.83; e =0.05; which yielded n_1= 43 and n_2= 96. The average of n_1 and n_2 was calculated as n= 69

Table 4. 1: Responses Report.

	Estimated	**Actual**
The total number of the questionnaire sent	216	260
Total number of valid responses	69	89
Response rate (%)	32.14	34.23

4.2 Questionnaire Descriptive Analysis

A detailed descriptive analysis of the questionnaire is shown in table 4.2. The table consists of the frequency of respondents in the following categories: Country; Gender; Age; Educational level; Position; Years of experience; Sector; and Project type.

Table 4. 2: Frequency table of responses

Category	Subcategory	Frequency	Relative Frequency	Cumulative Frequency	Relative Cumulative Frequency
Country	Iran	31	34.8	31	34.8
	Nigeria	58	65.2	89	100.0
	Total	89	100.0		
Gender	Male	76	85.4	76	85.4
	Female	13	14.6	89	100.0
	Total	89	100.0		
Age	Below 30	32	35.96	32	35.96
	30-40	32	35.96	64	71.92
	40-50	15	16.85	79	88.77
	Above 50	10	11.23	89	100.0
	Total	89	100.0		
Education	High school or equivalent degree	10	11.2	10	11.2
	Bachelor’s degree	41	46.1	51	57.3
	Master’s degree	32	36.0	83	93.3
	Ph.D. or higher	6	6.7	89	100.0
	Total	89	100.0		
Position	Owner/Client	25	28.1	25	28.1
	Contractor	26	29.2	51	57.3
	Consultant	38	42.7	89	100.0
	Total	89	100.0		
Experience	Less than 1 year	9	10.1	9	10.1
	1-5 years	37	41.6	46	51.6
	6-10 years	22	24.7	68	76.4
	11-15 years	10	11.2	78	87.6
	Over 15 years	11	12.4	89	100.0
	Total	89	100.0		
Sector	Public	21	23.6	21	23.6
	Private	68	76.4	89	100.0
	Total	89	100.0		
Project Type	Office buildings	7	7.9	7	7.9
	Residential Buildings	44	49.4	51	57.3
	Retail Buildings	4	4.5	55	61.8
	Hospitality Buildings	4	4.5	59	66.3
	Multi-purpose buildings	4	4.5	63	70.8
	Institutional civil buildings	5	5.6	68	76.4
	Gathering Buildings	2	2.2	70	78.6
	Educational Buildings	4	4.5	74	83.1
	Industrial Buildings	3	3.4	77	86.5
	Agricultural Buildings	5	5.6	82	92.1
	Terminals	3	3.4	85	95.5
	Recreational Buildings	4	4.5	89	100.0
	Total	89	100.0		

The frequency for each category stated in table 4.2 is represented in as pie charts as shown in the series of figures below;

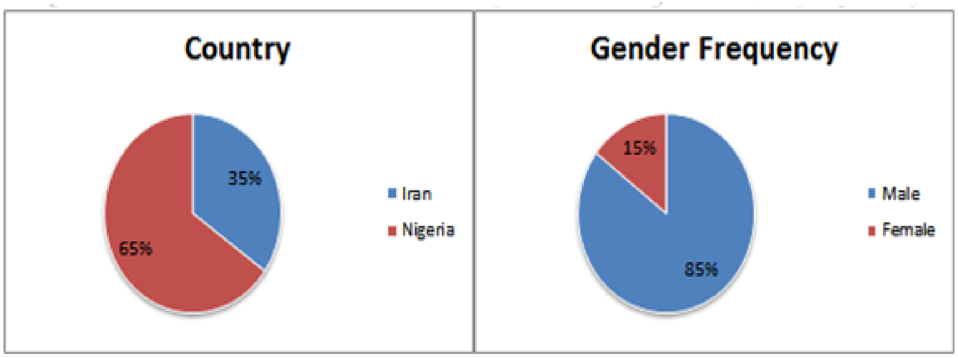

Figure 4. 1: Respondent’s country representation and gender frequency

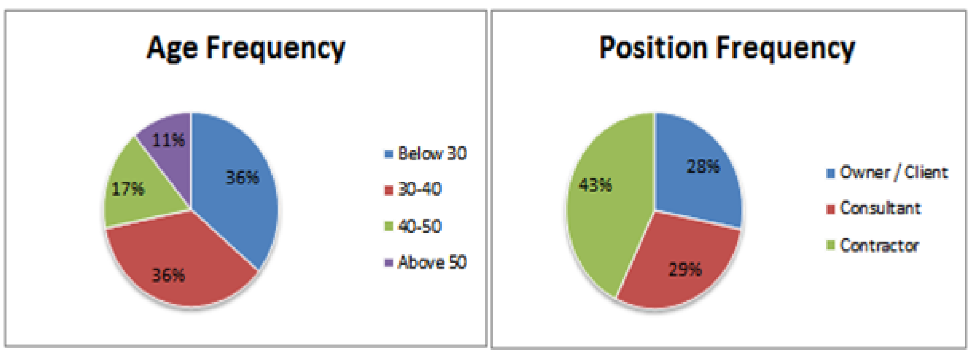

Figure 4. 2: Age frequency and position frequency of respondents

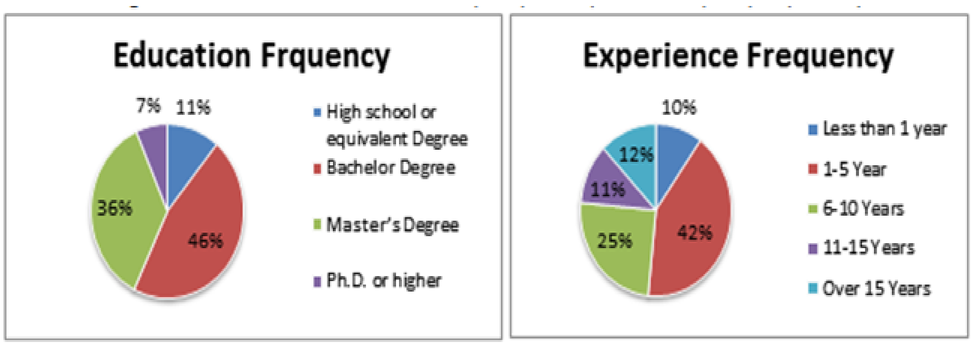

Figure 4. 3: Education and experience frequency of respondents

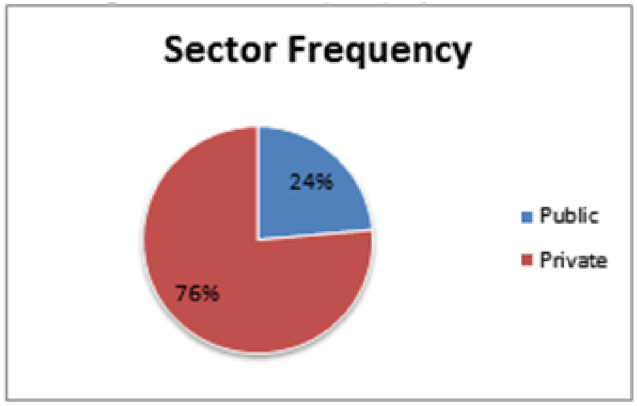

Figure 4. 4: Sector frequency representation

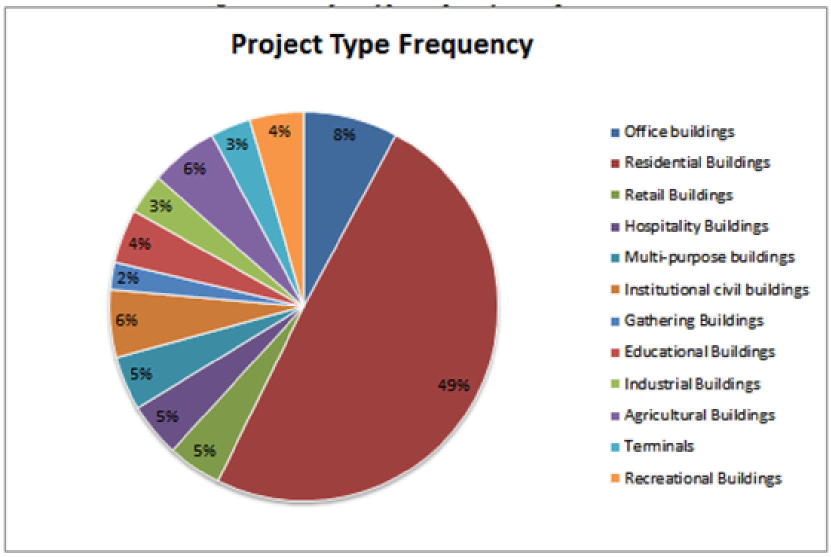

Figure 4. 5: Project type frequency of respondents

4.3 Cross-Tabulation Relationships

The cross-tabulation relationship of owner/client, contractor, and consultant with their respective years of experience is shown in table 4.3 and illustrated in a histogram form in figure 4.9. And the relationship between the position of respondents (owner/client, contractor, and consultant) and their respective level of education is shown in table 4.4 and the relationship is also represented as a histogram in figure 4.10.

Table 4. 3: Experience & position cross-tabulation

Experience	Position			Total
	Owner / Client	Consultant	Contractor	
Less than 1 year	7	0	2	9
1-5 Year	8	12	17	37
6-10 Years	6	4	12	22
11-15 Years	1	7	2	10
Over 15 Years	3	3	5	11
Total	25	26	38	89

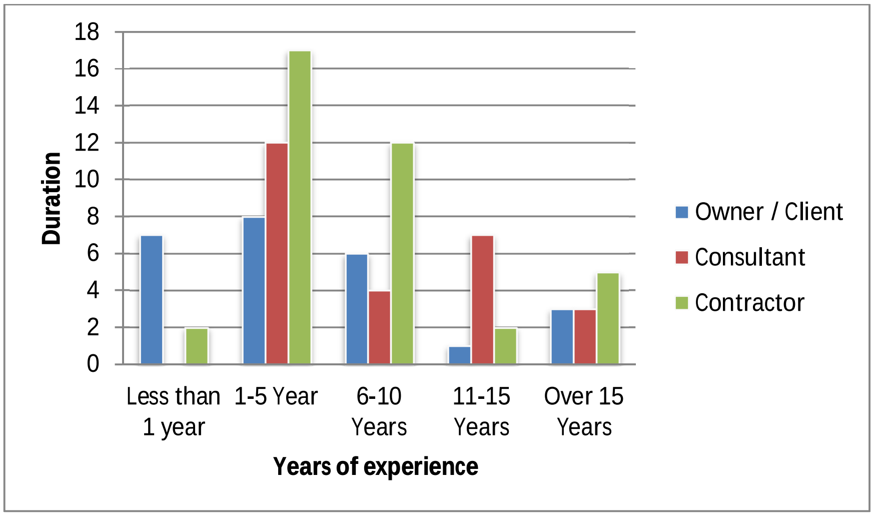

Figure 4. 6: Experience & position cross-tabulation

Table 4. 4: Education & position cross-tabulation

Education Level	Position			Total
	Owner / Client	Consultant	Contractor	
High school or equivalent Degree	4	0	6	10
Bachelor Degree	14	12	15	41
Master's Degree	7	12	13	32
Ph.D. or higher	0	2	4	6
Total	25	26	38	89

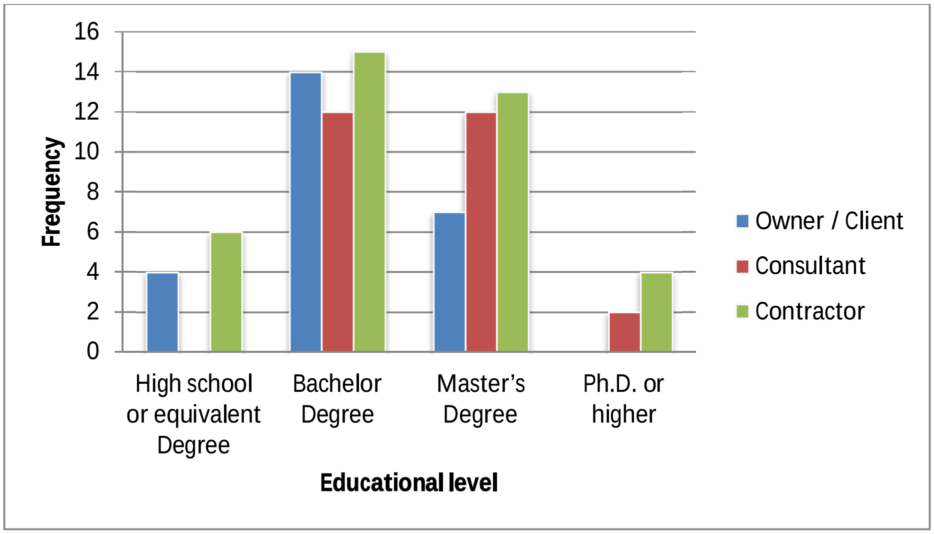

Figure 4. 7: Education & position cross-tabulation

4.4 Reliability Test

Reliability tests were established through Cronbach's alpha method for four sets of all the causes of cost overrun. Since the questionnaire was supposed to measure the responses from a different point of view for cost overrun causes including the probability of occurrence, impact, and manageability, therefore to implement rigorous reliability tests, tests were performed for each one of the prospective separately. In addition, a general reliability test was performed for the overall questionnaire to investigate the entire questionnaire's reliability. The results revealed that from all the prospective including the probability of occurrence, impact, and manageability as well as overall questionnaire the values of Cronbach's alpha are above 0.90 which indicated excellent internal consistency of the questionnaire. From the result, it is obvious that none of the causes are required to be removed since their removal does not enhance Cronbach's alpha value. The reliability statistics are summarized in Table 4.5

Table 4. 5: Reliability statistics

Scale	Cronbach's alpha	No of items
Probability of occurrence	0.961	38
Impact	0.970	38
Manageability	0.965	38
Overall	0.987	114

4.5 Parametric Vs Non-Parametric

In order to perform a parametric test following criteria should be met:

1. Dependent variable that is continuous (i.e. interval, ordinal or ratio level) here it is scores for probability, impact, and manageability which are ordinal.
2. Independent variable that is categorical (i.e. two or more groups).
3. Random sampling.
4. Independent samples/groups (i.e. independence of observations).
5. Normality assumption.
6. Homogeneity of variances.

Violation of any of the aforementioned assumptions will lead to unreliable parametric test results and in this study, the normalty assumption and homogeneity of variances were violated, consequently, non-parametric test was therefore implemented.

4.6 Normality Assumption

The results for the normality test indicated according to Kolmogorov-Smirnov and Shapiro –Wilk tests, all the cost overrun causes from probability, impact, and manageability perspective yielded p-values less than 0.05. It means in all the cases, the null hypothesis for the normality test which is “H0: The population is normally distributed” was rejected and therefore normality assumption is violated in this case.

4.7 Homogeneity of Variances

The Homogeneity of variances assumption between Iran and Nigeria was examined through the Levene’s tests. Due to highly skewed dataset in most of the causes, p-value based on the median was considered as a reliable measure to examine Homogeneity of variances assumption. The result indicated that from probability, impact and manageability point of view for several causes p-value was less than 0.05 which indicated null hypothesis. The null hypothesis for homogeneity of variances H0= the population variances of Iran and Nigeria are equal, was rejected and so therefore the homogeneity of variance assumption is violated in this cases.

Using the trimmed mean performed best when the underlying data had a heavy-tailed distribution and the median performed best when the underlying data had a skewed distribution. Using the mean provided the best power for symmetric and moderate-tailed distributions. Table 4.6 shows the test of the homogeneity of variances for the causes from probability, impact and manageability point of view with p-values (Sig.) less than 0.05 (i.e. rejects the null hypothesis).

Table 4. 6: Test for homogeneity of variance

Cause ID	Sig.	LEVENE STATISTIC
34(P)	.002	10.151
8(I)	.001	11.935
9(I)	.000	15.822
11(I)	.004	9.003
12(I)	.003	9.732
26(I)	.003	9.377
34(I)	.000	13.767
35(I)	.000	14.242
38(I)	.000	21.569
2(M)	.001	10.860

Since two of the assumptions of parametric test criteria were violated, therefore in order to examine research hypothesis, Mann Whitney U non-parametric test which is equivalent to the parametric independent t-test was adopted for this study.

4.8 Mann Whitney U Test

4.8.1 Level of Agreement between Iran and Nigerian Responses

Three different hypothesis have been developed to investigate the level of agreement between responses from Iran and Nigeria. For each one of the hypothesis using Mann Whitney U test, the level of agreement between Iran and Nigeria in terms of scoring cost overrun causes was separately evaluated:

1. **(Null hypothesis) H0:** There was a significant agreement among the responses from Iran and Nigeria concerning the **probability of occurrence for each cause** of cost overrun (i.e. There is not a significant difference among responses from Iran and Nigeria concerning scoring **the probability of occurrence** for each cause of cost overrun).

   (**Alternate hypothesis) H1:** There was a significant disagreement among the responses from Iran and Nigeria concerning the **probability of occurrence for each cause** of cost overrun (i.e. There was a significant difference among responses from Iran and Nigeria concerning scoring **the probability of occurrence** for each cause of cost overrun).

The results revealed that there were significant differences between responses for scoring the causes of cost overrun based on their probability of occurrences between Iran and Nigeria. The total numbers of respondents were 89 and from the total for each cause. 31 responses were from Iran while 58 were from Nigeria. Table 4.7 summarized the result for the cases that had disagreements in the probability of occurrence of cost overrun causes. In the table, U represents Mann Whitney U values, Z is a z-value for the test and r represents the effect size of the test and can be calculated by the following formula (Newcombe, 2006):

$$r = \frac{z}{\sqrt{N}}$$

Where; Z = obtained z-value from the test and N = total number of respondents.

Table 4. 7: Result for the cases of disagreements for probability of occurrence of cost overrun causes

Cause ID	U	Z	P	R	Median (Iran)	Median (Nigeria)
C1	**578.5**	**-2.873**	**0.004**	**0.304**	**3.00**	**2.00**
C2	**458.5**	**-3.890**	**0.000**	**0.412**	**4.00**	**3.00**
C3	617.5	-2.546	0.011	0.269	3.00	2.00
C6	672.5	-2.055	0.040	0.217	2.00	1.50
C7	**533**	**-3.246**	**0.001**	**0.344**	**4.00**	**2.00**
C13	625	-2.453	0.014	0.260	3.00	3.00
C14	**576**	**-2.872**	**0.004**	**0.304**	**4.00**	**2.00**
C16	610	-2.604	0.009	0.276	3.00	2.00
C24	630.5	-2.411	0.016	0.255	3.00	2.00
C25	585.5	-2.798	0.005	0.296	3.00	2.00
C27	**551**	**-3.080**	**0.002**	**0.326**	**4.00**	**2.00**
C28	596.5	-2.685	0.007	0.284	4.00	2.00
C34	631.5	-2.382	0.017	0.252	4.00	3.00
C36	**535**	**-3.222**	**0.001**	**0.341**	**3.00**	**2.00**

According to (Newcombe, 2006) the effect size of these disagreements in most of the cases where; r is less than 0.3 is negligible but in C1, C2, C7, C14, C27 and C36 where $0.3 < r < 0.5$ is considerable:

2. **(Null hypothesis) H0:** There was a significant agreement among the responses from Iran and Nigeria concerning **impact of each causes** of cost overrun (i.e. There was no significant difference among responses from Iran and Nigeria concerning scoring the **impact of each causes** of cost overrun).

(**Alternate hypothesis) H1:** There was a significant disagreement among the responses from Iran and Nigeria concerning **impact of each causes** of cost overrun (i.e. There was significant difference among responses from Iran and Nigeria concerning scoring **impact of each causes** of cost overrun).

The results revealed that there were significant differences between responses for scoring the causes of cost overrun based on their impact between Iran and Nigeria. Table 4.8 summarized the result for the cases of disagreements for the impact of cost overrun causes.

Table 4. 8: Result for the cases of disagreements for the impact of cost overrun causes

Cause ID	**U**	**Z**	**P**	**R**	**Median (Iran)**	**Median (Nigeria)**
C1	592	-2.728	0.006	0.289	3.00	2.00
C2	592	-2.728	0.006	0.289	3.00	2.00
C4	652	-2.206	0.027	0.233	3.00	2.00
C11	590	-2.725	0.006	0.288	4.00	3.00
C12	**544**	**-3.144**	**0.002**	**0.333**	**4.00**	**2.00**
C14	672	-2.036	0.042	0.215	3.00	2.50
C15	**592.5**	**-3.268**	**0.001**	**0.346**	**4.00**	**2.00**
C16	605	-2.599	0.009	0.275	3.00	2.00
C18	592.5	-2.308	0.021	0.244	3.00	2.00
C28	**526.5**	**-3.299**	**0.000**	**0.349**	**3.00**	**3.00**
C30	**537**	**-3.194**	**0.001**	**0.338**	**4.00**	**2.00**
C34	**566.5**	**-2.991**	**0.003**	**0.317**	**4.00**	**3.00**
C35	678.5	-1.971	0.049	0.208	4.00	3.00
C37	**533.5**	**-3.224**	**0.001**	**0.341**	**4.00**	**2.00**
C38	**466.5**	**-3.837**	**0.000**	**0.406**	**4.00**	**3.00**

The effect size of disagreements between respondents for cases C12, C15, C28, C30, C34, C37, and C38 were considerable:

3. **(Null hypothesis) H0:** There was a significant agreement among the responses from Iran and Nigeria concerning **manageability of each cause** of cost overrun (i.e. There was no a significant difference among responses from

Iran and Nigeria concerning scoring the **manageability of each cause** of cost overrun).

(**Alternate hypothesis) H1:** There was a significant disagreement among the responses from Iran and Nigeria concerning the **manageability of each cause** of cost overrun (i.e. There was a significant difference among responses from Iran and Nigeria concerning scoring **manageability of each cause** of cost overrun).

The results revealed that there were significant differences between responses for scoring the causes of cost overrun based on their manageability between Iran and Nigeria. Table 4.9 summarized the result for the cases of disagreements for the manageability of cost overrun causes.

Table 4. 9: Result for the cases of disagreements for the manageability of cost overrun causes

Cause ID	**U**	**Z**	**P**	**r**	**Median (Iran)**	**Median (Nigeria)**
1	**405.000**	**-3.796**	**0.000**	**0.402**	**3.50**	**2.00**
2	**473.500**	**-3.797**	**0.000**	**0.402**	**5.00**	**3.00**
3	631.500	-2.368	0.018	0.251	3.00	2.00
5	**510.000**	**-3.450**	**0.001**	**0.366**	**4.00**	**2.00**
6	**459.500**	**-3.916**	**0.000**	**0.415**	**3.00**	**2.00**
7	**551.500**	**-3.085**	**0.002**	**0.327**	**3.00**	**2.00**
9	608.500	-2.577	0.010	0.273	3.00	2.00
10	624.000	-2.470	0.014	0.262	3.00	3.00
12	**571.500**	**-2.907**	**0.004**	**0.308**	**3.00**	**2.00**
15	635.000	-2.347	0.019	0.249	3.00	2.00
16	**554.500**	**-2.979**	**0.003**	**0.316**	**3.00**	**2.00**
17	**580.500**	**-2.827**	**0.005**	**0.300**	**3.00**	**2.00**
24	597.500	-2.688	0.007	0.285	3.00	2.00

25	689.000	-1.855	0.064	0.197	4.00	2.00
26	593.500	-2.694	0.007	0.286	4.00	2.00
31	622.500	-2.450	0.014	0.260	3.00	3.00
33	673.500	-2.012	0.044	0.213	3.00	2.00
38	623.500	-2.469	0.014	0.262	1.00	2.00

The effect size of disagreements between respondents for cases C1, C2, C5, C6, C7, C12, C16, and C17 are considerable.

4.8.2 Level of Agreement between Stakeholder Positions

Three different hypotheses have been developed to investigate the level of agreement between responses from Owners, Contractors, and consultants:

1. **(Null hypothesis) H0:** There was a significant agreement among the responses **from Owners, Contractors, and consultants** concerning the **probability of occurrence for each cause** of cost overrun (i.e. There was no significant difference among responses from **Owners, Contractors, and consultants** concerning scoring **the probability of occurrence** for each cause of cost overrun).

   (**Alternate hypothesis) H1:** There was a significant disagreement among the responses **from Owners, Contractors, and consultants** concerning the **probability of occurrence for each cause** of cost overrun (i.e. There was a significant difference among responses **from Owners, Contractors, and consultants** concerning scoring **the probability of occurrence** for each cause of cost overrun).

2. **(Null hypothesis) H0:** There was a significant agreement among the responses **from Owners, Contractors, and consultants** concerning the

impact of each cause of cost overrun (i.e. There was no significant difference among responses **from Owners, Contractors, and consultants** concerning scoring the **impact of each cause** of cost overrun).

(**Alternate hypothesis) H1:** There was a significant disagreement among the responses **from Owners, Contractors, and consultants** concerning the **impact of each cause** of cost overrun (i.e. There was a significant difference among responses **from Owners, Contractors, and consultants** concerning the scoring **impact of each cause** of cost overrun).

3. **(Null hypothesis) H0:** There was a significant agreement among the responses **from Owners, Contractors, and consultants** concerning **manageability of each cause** of cost overrun (i.e. There was no significant difference among responses **from Owners, Contractors, and consultants** concerning scoring the **manageability of each cause** of cost overrun).

   (**Alternate hypothesis) H1:** There was a significant disagreement among the responses **from Owners, Contractors, and consultants** concerning **manageability of each cause** of cost overrun (i.e. There was a significant difference among responses **from Owners, Contractors, and consultants** concerning scoring **manageability of each cause** of cost overrun).

The results for the normality test previously proved that the normality assumption is violated. Therefore to evaluate the level of agreement between respondents from owners, contractors, and consultant groups (stakeholders) an equivalent non-parametric Kruskal-Wallis H Test was adopted in place of the One-Way ANOVA parametric test since the groups are more than two.

4.9 Kruskal-Wallis H Test

For each one of the hypotheses using the Kruskal-Wallis H test, the level of agreement between owners, contractors, and consultants in terms of scoring cost overrun causes was separately evaluated:

1. **(Null hypothesis) H0:** There was a significant agreement among the responses **from Owners, Contractors, and consultants** concerning the **probability of occurrence for each cause** of cost overrun (i.e. There was no significant difference among responses from **Owners, Contractors, and consultants** concerning scoring **the probability of occurrence** for each cause of cost overrun).

   (**Alternate hypothesis) H1:** There was a significant disagreement among the responses **from Owners, Contractors, and consultants** concerning the **probability of occurrence for each cause** of cost overrun (i.e. there was a significant difference among responses **from Owners, Contractors, and consultants** concerning scoring **the probability of occurrence** for each cause of cost overrun).

Since the distribution of scores for each group of the independent variable (i.e. Owners, contractors, and consultants) have a **different shape,** the Kruskal-Wallis H test to compare **mean ranks** was implemented.

The results revealed that there were significant differences between responses for scoring the causes of cost overrun based on their probability of occurrences between owners, contractors, and consultants. The total numbers of respondents are 89 and from the total for each cause, 25 responses were from owners, 26 were from consultants, and 28 from contractors. Table 4.10 summarized the result for the cases of disagreements for the probability of occurrence of cost overrun causes. In the table, the values for Chi-Square value, degree of freedom (Df), and p-value (p) are shown.

Table 4. 10: Result for the cases of disagreements for the probability of occurrence of cost overrun causes

Cause ID	Chi-Square	Df	p
2	6.205	2	0.045
3	9.642	2	0.008
4	13.561	2	0.001
7	6.235	2	0.044
9	7.715	2	0.021
12	6.143	2	0.046
16	7.268	2	0.026
20	6.265	2	0.044
31	10.248	2	0.006

Post hoc test: Since there were differences between owners, contractors and, consultants in the mean ranks of scoring the probability of occurrences for each cost overrun cause, therefore a post hoc test was required to clarify where the sources of disagreement was between each pair of parties within the group. Subsequently, a post hoc test using Dunn's procedure was performed and the results for the sources of disagreement were summarized. It is notable that through Bonferroni correction, the p-value obtained from Dunn's procedure was adjusted and presented in the table 4.11, 4.13 and 4.15. Results from the tables indicated for each identified cost overrun causes from the probability of occurrence, impact and manageability point of view and which pair of the three subgroups (owners, contractors, and consultants) had significant disagreement in the mean ranking of the scores.

Table 4. 11: Post-hoc test results for each identified cost overrun causes from the probability of occurrence

Cause ID	Groups	Adj.sig
2	Owner- contractor	0.043
3	Owner- consultant	0.006
4	Owner- consultant	0.001
7	Owner- contractor	0.039
9	Owner- contractor	0.044
9	Owner- consultant	0.042
12	Owner- consultant	0.049
16	Owner- contractor	0.022
31	Owner- consultant	0.004

2. **(Null hypothesis) H0:** There was a significant agreement among the responses **from Owners, Contractors, and consultants** concerning the **impact of each cause** of cost overrun (i.e. There was no significant difference among responses **from Owners, Contractors, and consultants** concerning scoring the **impact of each cause** of cost overrun).

   (**Alternate hypothesis) H1:** There was a significant disagreement among the responses **from Owners, Contractors, and consultants** concerning the **impact of each cause** of cost overrun (i.e. there was a significant difference among responses **from Owners, Contractors, and consultants** concerning scoring **impact of each cause** of cost overrun).

Table 4. 12: Kruskal-wallis results 2

Cause ID	Chi-Square	Df	P
4	6.788	2	0.034

The results revealed that there were significant differences between responses for scoring the causes of cost overrun based on the impact of each cause of cost overrun between owners, contractors, and consultants therefore rejecting the null hypothesis.

Table 4.12 summarized the result for the case of disagreements for the impact of cost overrun causes. In the table, the values for Chi-Square value, degree of freedom (Df), and p-value (p) are shown.

Table 4. 13: Post-hoc test results 2

Cause ID	Groups	Adj.sig
4	Owner- consultant	0.045

3. **(Null hypothesis) H0:** There was a significant agreement among the responses **from Owners, Contractors, and consultants** concerning **manageability of each cause** of cost overrun (i.e. There was no a significant difference among responses **from Owners, Contractors, and consultants** concerning scoring the **manageability of each cause** of cost overrun).

   (**Alternate hypothesis) H1:** There was a significant disagreement among the responses **from Owners, Contractors, and consultants** concerning **manageability of each cause** of cost overrun (i.e. there was a significant difference among responses **from Owners, Contractors, and consultants** concerning scoring **manageability of each cause** of cost overrun).

Table 4. 14: Kruskal-wallis results 3

Cause ID	Chi-Square	df	P
3	8.250	2	0.016

The results revealed that there were significant differences between responses for scoring the causes of cost overrun based on the manageability of each cause of cost overrun between owners, contractors, and consultants therefore rejecting the null hypothesis. Table 4.14 summarized the result for the case of disagreements for the manageability of cost overrun causes. In the table, the values for Chi-Square value, degree of freedom (Df), and p-value (p) are shown.

Table 4. 15: Post-hoc test results 3

Cause ID	Groups	Adj.sig
3	Owner- consultant	0.017

4.10 Cost Overrun Cause Ranking

The ranking of the causes for total respondents based on the probability of occurrences, Impact on the cost overrun and manageability of the cost overrun causes as well as total risk is provided in the table 4.16. They were ranked based on their relative importance index value.

Table 4. 16: Ranking of the causes for total respondents based on the probability, Impact and manageability

Rank	Cause ID	RII (P)	Cause ID	RII (I)	Cause ID	RII (M)	Cause ID	RII (TR)
1	34	0.73	34	0.74	36	0.60	2	0.210
2	2	0.68	2	0.73	32	0.59	34	0.204
3	13	0.59	35	0.72	19	0.58	35	0.168
4	35	0.59	38	0.68	25	0.58	13	0.135
5	23	0.57	13	0.65	27	0.58	7	0.130
6	7	0.56	11	0.63	10	0.58	37	0.127
7	28	0.56	29	0.62	15	0.58	28	0.125
8	24	0.55	19	0.61	14	0.57	11	0.121
9	36	0.55	37	0.61	13	0.57	23	0.116
10	10	0.55	12	0.61	24	0.57	38	0.115
11	14	0.55	30	0.60	22	0.57	29	0.115
12	27	0.54	7	0.60	33	0.57	24	0.112
13	5	0.53	25	0.60	5	0.56	10	0.112
14	25	0.53	36	0.59	23	0.56	25	0.109
15	22	0.53	10	0.59	31	0.56	36	0.108
16	37	0.53	15	0.59	26	0.55	12	0.108
17	33	0.51	28	0.59	12	0.55	5	0.108

18	19	0.50	32	0.59	20	0.54	17	0.108
19	11	0.50	26	0.59	21	0.54	14	0.107
20	26	0.49	24	0.58	30	0.53	8	0.107
21	12	0.49	17	0.57	28	0.53	19	0.105
22	29	0.49	1	0.57	29	0.53	26	0.105
23	32	0.49	5	0.57	34	0.53	27	0.103
24	21	0.48	23	0.56	9	0.52	30	0.102
25	3	0.47	8	0.56	11	0.52	22	0.102
26	31	0.47	14	0.56	18	0.52	1	0.099
27	9	0.47	20	0.56	1	0.52	33	0.099
28	16	0.47	27	0.56	4	0.52	3	0.098
29	18	0.46	9	0.55	7	0.52	9	0.097
30	17	0.46	18	0.55	3	0.51	32	0.097
31	20	0.46	22	0.55	37	0.51	18	0.097
32	8	0.46	33	0.54	16	0.50	16	0.096
33	30	0.45	3	0.53	35	0.50	20	0.095
34	15	0.45	4	0.52	17	0.49	15	0.092
35	1	0.45	16	0.52	6	0.49	21	0.090
36	6	0.43	21	0.51	8	0.48	4	0.085
37	4	0.42	6	0.48	2	0.47	6	0.085
38	38	0.39	31	0.47	38	0.46	31	0.079

From the RII ranking of the factors causing cost overrun, the top 10 causes interms of the total risk are: Change in the foreign exchange rate; Inflation in prices of (labor, material, equipment, services, land, permissions, and so on); Governmental policies related issues (corruption, legislation, political…); Inaccurate project cost Estimation and control; Delays in the construction schedule; special issues related to Unforeseen site conditions, adverse weather condition, or other unpredicted condition in construction site; Reworks or additional works during the construction stage; Financial difficulties related to the owner; Number and level of competitors; Force Majeure causes including outbreak of war, projectile missile, hostilities, contamination, and other such risk.

4.11 Spearman Rank-Order Correlation Test

The Spearman rank-order correlation test was performed in terms of the stakeholder positions (Client, Contractor and Consultant) and the two countries involved in this study (Iran and Nigeria). For the stakeholder positions, the test was performs for the probability of occurrence, impact, manageability and total risk. For the countries, the test was also performs for the probability of occurrence, impact, manageability and total risk.

The results for ranking cost overrun causes based on probability of occurrences from owners, contractors, and consultant point of view is provided in table 4.17. The highest RII value from the owner's point of view is 0.664 and the least is 0.32. From the contractor's point of view, the highest RII value is 0.774 and the lowest is 0.363. And finally from the perspective of the consultant, the highest value is 0.715 while the lowest is 0.431.

Table 4. 17: Spearman rank-order correlation test for probability of occurrence

Rank	Cause ID	RII P (Owners)	Cause ID	RII P (Contractors)	Cause ID	RII P(Consultants)
1	34	0.664	34	0.774	34	0.715
2	2	0.576	2	0.753	2	0.662
3	13	0.560	7	0.642	35	0.662
4	35	0.560	27	0.616	23	0.654
5	22	0.528	13	0.611	10	0.608
6	28	0.520	28	0.595	5	0.600
7	24	0.512	24	0.589	13	0.585
8	25	0.512	14	0.584	26	0.585
9	10	0.504	36	0.574	37	0.585
10	23	0.504	23	0.563	3	0.577
11	14	0.496	25	0.558	22	0.569
12	36	0.496	35	0.553	31	0.569
13	27	0.472	5	0.547	36	0.569
14	7	0.464	19	0.542	12	0.554
15	37	0.464	10	0.537	33	0.554
16	33	0.456	37	0.532	7	0.546

17	5	0.448	11	0.526	14	0.546
18	19	0.448	33	0.526	28	0.546
19	26	0.448	16	0.521	24	0.531
20	32	0.448	29	0.521	4	0.523
21	11	0.440	21	0.511	9	0.523
22	17	0.424	8	0.500	11	0.523
23	29	0.416	9	0.500	21	0.523
24	12	0.408	12	0.500	18	0.515
25	15	0.408	22	0.500	29	0.515
26	18	0.400	20	0.495	32	0.515
27	30	0.400	1	0.489	25	0.508
28	8	0.392	32	0.489	15	0.500
29	6	0.384	3	0.479	19	0.500
30	16	0.384	17	0.479	27	0.492
31	20	0.384	30	0.474	1	0.485
32	21	0.384	18	0.468	20	0.485
33	31	0.384	26	0.463	30	0.477
34	38	0.376	31	0.463	17	0.469
35	1	0.352	6	0.453	16	0.462
36	3	0.352	15	0.447	8	0.454
37	9	0.352	4	0.416	38	0.454
38	4	0.320	38	0.363	6	0.431

The results for ranking cost overrun causes based on the impact of each cause on cost overrun from owners, contractors, and consultant point of view is provided in table 4.18. The highest RII value from the owner's point of view is 0.680 and the least is 0.400. From the contractor's point of view, the highest RII value is 0.763 and the lowest is 0.437. And finally from the perspective of the consultant, the highest value is 0.792 while the lowest is 0.500.

Table 4. 18: Spearman rank-order correlation test for Impact

Rank	Cause ID	RII I (Owners)	Cause ID	RII I (Contractors)	Cause ID	RII I (Consultants)
1	34	0.680	34	0.763	35	0.792
2	2	0.648	2	0.753	34	0.777
3	35	0.640	35	0.721	38	0.769
4	38	0.624	11	0.679	2	0.762
5	32	0.592	13	0.679	13	0.700
6	14	0.576	19	0.663	37	0.692
7	13	0.568	29	0.663	10	0.677
8	23	0.568	12	0.647	11	0.662
9	24	0.568	38	0.647	15	0.638
10	25	0.560	7	0.642	26	0.638
11	29	0.560	28	0.642	12	0.623
12	26	0.552	30	0.626	30	0.623
13	36	0.544	17	0.616	3	0.615
14	7	0.536	25	0.611	36	0.615
15	19	0.536	36	0.611	5	0.608
16	30	0.536	37	0.611	9	0.608
17	10	0.528	5	0.605	19	0.608
18	11	0.528	15	0.605	22	0.608
19	12	0.528	20	0.605	25	0.608
20	22	0.528	24	0.605	29	0.608
21	33	0.528	1	0.595	8	0.600
22	15	0.520	27	0.589	28	0.600
23	18	0.520	32	0.589	1	0.592
24	37	0.520	14	0.579	7	0.592
25	1	0.512	26	0.579	17	0.592
26	8	0.512	10	0.574	32	0.592
27	28	0.504	33	0.574	4	0.577
28	9	0.496	8	0.568	21	0.577
29	17	0.488	23	0.568	27	0.577
30	20	0.488	3	0.558	18	0.562
31	27	0.480	16	0.558	23	0.554
32	5	0.464	4	0.553	24	0.554
33	21	0.464	18	0.553	20	0.546
34	16	0.456	9	0.537	31	0.538
35	6	0.440	22	0.516	16	0.523
36	31	0.440	6	0.495	14	0.515
37	4	0.424	21	0.484	33	0.515
38	3	0.400	31	0.437	6	0.500

The results for ranking cost overrun causes based on the manageability of each cost overrun cause from owners, contractors, and consultant point of view is provided in table 4.19. The highest RII value from the owner's point of view is 0.592 and the least is 0.408. From the contractor's point of view, the highest RII value is 0.616 and the lowest is 0.421. And finally from the perspective of the consultant, the highest value is 0.646 while the lowest is 0.446.

Table 4. 19: Spearman rank-order correlation test for manageability

Rank	Cause ID	RII M (Owners)	Cause ID	RII M (Contractors)	Cause ID	RII M (Consultants)
1	32	0.592	15	0.616	36	0.646
2	36	0.592	5	0.605	25	0.623
3	23	0.576	19	0.600	27	0.623
4	21	0.568	14	0.589	32	0.615
5	12	0.560	10	0.584	22	0.608
6	29	0.560	13	0.584	24	0.608
7	10	0.552	32	0.579	23	0.600
8	19	0.552	33	0.579	26	0.600
9	22	0.552	36	0.579	10	0.592
10	25	0.552	24	0.574	19	0.592
11	27	0.552	25	0.568	31	0.585
12	30	0.552	27	0.568	13	0.577
13	31	0.552	7	0.563	14	0.577
14	13	0.544	20	0.563	15	0.569
15	14	0.544	28	0.558	33	0.569
16	33	0.544	12	0.553	2	0.562
17	26	0.536	8	0.547	3	0.554
18	11	0.528	22	0.547	4	0.554
19	15	0.528	1	0.542	5	0.554
20	24	0.520	4	0.542	18	0.554
21	34	0.520	9	0.542	1	0.546
22	18	0.512	31	0.537	16	0.546
23	20	0.512	11	0.532	38	0.546
24	5	0.504	26	0.532	9	0.538
25	28	0.496	6	0.526	21	0.538
26	37	0.496	29	0.526	30	0.538
27	9	0.480	34	0.526	34	0.538
28	35	0.472	3	0.521	12	0.531
29	7	0.456	16	0.521	20	0.531

30	1	0.448	21	0.521	35	0.531
31	3	0.448	30	0.521	17	0.523
32	16	0.448	17	0.516	37	0.523
33	4	0.440	18	0.511	28	0.515
34	38	0.432	23	0.511	7	0.508
35	2	0.416	35	0.500	11	0.508
36	6	0.416	37	0.500	29	0.500
37	17	0.416	2	0.437	6	0.492
38	8	0.408	38	0.421	8	0.446

Table 4.20 provided the results for ranking cost overrun causes based on the total risk index from owners, contractors, and consultant point of view. The highest RII value from the owner's point of view is 0.179 and the least is 0.061. From the contractor's point of view, the highest RII value is 0.259 and the lowest is 0.075. And finally from the perspective of the consultant, the highest value is 0.206 while the lowest is 0.088.

Table 4. 20: Spearman rank-order correlation test for total risk

Rank	Cause ID	RII TR (Owners)	Cause ID	RII TR (Contractors)	Cause ID	RII TR (Consultants)
1	2	0.179	2	0.259	34	0.206
2	34	0.174	34	0.224	35	0.198
3	35	0.152	35	0.159	2	0.179
4	13	0.117	7	0.146	37	0.155
5	24	0.112	13	0.142	13	0.142
6	7	0.109	28	0.137	10	0.139
7	38	0.109	11	0.134	11	0.136
8	28	0.106	29	0.131	5	0.132
9	14	0.105	37	0.130	12	0.130
10	25	0.104	27	0.128	3	0.128
11	22	0.101	23	0.125	38	0.128
12	17	0.099	24	0.124	7	0.127
13	23	0.099	36	0.121	28	0.127
14	8	0.098	25	0.120	29	0.125
15	37	0.097	19	0.120	26	0.124
16	10	0.096	12	0.117	8	0.122
17	26	0.092	14	0.115	23	0.121
18	36	0.091	17	0.114	9	0.118

19	32	0.090	30	0.114	22	0.114
20	33	0.089	38	0.112	15	0.112
21	11	0.088	16	0.112	21	0.112
22	19	0.087	5	0.109	30	0.110
23	29	0.083	1	0.107	4	0.109
24	5	0.082	20	0.106	36	0.108
25	27	0.082	10	0.105	17	0.106
26	18	0.081	33	0.104	1	0.105
27	6	0.081	8	0.104	31	0.105
28	1	0.080	3	0.103	18	0.105
29	15	0.080	18	0.101	19	0.103
30	16	0.078	26	0.101	33	0.100
31	30	0.078	32	0.100	20	0.100
32	12	0.077	9	0.099	32	0.099
33	20	0.073	21	0.095	25	0.099
34	9	0.073	22	0.094	14	0.098
35	3	0.063	15	0.088	24	0.097
36	21	0.063	6	0.085	27	0.091
37	4	0.062	4	0.085	16	0.088
38	31	0.061	31	0.075	6	0.088

The results for ranking cost overrun causes based on the probability of occurrence index from Iran and Nigeria point of view is provided in table 4.21. The highest RII value from the Iran is 0.832 and the least is 0.329. And from Nigeria, the highest RII value is 0.672 and the lowest is 0.393.

Table 4. 21: Spearman rank-order correlation test for probability of occurrence from Iran and Nigeria POV

Rank	Cause ID	RII P (Iran)	Cause ID	RII P (Nigeria)
1	2	0.832	34	0.672
2	34	0.826	2	0.593
3	7	0.690	35	0.586
4	13	0.665	23	0.552
5	27	0.665	13	0.548
6	36	0.665	37	0.531
7	28	0.658	10	0.528
8	14	0.652	5	0.524
9	24	0.619	22	0.517
10	23	0.613	26	0.517

11	25	0.613	24	0.514
12	10	0.587	28	0.507
13	35	0.587	7	0.497
14	19	0.561	33	0.497
15	1	0.555	14	0.493
16	5	0.555	31	0.490
17	21	0.555	32	0.490
18	16	0.548	36	0.490
19	22	0.548	25	0.486
20	33	0.548	11	0.483
21	3	0.542	29	0.476
22	11	0.535	19	0.472
23	12	0.529	27	0.472
24	37	0.523	4	0.469
25	29	0.516	12	0.469
26	18	0.497	20	0.466
27	9	0.490	17	0.455
28	6	0.484	30	0.455
29	15	0.484	9	0.452
30	32	0.477	8	0.448
31	8	0.471	18	0.445
32	17	0.471	21	0.438
33	20	0.452	3	0.434
34	26	0.452	15	0.434
35	30	0.452	38	0.428
36	31	0.439	16	0.421
37	4	0.329	6	0.397
38	38	0.329	1	0.393

The results for ranking cost overrun causes based on the impact index of each cause on cost overrun from Iran and Nigeria point of view in provided in table 4.22. The highest RII value from the Iran is 0.877 and the least is 0.497. And from Nigeria, the highest RII value is 0.679 and the lowest is 0.452.

Table 4. 22: from Iran and Nigeria POV, Spearman rank-order correlation test

Rank	Cause ID	RII I (Iran)	Cause ID	RII I (Nigeria)
1	2	0.877	34	0.679
2	34	0.865	35	0.669
3	38	0.858	2	0.645
4	35	0.813	13	0.617
5	11	0.748	25	0.586
6	12	0.748	38	0.579
7	37	0.735	19	0.576
8	13	0.723	26	0.572
9	30	0.723	11	0.569
10	15	0.716	29	0.569
11	28	0.710	24	0.566
12	29	0.710	10	0.559
13	1	0.703	32	0.559
14	7	0.677	7	0.555
15	19	0.677	36	0.555
16	17	0.671	9	0.548
17	36	0.665	22	0.548
18	10	0.652	23	0.545
19	32	0.652	37	0.541
20	18	0.632	5	0.538
21	3	0.626	8	0.534
22	5	0.619	30	0.534
23	8	0.619	12	0.531
24	26	0.619	14	0.531
25	14	0.613	28	0.528
26	16	0.613	15	0.524
27	20	0.613	20	0.524
28	25	0.613	27	0.524
29	27	0.613	33	0.524
30	24	0.606	17	0.521
31	4	0.600	21	0.503
32	23	0.600	1	0.500
33	33	0.581	18	0.500
34	9	0.542	4	0.483
35	22	0.542	3	0.479
36	6	0.529	16	0.469
37	21	0.510	6	0.455
38	31	0.497	31	0.452

Table 4.23 provided the results for ranking cost overrun causes based on manageability index for each cost overrun cause from Iran and Nigeria POV. The highest RII value from the Iran is 0.677 and the least is 0.361. And from Nigeria, the highest RII value is 0.600 and the lowest is 0.407.

Table 4. 23: Spearman rank-order correlation test for manageability from Iran and Nigeria POV

Rank	Cause ID	RII M (Iran)	Cause ID	RII M (Nigeria)
1	5	0.677	36	0.600
2	15	0.658	32	0.583
3	24	0.658	14	0.562
4	26	0.658	19	0.562
5	10	0.652	27	0.562
6	25	0.652	13	0.555
7	1	0.645	23	0.555
8	12	0.645	22	0.548
9	31	0.639	34	0.548
10	6	0.632	25	0.541
11	33	0.632	10	0.538
12	19	0.626	35	0.538
13	7	0.613	15	0.534
14	27	0.613	20	0.531
15	32	0.613	33	0.531
16	9	0.606	30	0.524
17	16	0.606	24	0.521
18	36	0.606	28	0.521
19	3	0.600	29	0.521
20	13	0.600	11	0.517
21	22	0.600	38	0.514
22	14	0.594	21	0.510
23	21	0.594	31	0.510
24	17	0.581	4	0.503
25	18	0.561	18	0.503
26	20	0.555	5	0.500
27	23	0.555	12	0.497
28	30	0.555	26	0.497
29	4	0.542	37	0.486
30	28	0.542	9	0.479
31	29	0.542	2	0.466
32	37	0.542	7	0.466

33	11	0.535	3	0.462
34	8	0.523	8	0.455
35	34	0.490	16	0.455
36	2	0.471	1	0.448
37	35	0.432	17	0.441
38	38	0.361	6	0.407

Table 4.24 provided the results for ranking cost overrun causes based on the total risk index from Iran and Nigeria POV. The highest RII value from the Iran is 0.310 and the least is 0.065. And from Nigeria, the highest RII value is 0.167 and the lowest is 0.085.

Table 4. 24: Spearman rank-order correlation test for total risk from Iran and Nigeria POV

Rank	Cause ID	RII TR (Iran)	Cause ID	RII TR (Nigeria)
1	2	0.310	34	0.167
2	34	0.291	2	0.164
3	35	0.221	35	0.146
4	28	0.172	13	0.122
5	13	0.160	26	0.119
6	38	0.156	7	0.118
7	7	0.153	37	0.118
8	11	0.150	5	0.113
9	36	0.146	24	0.112
10	37	0.142	10	0.110
11	29	0.135	23	0.108
12	14	0.135	17	0.107
13	27	0.133	11	0.106
14	23	0.133	25	0.105
15	12	0.123	8	0.105
16	19	0.122	29	0.104
17	1	0.121	22	0.103
18	30	0.118	9	0.103
19	10	0.117	28	0.103
20	25	0.115	12	0.100
21	24	0.114	33	0.098
22	3	0.113	19	0.097
23	18	0.112	38	0.096

24	8	0.112	32	0.094
25	16	0.111	14	0.093
26	17	0.109	30	0.093
27	15	0.105	20	0.092
28	32	0.102	36	0.091
29	5	0.101	3	0.090
30	33	0.101	4	0.090
31	20	0.100	6	0.089
32	22	0.099	18	0.088
33	21	0.095	27	0.088
34	9	0.088	1	0.088
35	26	0.085	16	0.087
36	6	0.081	31	0.087
37	4	0.073	21	0.086
38	31	0.068	15	0.085

Before conducting Spearman rank-order correlation the assumption of test must be evaluated for each pair under examination. Spearman rank-order correlation assumptions are as follows;

- Two variables should be measured on an **ordinal**, **interval** or **ratio scale**
- Two variables represent **paired observations**
- There is a **monotonic relationship** between the two variables.

In these cases, the first and second assumptions are already fulfilled. Third assumption through scatter plot has been evaluated and except for manageability between Iran and Nigeria there are approximate monotonic associations between each pairs.

Further hypotheses were examined using the Spearman rank-order correlation test to evaluate the level of agreement in ranking cost overrun causes between different pair of parties from owners, contractors and consultants as well as the Iran and Nigeria.

The process is crucial to measure the association between rankings of two parties for ranking cost overrun causes**.**

(Null hypothesis) H0: There was a significant agreement among the responses from different pairs of job positions concerning **ranking the cost overrun causes based on the probability, impact, manageability and total risk indices,** (i.e. There was a monotonic association among responses from different pairs of job positions and countries concerning **ranking the cost overrun causes based on the probability, impact, manageability and total risk indices**).

(**Alternate hypothesis) H1:** There was a significant disagreement among the responses from different pairs of job positions concerning **ranking the cost overrun causes based on the probability, impact, manageability and total risk indices,** (i.e. There was no monotonic association among responses from different pairs of job positions and countries concerning **ranking the cost overrun causes based on the probability, impact, manageability and total risk indices**).

The results for Spearman rank-order correlation test for different position groups is summarized in table 4.25 the results revealed that, in term of ranking the causes based on their probability of occurrences all the correlations were significant. The highest agreement for ranking the causes was between owners and contractors with correlation coefficient (Spearman Rho) was 0.786 and the lowest between contractors and consultant with correlation coefficient (Spearman Rho) was 0.455. In term of ranking the causes based on their impact the correlations between contractors and consultants were insignificant. The highest agreement for ranking the causes was between owners and contractors with correlation coefficient (Spearman Rho) was

0.616. In term of ranking the causes based on their manageability also the correlations between contractors and consultants were insignificant. The highest agreement for ranking the causes was between owners and consultants with correlation coefficient (Spearman Rho) was 0.540. Finally considering the ranking of the causes based on their total risk, all the correlations were significant. The highest agreement for ranking the causes was between owners and consultants with correlation coefficient (Spearman Rho) was 0.671 while the lowest was between owners and consultant with correlation coefficient (Spearman Rho) was 0.352.

Table 4. 25: Spearman rank-order correlation test summary

Probability of occurrence			
		Owners	Contractors
Contractors	Spearman rho	.786**	
	Sig. (2-tailed)	0.000	
Consultants	Spearman rho	.585**	.455**
	Sig. (2-tailed)	0.000	0.004
Impact			
		Owners	Contractors
Contractors	Spearman rho	.616**	
	Sig. (2-tailed)	0.000	
Consultants	Spearman rho	.448**	0.271
	Sig. (2-tailed)	0.005	0.100
Manageability			
		Owners	Contractors
Contractors	Spearman rho	.374*	
	Sig. (2-tailed)	0.021	
Consultants	Spearman rho	.540**	0.129
	Sig. (2-tailed)	0.000	0.442
Total risk			
		Owners	Contractors
Contractors	Spearman rho	.671**	
	Sig. (2-tailed)	0.000	
Consultants	Spearman rho	.352*	.389*
	Sig. (2-tailed)	0.030	0.016

The result for Spearman rank-order correlation test for the two countries is summarized in table 4.26. The result revealed that, in term of ranking the causes based on their probability, impact, manageability and total calculated risk with the exception of manageability were significant. The highest agreement for ranking the causes between Iran and Nigeria in terms of probability of occurrences with correlation coefficient (Spearman Rho) was 0.531. However, surprisingly there was no slightest agreement (correlation) between Iran and Nigeria in ranking the causes based on their manageability.

Table 4. 26: Spearman rank-order correlation test summary of Iran and Nigeria POV

Probability of occurrence		
		Iran
Nigeria	Correlation Coefficient	.531**
	Sig. (2-tailed)	0.001
Impact		
		Iran
Nigeria	Correlation Coefficient	.526**
	Sig. (2-tailed)	0.001
Manageability		
		Iran
Nigeria	Correlation Coefficient	0.000
	Sig. (2-tailed)	0.999
Total risk		
		Iran
Nigeria	Correlation Coefficient	.470**
	Sig. (2-tailed)	0.003

4.12 Pareto Analysis

From the standpoint of the total risk index, a Pareto analysis was done on the sources of cost overruns. Given that the total risk formula result may vary from 0.2 to 25, the frequency for the total risk of greater than 20 was regarded a high risk cost overrun reason, and a Pareto analysis was done to choose an appropriate high risk class based on the Likert points numbers. The results revealed that approximately 31% of the cost overrun causes have 80% of impact on total cost overrun. The results from Pareto analysis summarized in table 4.27.

Table 4. 27: Pareto analysis result

Cause ID	Frequency based on total risk bigger than 20	Cumulative Frequency	Cumulative Frequency
34	8	8	17%
2	8	16	35%
35	3	19	41%
10	3	22	48%
25	3	25	54%
7	2	27	59%
9	2	29	63%
24	2	31	67%
11	2	33	72%
17	2	35	76%
3	1	36	78%
8	1	37	80%
28	1	38	83%
36	1	39	85%
37	1	40	87%
38	1	41	89%
26	1	42	91%
4	1	43	93%
5	1	44	96%
12	1	45	98%
29	1	46	100%
1	0	46	100%
6	0	46	100%
16	0	46	100%
21	0	46	100%
27	0	46	100%
31	0	46	100%
13	0	46	100%

14	0	46	100%
15	0	46	100%
19	0	46	100%
20	0	46	100%
30	0	46	100%
33	0	46	100%
18	0	46	100%
22	0	46	100%
23	0	46	100%
32	0	46	100%

The most influential causes of cost overrun are shown the Pareto chart in figure 4.11. The chart indicates that the top 12 causes of cost overrun making up about 31% causes of cost overrun shown in the chart have the most significance and causes 80% impact on the total causes of cost overrun.

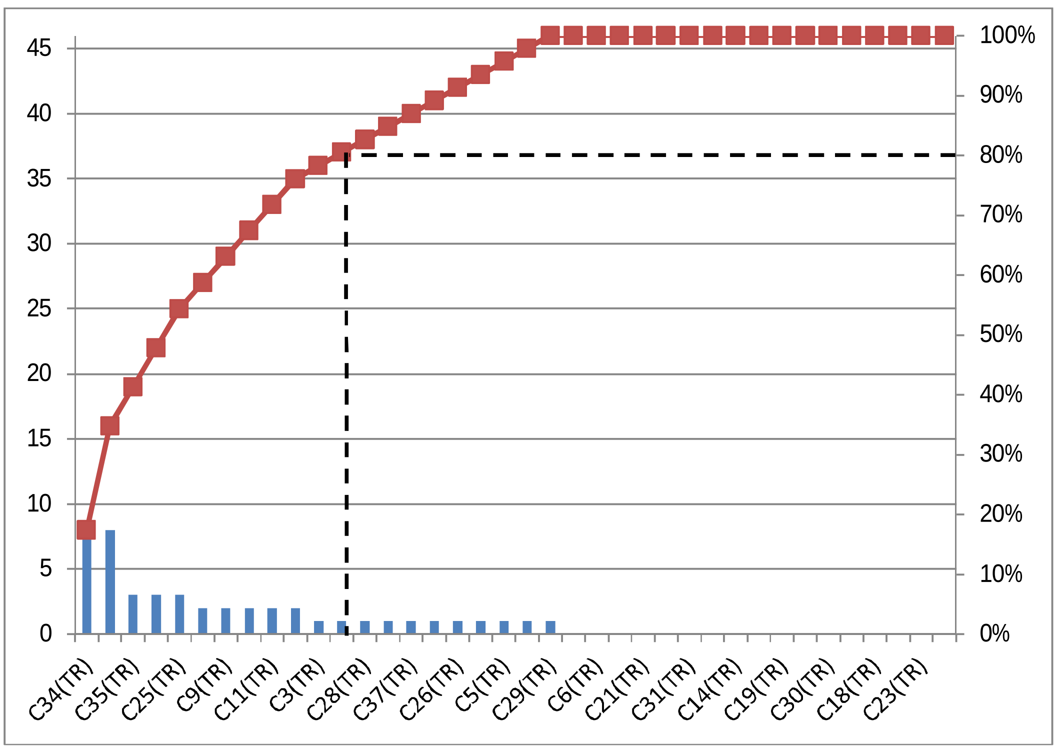

Figure 4. 8: Pareto analysis chart

Chapter 5

CONCLUSION

This study aimed to assess the factors causing cost overrun in building construction projects. The study's summary and conclusion is shown the following paragraphs:

The approach that was adopted for this study was a quantitative approach in which a questionnaire survey was conducted and distributed to respondents consisting of clients/owner, contractor and consultants. A total of 260 questions were distributed and had a response rate of 34.23% (i.e. 89 valid responses was received). This satisfied the requirement for a significance level of 95%. Iran and Nigeria were the regions of focus for this study. 31 responses received were from Iran while the remaining 58 responses were from Nigeria.

A systematic framework was developed for this study which involved the following processes: Question formation; Search for relevant documents; Document selection; Identification of factors; Pilot questionnaire and study; Modify questionnaire and conduct survey; and finally Analysis and synthesis of result.

The factors causing cost overrun was extracted from the selected relevant documents through the process of keyword filtering and Boolean "and" "or" operation by an extensive literature review. 210 factors were extracted and reduced to 38 unique factors through the elimination of repeated factors, fine-tuning factors and pilot test with experts (by series of interviews to ensure highest relevance and affinity with both Iranian and Nigerian construction industry).

The Cronbach's alpha reliability test method adopted was performed in for sets from different point of view of the probability of occurrence, impact, manageability and overall. A general reliability test was also performed to check the reliability of the questionnaire. The results of the test showed that the Cronbach's alpha value for each point of view was greater than 0.90 which meant that the internal consistency of the questionnaire was excellent.

Because some of the assumptions of parametric test were violated, non-parametric test were adopted instead in this study. Specifically, Mann-Whitney Tests, Kruskal Wallis Tests and Spearman's correlation test. Kolmogorov-Smirnov and Shapiro Wilk tests for normality rejected the null hypothesis H0: the population was normally distributed. The null hypothesis for homogeneity of variances H0= the population variances of Iran and Nigeria are equal, was rejected and so therefore the homogeneity of variance assumption is violated in this cases.

The Mann Whitney U test determined the level of agreement between Iran and Nigerian responses. The following resolutions were made;

- The results revealed that there were significant differences between responses for scoring the causes of cost overrun based on their probability of occurrences between Iran and Nigeria therefore rejecting the null hypothesis H0: there was a significant agreement among the responses from Iran and Nigeria concerning probability of occurrence for each causes of cost overrun.

- The results revealed that there were significant differences between responses for scoring the causes of cost overrun based on their impact between Iran and Nigeria therefore rejecting the null hypothesis H0: There was a significant agreement among the responses from Iran and Nigeria concerning impact of each causes of cost overrun.
- The results revealed that there were significant differences between responses for scoring the causes of cost overrun based on their manageability between Iran and Nigeria therefore rejecting the null hypothesis H0: There was a significant agreement among the responses from Iran and Nigeria concerning manageability of each causes of cost overrun.

The level of agreement between owner, contactor and consultant could not be determined because the results for the normality test previously proved that the normality assumption is violated. Therefore in order to evaluate the level of agreement between respondents from owners, contractors and consultant group since the groups are more than two, Kruskal-Wallis H test was performed. The results revealed that;

- There were significant differences between responses for scoring the causes of cost overrun based on their probability of occurrences between owners, contractors, and consultants therefore reject the null hypothesis H0: There was a significant agreement among the responses from Owners, Contractors, and consultants concerning the probability of occurrence for each cause of cost overrun.
- There were significant differences between responses for scoring the causes of cost overrun based on their impact between owners, contractors, and

consultants therefore reject the null hypothesis H0: There was a significant agreement among the responses from Owners, Contractors, and consultants concerning the impact for each cause of cost overrun.

- There were significant differences between responses for scoring the causes of cost overrun based on their manageability between owners, contractors, and consultants therefore reject the null hypothesis H0: There was a significant agreement among the responses from Owners, Contractors, and consultants concerning the manageability for each cause of cost overrun.

Because of the difference between owners, contractors and, consultants in the mean ranks of scoring the probability of occurrences, impact and manageability for each cost overrun cause, post hoc test was performed to clarify the disagreement using Dunn's procedure was performed and the results for the sources of disagreement were summarized in table 4.11, 4.13 and 4.15. Results from the table indicated for each identified cost overrun causes that had significant disagreement in the mean ranking of the scores.

RII value was determined for the probability of occurrence, impact, manageability and total risk so as to get a ranking order for the causes of cost overrun. The ranking is shown in table 4.16. Hypotheses were examined using the Spearman rank-order correlation test to evaluate the level of agreement in ranking cost overrun causes between different pair of parties from owners, contractors and consultants as well as the Iran and Nigeria. The process is crucial to measure the association between rankings of two parties for ranking cost overrun causes. The following resolutions were reached;

- In term of ranking the causes based on their probability of occurrences all the correlations were significant.
- In term of ranking the causes based on their impact the correlations between contractors and consultants were insignificant.
- In term of ranking the causes based on their manageability also the correlations between contractors and consultants were insignificant.
- Finally considering the ranking of the causes based on their total risk, all the correlations were significant.

From the standpoint of the total risk index, a Pareto analysis was peformed on the causes of cost overruns. The Pareto chart in figure 4.11 depicts the most important factors of cost overrun. The chart revealed that the top 12 causes of cost overrun making up about 31% causes of cost overrun shown in the chart have the most significance and causes 80% impact on the total cost overrun. The top 12 causes are: Inflation in prices of (labor, material, equipment, services, land, permissions, and so on); Change in the foreign exchange rate; Governmental policies related issues (corruption, legislation, political…); Financial difficulties related to the contractor; Poor site management and supervision; Delays in the construction schedule; Errors or omissions in construction work; Poor financial control on site; Financial difficulties related to the owner; Insufficient geotechnical investigation; Change in project design; Errors or inconsistencies in project documents.

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APPENDICES

Appendix A: Questionnaire

Please answer the following questions if you have ever been experiencing cost overrun in building construction projects that you have been involved in.

***Introduction and Instruction*:**

The purpose of this study is to examine the contribution of cost overrun causes in building construction cost Escalation. This study is being conducted by the construction management group of the Civil engineering department at Eastern Mediterranean University (EMU). This questionnaire is comprised of three sections. Through the first section, we kindly request you to share some basic personal information about yourself. Second is belonging to specification of the project that you experienced cost overrun. Subsequently, through the section, we will be gathering your opinion on the probability, impact, and manageability of a variety of cost overrun causes on the building construction industry. The result of this research will be further analyzed and employed for the identification and prioritization of the cost overrun causes in the building construction industry. Therefore, we kindly request your participation in this study by filling out and/or answering the questionnaire below.

We assure you that the information collected from you will be kept confidential.

Thanks in advance for your corporation.

SECTION 1:

What is your Gender?

- Female
- Male

What is your age?

- Below 30
- 30-40
- 40-50
- Above 50

What is your educational status?

- High school or equivalent Degree
- Bachelor Degree
- Master’s Degree
- Ph.D. or higher

SECTION 2:

Which one of the following categories best describes your position in the construction field?

- Owner
- Consultant
- Contractor

How many years of experience do you have in the construction field?

- Less than 1 year
- 1-5 Year
- 6-10 Years
- 11-15 Years
- Over 15 Years

The following questions should be answered concerning a particular project in which you have experienced cost overrun:

What was the project budget (In US Dollars):

How much was the project cost overrun (In percentage):

What sector were you cooperating with?

- Private
- Public

What type of projects you were dealing with?

- Residential buildings
- Commercial buildings
- Industrial buildings
- High-rise Buildings (Towers)
- Mass Buildings
- Villa Houses
- Others (specify) ___________________

SECTION 3

Following causes have been identified as a part of factors that might be leading to cost overrun in building's construction. The below questionnaire has been developed based on a 5-point Likert scale to evaluate the impact of each cause on the total cost escalation of the building construction. Please state your perception of each cost overrun causes based on their probability, impact, and manageability by scoring them in the project under concern.

DEFINITION OF RISK EVALUATION PARAMETERS:

Probability: the likelihood of the causes occurring.

Impact: the potential effect on the project cost deviation.

Manageability: the ability of project stakeholders to tackle the probability or the impact of causes.

Definition of scale for probability

1. Extremely unlikely and only occurs in rare situations (<10% chance)
2. In most cases, the likelihood of occurrence is low (10% < chance < 35%)
3. There is a moderate likelihood that this will happen in most cases (35% < chance < 65%)
4. There is a good likelihood that this will happen in most cases (65% < chance < 90%)
5. There is a very good possibility that it will happen, and it is virtually guaranteed that it will happen (90% or greater chance of occurrence)

Definition of scale for impact

1. The effect is negligible (5% < increase in cost)
2. The effect is minor (5% < increase in cost <10%)
3. The effect is moderate (10% < increase in cost <20%)
4. The effect is significant and could jeopardize the project's objectives (20% < increase in cost <50%)
5. The effect is severe and would prevent functional objectives from being met (50% or greater increase in cost)

Definition of scale for manageability

1. The influence of project stakeholders was negligible and risk reduction measures were unlikely to be cost-effective.
2. The influence of project stakeholders was minor and risk reduction measures were rarely to be cost-effective.

3. The influence of project stakeholders on the probability and/or impact of the causes was moderate and risk reduction measures were often to be cost-neutral.
4. The influence of project stakeholders on the probability and/or impact of the causes was significant and risk reduction measures were cost-effective.
5. The influence of project stakeholders on the probability and/or impact of the causes was extreme and risk reduction measures were highly cost-effective.

Factors Causing Cost Overrun	Probability					Impact					manageability				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Variations of clients															
Change in the foreign exchange rate															
Change in project design															
Change in the scope of the project															
Contract related issues															
Delay preparation and approval of drawings															
Delays in the construction schedule															
Errors or inconsistencies in project documents															
Errors or omissions in construction work															
Financial difficulties related to the contractor															
Financial difficulties related to the owner															
Improper construction methods															
Inaccurate project cost Estimation and control															
Inaccurate scheduling and planning															
Inadequate contractor's experience															
Incomplete design at the time of tender															
Insufficient geotechnical investigation															
Lack of Identification of needs															
Lack of material, Equipment availability, or failure															
Lack of Requirement specifications in tender documents															
Lowest bidding procurement method															
Material quality change															
Number and level of competitors															
Poor financial control on site															
Poor site management and supervision															
Project complexity															
Subcontractor related issues															
Reworks or additional works during the construction stage															
Mistakes and defective works in design and construction stages															
Lack of preliminary examination before design or tendering															
The long period between design and time of bidding/tendering															
Labor productivity-related issues (labor shortage, unskilled labor, etc.)															
Lack of communication and coordination and agreement between project's parties															

Inflation in prices of (labor, material, equipment, services, land, permissions, and so on)															
Governmental policies related issues (corruption, legislation, political…)															
Financial difficulties related to the cash flow (including mode of financing, bonds, and payments)															
special issues related to Unforeseen site conditions, adverse weather condition, or other unpredicted condition in construction site															
Force Majeure causes including outbreak of war, projectile missile, hostilities, contamination, and other such risks															

Thank you for your participation

Appendix B: Overall Reliability Test

Reliability Statistics	
Cronbach's Alpha	N of Items
.987	114

Table 6. 1: Overall reliability test result for all causes

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C1(M)	311.55	8090.689	.758	.987
C2(M)	310.86	8084.857	.746	.987
C3(M)	311.70	8094.530	.660	.987
C4(M)	311.86	8161.296	.508	.987
C5(M)	311.66	8121.641	.644	.987
C6(M)	312.00	8103.122	.665	.987
C7(M)	311.90	8151.259	.506	.987
C8(M)	312.00	8139.171	.511	.987
C9(M)	311.82	8141.662	.545	.987
C10(M)	311.57	8153.249	.528	.987
C11(M)	311.81	8128.938	.547	.987
C12(M)	311.70	8103.433	.659	.987
C13(M)	311.55	8107.104	.684	.987
C14(M)	311.57	8103.785	.702	.987
C15(M)	311.54	8111.276	.668	.987
C16(M)	311.89	8118.293	.629	.987
C17(M)	311.94	8096.326	.684	.987
C18(M)	311.77	8099.545	.715	.987
C19(M)	311.49	8089.814	.758	.987
C20(M)	311.76	8089.917	.715	.987
C21(M)	311.72	8129.398	.563	.987
C22(M)	311.57	8121.810	.659	.987
C23(M)	311.63	8135.530	.550	.987
C24(M)	311.57	8140.590	.540	.987
C25(M)	311.58	8106.710	.628	.987
C26(M)	311.59	8098.172	.653	.987
C27(M)	311.59	8122.416	.664	.987
C28(M)	311.81	8154.353	.547	.987
C29(M)	311.81	8142.158	.631	.987
C30(M)	311.75	8111.703	.679	.987

C31(M)	311.70	8109.164	.658	.987
C32(M)	311.47	8115.130	.689	.987
C33(M)	311.59	8127.464	.634	.987
C34(M)	311.77	8170.276	.405	.987
C35(M)	311.86	8169.442	.344	.987
C36(M)	311.45	8152.592	.520	.987
C37(M)	311.88	8151.766	.523	.987
C38(M)	312.07	8182.848	.319	.987
C1(P)	312.13	8132.775	.577	.987
C2(P)	311.17	8113.776	.596	.987
C3(P)	312.02	8107.146	.634	.987
C4(P)	312.30	8153.945	.514	.987
C5(P)	311.81	8124.401	.681	.987
C6(P)	312.27	8128.856	.598	.987
C7(P)	311.58	8121.003	.569	.987
C8(P)	312.14	8143.857	.528	.987
C9(P)	312.06	8117.643	.618	.987
C10(P)	311.66	8128.226	.661	.987
C11(P)	311.87	8117.848	.591	.987
C12(P)	312.01	8120.988	.691	.987
C13(P)	311.51	8134.985	.586	.987
C14(P)	311.66	8125.397	.621	.987
C15(P)	312.18	8153.125	.558	.987
C16(P)	312.12	8160.010	.517	.987
C17(P)	312.10	8110.259	.657	.987
C18(P)	312.10	8101.771	.659	.987
C19(P)	311.94	8151.716	.543	.987
C20(P)	312.12	8126.985	.648	.987
C21(P)	312.02	8138.438	.496	.987
C22(P)	311.84	8121.304	.608	.987
C23(P)	311.53	8125.398	.557	.987
C24(P)	311.66	8103.665	.722	.987
C25(P)	311.76	8094.795	.732	.987
C26(P)	311.95	8135.803	.568	.987
C27(P)	311.73	8128.490	.570	.987
C28(P)	311.63	8130.188	.561	.987
C29(P)	311.98	8138.560	.580	.987
C30(P)	312.12	8114.693	.615	.987
C31(P)	312.07	8123.361	.598	.987
C32(P)	312.02	8139.999	.559	.987
C33(P)	311.88	8125.083	.609	.987
C34(P)	310.92	8094.127	.720	.987

C35(P)	311.48	8149.741	.526	.987
C36(P)	311.66	8119.690	.616	.987
C37(P)	311.77	8122.520	.627	.987
C38(P)	312.43	8203.224	.271	.987
C1(I)	311.87	8131.629	.584	.987
C2(I)	311.87	8131.629	.584	.987
C3(I)	312.07	8160.726	.411	.987
C4(I)	311.80	8123.165	.633	.987
C5(I)	311.66	8086.885	.768	.987
C6(I)	312.00	8106.634	.632	.987
C7(I)	311.55	8094.299	.661	.987
C8(I)	311.67	8084.905	.706	.987
C9(I)	311.72	8098.593	.731	.987
C10(I)	311.46	8109.300	.678	.987
C11(I)	311.34	8077.495	.696	.987
C12(I)	311.46	8045.544	.812	.986
C13(I)	311.19	8085.987	.738	.987
C14(I)	311.66	8115.031	.699	.987
C15(I)	311.46	8095.398	.682	.987
C16(I)	311.78	8091.830	.715	.987
C17(I)	311.51	8045.985	.805	.986
C18(I)	311.69	8077.876	.780	.987
C19(I)	311.37	8075.359	.788	.986
C20(I)	311.67	8077.929	.754	.987
C21(I)	311.93	8163.629	.456	.987
C22(I)	311.71	8122.257	.570	.987
C23(I)	311.63	8138.115	.539	.987
C24(I)	311.54	8103.910	.637	.987
C25(I)	311.47	8078.179	.763	.987
C26(I)	311.53	8067.545	.795	.986
C27(I)	311.65	8103.742	.717	.987
C28(I)	311.51	8107.155	.652	.987
C29(I)	311.37	8111.164	.674	.987
C30(I)	311.48	8088.619	.721	.987
C31(I)	312.06	8144.521	.485	.987
C32(I)	311.46	8112.837	.685	.987
C33(I)	311.71	8127.257	.606	.987
C34(I)	310.83	8110.825	.655	.987
C35(I)	310.94	8086.691	.705	.987
C36(I)	311.46	8117.885	.634	.987
C37(I)	311.36	8084.038	.713	.987
C38(I)	311.11	8079.927	.664	.987

Appendix C: Normality Test

Table 6. 2: Normality test result for all causes

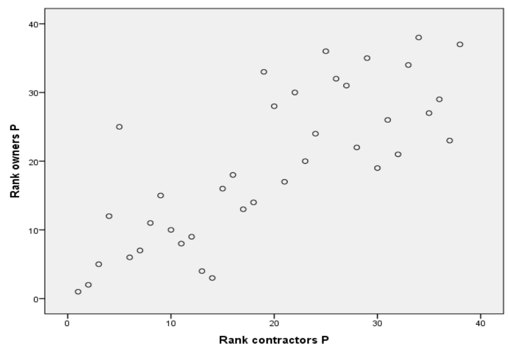
Tests of Normality						
Cause ID	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
1(P)	.188	83	.000	.871	83	.000
2(P)	.178	83	.000	.888	83	.000
3(P)	.198	83	.000	.865	83	.000
4(P)	.220	83	.000	.853	83	.000
5(P)	.198	83	.000	.907	83	.000
6(P)	.242	83	.000	.825	83	.000
7(P)	.215	83	.000	.890	83	.000
8(P)	.256	83	.000	.857	83	.000
9(P)	.202	83	.000	.869	83	.000
10(P)	.224	83	.000	.893	83	.000
11(P)	.192	83	.000	.885	83	.000
12(P)	.192	83	.000	.892	83	.000
13(P)	.199	83	.000	.910	83	.000
14(P)	.194	83	.000	.904	83	.000
15(P)	.221	83	.000	.872	83	.000
16(P)	.230	83	.000	.886	83	.000
17(P)	.198	83	.000	.868	83	.000
18(P)	.213	83	.000	.852	83	.000
19(P)	.262	83	.000	.883	83	.000
20(P)	.259	83	.000	.870	83	.000
21(P)	.194	83	.000	.857	83	.000
22(P)	.172	83	.000	.895	83	.000
23(P)	.193	83	.000	.898	83	.000
24(P)	.207	83	.000	.894	83	.000
25(P)	.208	83	.000	.890	83	.000
26(P)	.232	83	.000	.886	83	.000
27(P)	.187	83	.000	.901	83	.000
28(P)	.202	83	.000	.902	83	.000
29(P)	.219	83	.000	.895	83	.000
30(P)	.208	83	.000	.854	83	.000
31(P)	.225	83	.000	.865	83	.000
32(P)	.200	83	.000	.889	83	.000
33(P)	.227	83	.000	.893	83	.000
34(P)	.190	83	.000	.872	83	.000
35(P)	.200	83	.000	.907	83	.000
36(P)	.172	83	.000	.908	83	.000

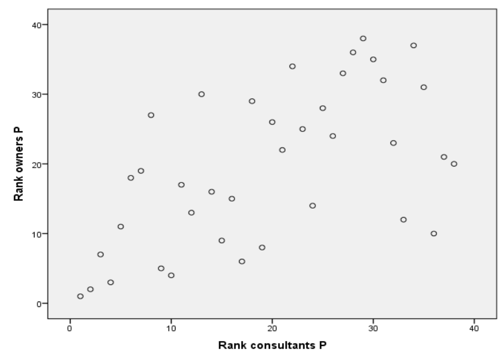
37(P)	.247	83	.000	.886	83	.000
38(P)	.271	83	.000	.812	83	.000
1(I)	.195	83	.000	.891	83	.000
2(I)	.195	83	.000	.891	83	.000
3(I)	.232	83	.000	.849	83	.000
4(I)	.231	83	.000	.884	83	.000
5(I)	.151	83	.000	.908	83	.000
6(I)	.203	83	.000	.866	83	.000
7(I)	.203	83	.000	.884	83	.000
8(I)	.174	83	.000	.906	83	.000
9(I)	.174	83	.000	.909	83	.000
10(I)	.216	83	.000	.897	83	.000
11(I)	.218	83	.000	.870	83	.000
12(I)	.219	83	.000	.865	83	.000
13(I)	.191	83	.000	.895	83	.000
14(I)	.193	83	.000	.905	83	.000
15(I)	.197	83	.000	.895	83	.000
16(I)	.170	83	.000	.896	83	.000
17(I)	.165	83	.000	.875	83	.000
18(I)	.185	83	.000	.898	83	.000
19(I)	.210	83	.000	.890	83	.000
20(I)	.193	83	.000	.895	83	.000
21(I)	.269	83	.000	.874	83	.000
22(I)	.233	83	.000	.884	83	.000
23(I)	.173	83	.000	.906	83	.000
24(I)	.222	83	.000	.882	83	.000
25(I)	.221	83	.000	.888	83	.000
26(I)	.155	83	.000	.901	83	.000
27(I)	.233	83	.000	.896	83	.000
28(I)	.164	83	.000	.905	83	.000
29(I)	.215	83	.000	.901	83	.000
30(I)	.176	83	.000	.903	83	.000
31(I)	.188	83	.000	.860	83	.000
32(I)	.199	83	.000	.905	83	.000
33(I)	.240	83	.000	.892	83	.000
34(I)	.209	83	.000	.838	83	.000
35(I)	.201	83	.000	.857	83	.000
36(I)	.202	83	.000	.889	83	.000
37(I)	.176	83	.000	.893	83	.000
38(I)	.219	83	.000	.845	83	.000
1(M)	.179	83	.000	.910	83	.000
2(M)	.205	83	.000	.857	83	.000

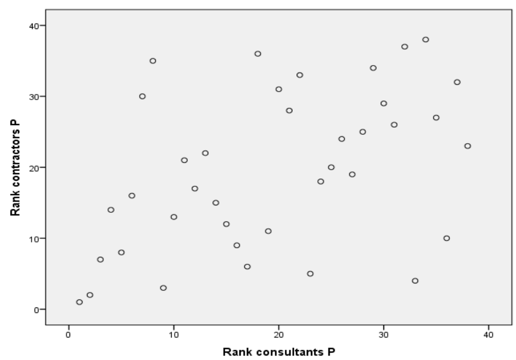
3(M)	.164	83	.000	.885	83	.000
4(M)	.270	83	.000	.881	83	.000
5(M)	.178	83	.000	.903	83	.000
6(M)	.194	83	.000	.866	83	.000
7(M)	.177	83	.000	.901	83	.000
8(M)	.194	83	.000	.866	83	.000
9(M)	.187	83	.000	.903	83	.000
10(M)	.189	83	.000	.915	83	.000
11(M)	.221	83	.000	.884	83	.000
12(M)	.215	83	.000	.892	83	.000
13(M)	.227	83	.000	.895	83	.000
14(M)	.201	83	.000	.905	83	.000
15(M)	.195	83	.000	.906	83	.000
16(M)	.220	83	.000	.875	83	.000
17(M)	.209	83	.000	.876	83	.000
18(M)	.218	83	.000	.898	83	.000
19(M)	.216	83	.000	.895	83	.000
20(M)	.175	83	.000	.896	83	.000
21(M)	.201	83	.000	.897	83	.000
22(M)	.203	83	.000	.907	83	.000
23(M)	.195	83	.000	.904	83	.000
24(M)	.215	83	.000	.900	83	.000
25(M)	.191	83	.000	.891	83	.000
26(M)	.154	83	.000	.893	83	.000
27(M)	.220	83	.000	.885	83	.000
28(M)	.225	83	.000	.901	83	.000
29(M)	.220	83	.000	.903	83	.000
30(M)	.267	83	.000	.879	83	.000
31(M)	.162	83	.000	.903	83	.000
32(M)	.165	83	.000	.915	83	.000
33(M)	.209	83	.000	.906	83	.000
34(M)	.209	83	.000	.902	83	.000
35(M)	.193	83	.000	.861	83	.000
36(M)	.166	83	.000	.916	83	.000
37(M)	.215	83	.000	.903	83	.000
38(M)	.195	83	.000	.856	83	.000
a. Lilliefors Significane corretion						

Appendix D: Scatter Plots

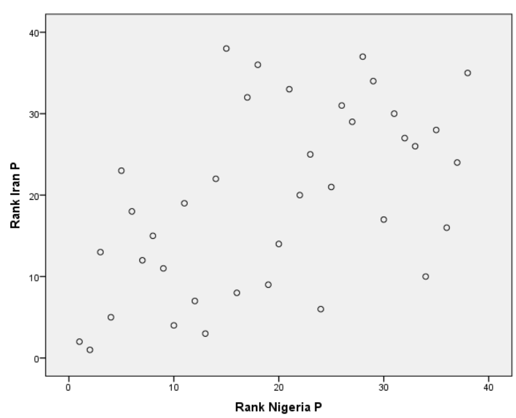
From the probability of occurrence of each cause for owners, contractors and consultants



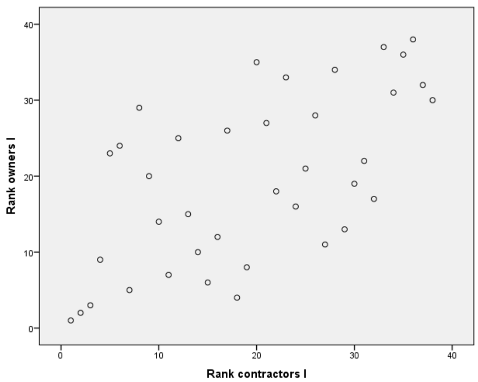


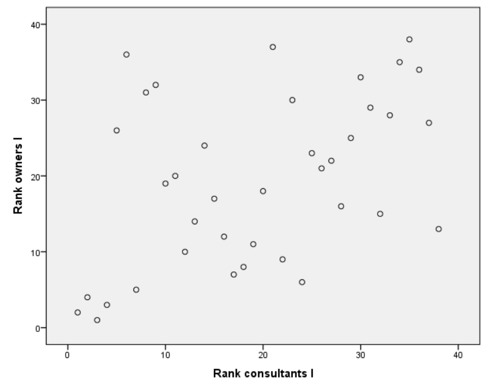


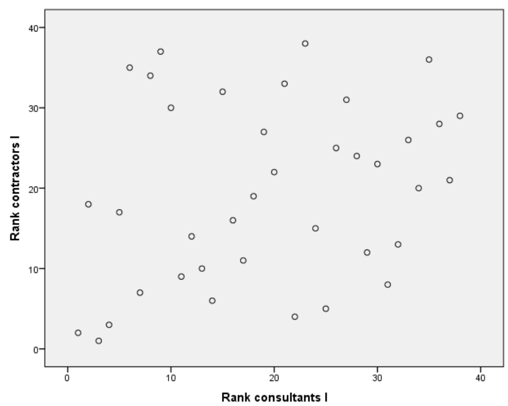
From the probability of occurrence of each cause for Iran and Nigeria



From the impact of each cause on cost overrun for owners, contractors and consultants







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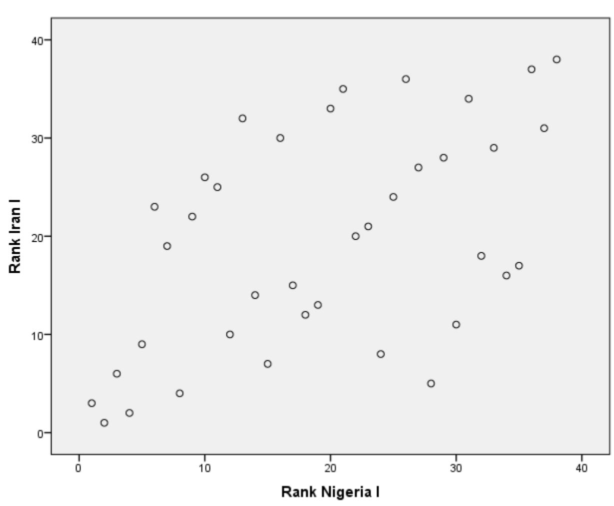

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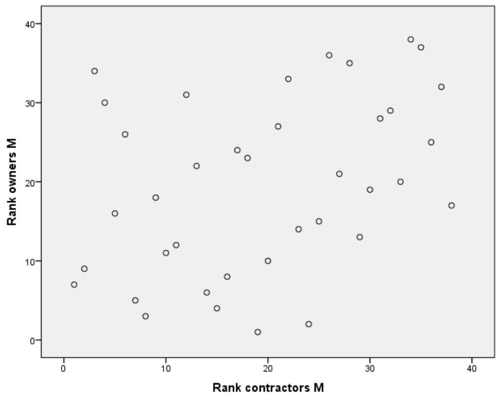

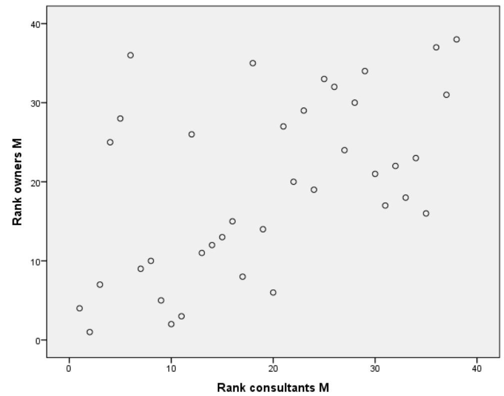

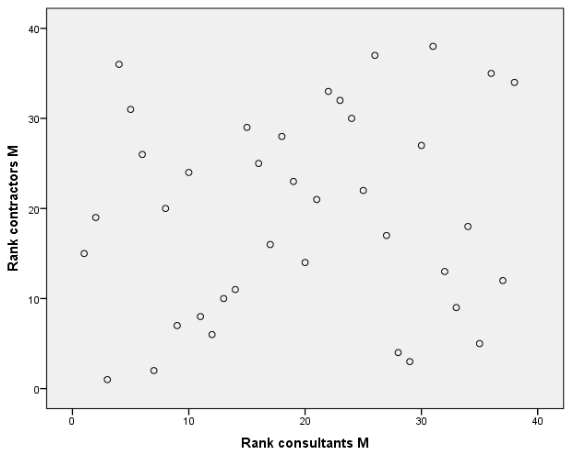

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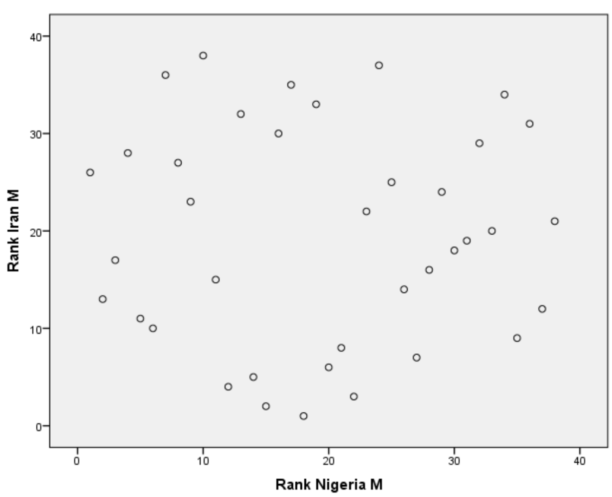
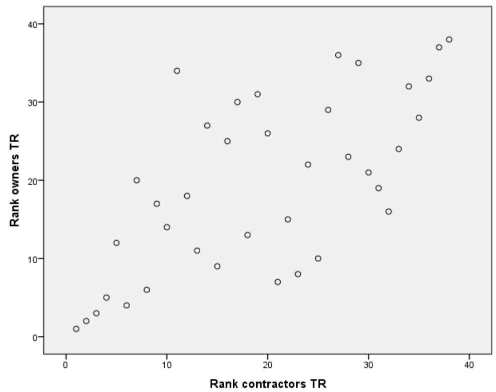
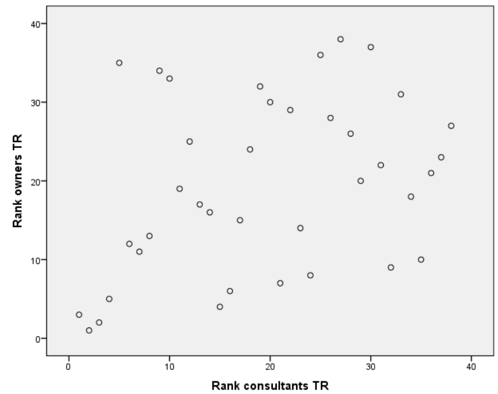
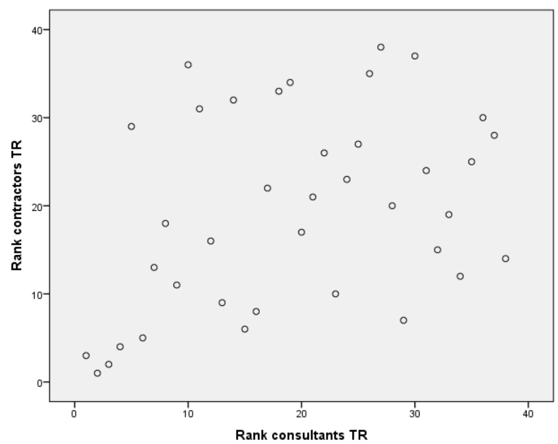


From the total risk of each cause on cost overrun for owners, contractors and consultants







From the total risk of each cause on cost overrun for Iran and Nigeria