

**Supply chain risk management in the construction sector in the
Kingdom of Saudi Arabia**

إدارة مخاطر سلسلة التوريد في قطاع البناء في المملكة العربية السعودية

Team Leader

Eng: Faisal Fares Al-Enezi: 221001547

Participants:

Eng: Muhammad Ghaith Al-Mutairi: 221002176

Supervision

Pro.Walid Soulaiman

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Abstract

This study aimed to determine construction supply chains risks in Saudi Arabia. Moreover, several solutions has been suggested to avoid and mitigate these risks. The study adopted questionnaire survey method to achieve the research goal .The sample size selected includes several construction projects in Saudi Arabia by asking project managers ,contractors, Site supervisions and logistic managers. then , Data of questionnaire has been analyzed using SPSS software in order to discuss and interpret the results. It has been affirmed that construction supply chains in the Kingdom of Saudi Arabia constitute a serious threat to the success of construction projects.so several mitigation strategies have been addressed to handle these risks

Chapter one

1.1 Introduction

Due to the great competition between companies, it has become difficult for companies to achieve the integration of all procedures required to produce a specific product at the specified speed and with the required quality in order to achieve customers satisfaction (Ermoshin,2018)

It has become the interest of companies in the first degree to increase competitiveness (Francis & Tharakan,2023); (Bhatti & Bauirzhanovna, 2023) and therefore there has been a need for outsourcing working on the performance and integration of all activities to obtain the final product (Inbound logistics,2023). These external sources are the creation of a supply chain consisting of other companies and suppliers that customize activities according to the company's requirements.

Supply chain can be defined as an integration of product life-cycle operation which includes several flows like physical, information, funds. The objective of supply chain is to achieve final -utilizer demands with a product or a service (Dammert, 2021). Supply chain includes a variety of procedures and activities that transmute the material via the SC from the initial suppliers to the end-user. consequently, supply chain comprise the internal tasks of the corporate addition to external outsourcing such as companies and suppliers. Supply chain is a grid that connect all these suppliers until the end user (Albertin,2017). SCM can be identified as the combination of several enterprises units of the entire supply chain and the organization of substances , information and financial flows to offer a product to an end user.the basic goal is to link business tasks and operations within and across firms in high performance manner(Pujawan & Bah,2022).

Risks can negatively affect the performance of the supply chain, which threatens the company's performance and affects the company's profitability. Risks also make the supply chain more complex (Mai et al,2022). It is possible through risk management, which is represented by identifying risks, assessing and prioritizing them, and then taking effective solutions to mitigate them. The goal of risk management is to ensure the flow of the planned processes and to preserve the firm versus supply chain issues (Albertin , 2017) and the Figure 1 shows risk management process

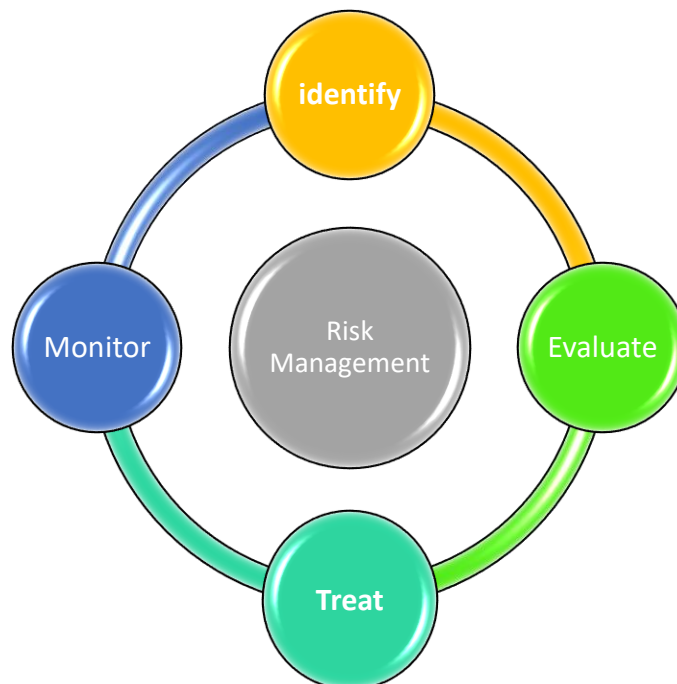


Figure 1. Risk Management (Albertin , 2017)

Due to inability of supply chain management to address the problems resulting from risks, the need arose for the term supply chain risk management, which expresses the integration between risk management and supply chain management as illustrated in Figure2 (Albertin , 2017)

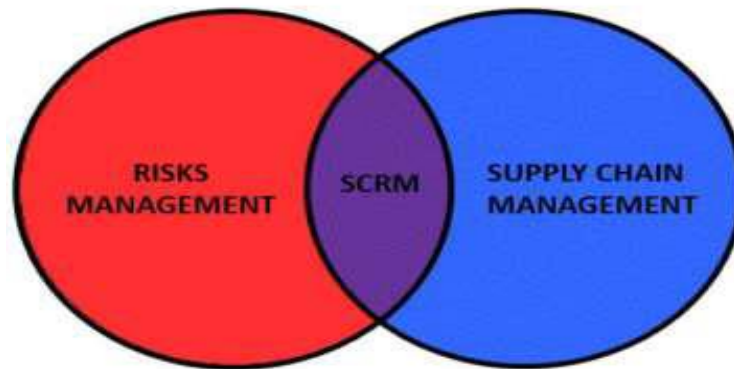


Figure 2. The combination between SCM and risk management issues (Albertin , 2017)

1.2 Problem Statement

Lack of planning and coordination of events and processes in the supply chain leads to disruptions and disruption of the supply chain that negatively affects the company's performance, as production costs increase, profitability decreases, losses increase, and the product is not delivered on time (Abdel-Basset et al, 2019)

Nowadays, the construction sector is facing numerous issues all over the world

One of the areas that is most affected by the disruptions resulting from the supply chain is the field of construction, where the construction sector faces many difficulties resulting from the risks of the supply chain (Qureshi et al,2020).In view of the great complexities occurring in construction projects and the risks facing the life of the project and the complex relationships between the various parties to the project, it is necessary to have an effective management of the risks facing the supply chain in the construction sector, which cause cost overruns and cause delays in projects (Shojaei & Haeri,2019).

Saudi Arabia is facing delays and cost overruns in construction projects due to supply chain disruptions (Alshihri et al, 2022). It has been noted that the construction industry in Saudi Arabia ended only 30% of projects within the planned period and the average period consumed was between (10% -30)% (Shahbaz et al, 2019). In view of the problems and complications resulting from the disturbances in the supply chain in the Saudi construction sector, this study is concerned with risk management in the supply chains related to the construction sector in Saudi Arabia.

1.3 The importance and Objective of the Research

The importance of this study comes from the fact that it tries to enhance the supply chain risk management strategies in the Saudi construction sector and enhance the performance of the construction supply chain. It also provides project managers with a reference for potential supply chain risk management.

The major goal is to identify, evaluating and analyzing, developing methods of reducing and managing supply chain hazards in the Saudi construction sector. Some of minor objectives can be achieved :

- 1- To identify all risk factors affects negatively on Supply Chain in construction sector.
- 2- To prioritize the most risk factors affects on construction supply chain in Saudi Arabia
- 3- To investigate the most effective strategies that mitigate risks in construction supply chain
- 4- To provide guideline and principle that can be benefit to raise awareness of managers construction companies about the potential risk supply chain and the effective and suitable strategies to treat these risks and mitigate them.

1.4 Research hypotheses

- a. providing all the demanded mankind , material, technological sources can achieve the efficient supply chain hazard management

- b. Creating a guidelines and manual to supply chain hazards management and train personnel helps to raise the knowledge and culture of hazard management activities.
- c. Raising awareness about construction supply chain hazards has a significant impact on avoiding time and cost overrun in construction projects.
- d. The correct exchange of information, effective control of supply chains, and communication channels contribute to reducing the risks of construction supply chains

1.5 Research Methodology

The methodology of this research is based on the following points:

- 1- Identification of potential risks in the supply chain of the construction sector through a complete review of the literature
- 2- Classifying risks into categories commensurate with the construction sector
- 3- Reviewing all the literature that includes supply chain risk management strategies in the construction sector.
- 4- Organizing a questionnaire targeting a number of Saudi contracting companies and the construction sector, including project managers, engineers, supervisors and workers, to assess risks in terms of the degree of impact and probability of occurrence, in addition to identifying the most effective strategies. Effectiveness to mitigate and control supply chain risks in the construction sector
- 5- Perform a statistical analysis of the data using the Spss software
- 6- Discuss the results and come up with a guide that benefits Saudi construction companies to identify potential risks before starting the project and effective supply chain risk management strategies for each potential risk

1.6 Research limits

This study requires conducting a survey on a large number of construction companies, which represents a great difficulty in conducting a visit to a large number of construction companies. This problem will be overcome by sending a questionnaire to the email.

1.7 The general perception of the research structure

The structure of the study will be based on the adoption of five chapters in the thesis:

Chapter One: The first chapter includes a general introduction to the thesis represented by providing a background on supply chain risks, presenting the research problem, the importance of research, research objectives, research hypotheses and research limitations.

The second chapter: It includes a literary review that includes the definition and types of risks, their evaluation, and ways to mitigate and control them, in addition to a review of all potential risks in supply chains in the construction sector. A complete review of supply chain risk management strategies in the construction industry will also be conducted.

Chapter Three: This chapter includes a presentation of the study methodology, the selection of the study sample and the questionnaire, and an explanation of data analysis methods using the SPSS program

Chapter Four: This chapter discusses the findings to identify the most potential risks in the supply chain and effective ways to manage these risks in the construction sector

Chapter Five: This chapter presents a summary and recommendations to increase construction companies' awareness of supply chain risks and provide them with effective risk management strategies

Chapter Two

Literature Review

2.1 Review of supply chain management concept

activities of SC transform natural sources , raw substances and components into a final outcome that is delivered to final purchaser

☐ In SCM, enterprises participate in SC by exchanging information correlated fluctuations of market , production abilities .

☐ SC can be defiened logistic grid is System of enterprises , People, Technology, Activities ,data and resources in transforming a product or service from supplier to consumer.

2.2 Supply Chain management in Construction sector

Inspite the significance contribution of the construction industry in economic development and infrastructure growth, the manufacture is faced by difficulties such as cost overruns, time delay of project , fluctuations material costs, late in payment to contractors, lack of skilled workers, (Boadu, Wang and Sunindijo, 2020:3; Pillay 2016:24; CIDB 2020; Master Build 2020).

Supply chain management in the construction project has a significance impact in enhancing the organization and communication between every stakeholder in the construction value chain, in addition to insuring the project quality and profitability of a construction project (cemex,2023). Also, in include the coordination of information exchange, cost ,resources ,raw material , cash flow and offering skilled labor (Ghufran et al,2021)

2.3 Supply chain Risks in construction projects

SCRM is defined as “the management of SC risk via organization or cooperation between the SC partners so as to insure profitability and continuity”. It is an operation of measuring or evaluation

hazards and then creating procedures to administer the risk. Risk management is considered the wide activity of planning and decision making designed to handle of risks occur.

2.4 Risk Assessment

Risk assessment is divided into of two scales: potential and influence. Potential measures the possibility that the action will happen. The accurate potential may be hard to identify if there is no historical data that can be utilized to know the frequency of the action happening. On behalf, an organization can utilize a method depend on the views and experts to know potential of even occur. Influence – measures the intensity of action occurred.

A risk score can be computed for each hazard by multiplying the influence times the possibility to know an expected value of the hazard. After that, risks are ranked using risk score.

Table 2.1: Scoring methodology according to potential (Health service executive,2009)

Potential degree	Potential score	description
Very low	1	Event is assumed no to occur
Low	2	Event is more potential not to occur
Moderate	3	Event may be occur or not
High	4	Event is more potential to occur
Very high	5	Event is assumed to occur

In Table 2.2, PMBOK(2013) describes influence on crucial components of project , that identifies relationship between numbers and main project areas.

Table 2.2: explain influence score on project components (PMBOK,2013)

Influence degree	Influence score	Description (Influence on/cost/quality/time)
Very low	1	It does not lead to an increase in cost and time/ no notable degradation on quality
Low	2	Cost increases by 10% / Time increases by 5%/there is a little impact on quality
Moderate	3	Cost increases from 10 to 20% / Time increases from 5 to 10% .quality is accepted
High	4	Cost increases from 20 to 40% / Time increases from 10 to 20% .quality is not accepted
Very high	5	The cost increases by more than 40% and the time increases by more than 20%. The quality of the project is very poor

Potential and influence scores are two major factors of this technique. Potential and influence matrix identifies which risks require detailed risk response plans. Specifically, the matrix utilized is 5*5 matrix, that is very low, low, medium, high and very high ranking. Table 2.3 illustrates a specimen of 5*5 matrix.

Table 2.3: A sample of potential and influence matrix (5*5 matrix)

		Threats				
Probability	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Impact				

Red: refers the high risks, play a great influences on objectives and significant occurrence potential.

Yellow condition: refers the risks that are comparatively significant in influence and potential.

Green condition: Green label refers the hazards with low influence or low occurrence potential

According to PMBOK (2013), each hazard should be prioritized in in respect of risk potential and risk influence within certain project. The employment of matrix contributes the project stakeholders to analyze the hazards and after that rank them depend on their influence on project. This technique computes risk score for each hazard by multiplying the hazard potential and risk influence ; in addition , all risks can be ranked depend on risk score. After that , the hazards can be given several colors on map or graph. Each color explain the intensity of hazard on project.

Potential and influence matrix that are shown in Table 2.3 is set to order the risks. Ranking of risks are conducted depend on their rates (PMBOK, 2013). In the matrix, the rating and color are assigned to explain the significance of each risk.

2.5 mitigation strategies of construction supply chain Risks

(planredar,2023) defined some strategies to mitigate construction supply chain Risks such as cooperation between supply chain partners, Diversity in sources of suppliers and materials and not focusing on one supplier and using data in managing supply chains.

(Liberty mutual,2023) implementing plan and budget for prices fluctuations in materials, Be intentional about automated risk monitoring.

(Jason Campbell,2018) determined the following strategies for risk mitigation: Optimize workplace safety, giving priority in communication, Insure of raw material sources

2.6 Beneficial Contribution of recent studies

With regard to the construction industry, a very limited number of studies addressed supply chain risk management:

(Marandi et al,2023) Conducted a supply chain risk assessment for green building projects. and found that evaluating supply chain hazards' in green residential mega projects is a novel contribution to mega construction-project management's body of knowledge. in addition , the major hazard factors were classified depend on the properties called driving power and dependence.

(construction uk magazines,2023) identified risk faces construction sectors:lack of skilled labor, lack of adequate labor,lack of materials

(Tang & Xu, 2023) Identified the risks facing the construction supply chain by reviewing the literature and conducting a statistical analysis, as it clarified the internal and external risks of the

supply chain. It also concluded that right information exchange , efficient control of supply chains, smooth communication channels, proper insurance, new utilization of novel technology are basic to address several construction supply chain hazards

(Ting et al ,2020) Conducted a literature review including all studies conducted between 2000 and 2018 on supply chain risk management practices in the construction sector. It was found that there is a lack of awareness and knowledge about the risks of construction supply chains, in addition to the lack of sufficient knowledge of effective supply management strategies in the construction sector.

(Nurdiana et al,2019) guided a research to identify the hazards of SC in construction industry, analyze the hazards, and investigated strategies to mitigate hazards. study method based on conducting questionnaire ad and descriptive statistical analysis . risk analysis adopted Promethee method, the results found that the most hazard in SCM is the price from sub-contractors.

(Liao et al,2019) published a research paper in which he emphasized that the effective management of the supply chain in construction sector has an important impact on improving the competitiveness of enterprises. He also stressed the need to manage supply chain risks in general to avoid cost overruns and delays in projects.

(Shojaei & Haeri,2019) suggested a comprehensive SCRM method for construction industry that utilizes grounded theory, fuzzy cognitive mapping, and grey relational analysis. A real world was utilized as case study to illustrate the degree of applicability and efficient of the suggested method. The proposed approach has demonstrated its ability to visualize risks in an efficient and accurate manner.

(Sugathadasa ,2018) identified the supply chain risks in the construction industry in Sri Lanka, and he classified the risks into three categories: risks arising from the client, risks arising from the consultant, and the third resulting from the contractor, represented by planning risks, decision-making risks, financial risks, communication risks and subcontractor risks.

(Darko et al ,2016) identified the most risk factors affect on supply chains in construction industry in Ghana . The risk factors have been collected using comprehensive literature review then the most risk factors evaluated using questionnaire by asking construction companies then the data were analyzed using statistical analysis . The results found that prices fluctuations , interest rates variations, lack of materials, repeated variations in SC inputs and unforeseen variations in demand are the most risks affects on construction supply chains.

Chapter Three

Research Methodology

3.1 Research approach and method

The study method includes research design and data collection methods. then, the collected data is analyzed and explained the obtained results. The research method adopted questionnaire to collect data.

This study aims to evaluate supply chain hazards and its strategies mitigation in construction industry in Saudi Arabia. The process of risk management seeks to determine and evaluate risks in order to have a clear knowledge about risks and enable to manage them correctly.

The process can be basically divided into three steps:

☐☐Risk determination.

☐☐Risk Analysis

☐☐Risk reduction or Mitigation.

3.2 Research Design

In order to identify how SC risk management utilized in construction sectors, Saudi Arabia construction firms were used as a case study.

To achieve this study, qualitative and quantitative technique has been selected.

When data is collected , It was designed questionnaire survey was depend on the knowledge of construction firm in Saudi Arabia. The questionnaires distributed to participants who had responsibilities on supply chain operation.

For the stage of risk identification and analysis, the risks were categorized in accordance with four major types: technical ,organizational, management and external thus, after categorizing the risks, risks will be ordered according to two criteria: Probability and Impact Matrix, in which, the analysis

will be conducted with potential and influence matrix to conduct qualitative hazard evaluation and prioritization. Potential and effect technique prioritizes determine risks depend on computed risk scores. From the following relation : $score = P_{\text{Potential}} \times \text{influence}$

3.3 Target population

The questionnaires were given away among the respondents include peoples who are personnel (site manager, project managers, logistic managers, contractor) of the Grade one construction firms in Saudi Arabia.

3.4 sampling technique

Sampling can be defined as a method of choosing a representative section of a population for the objective of identifying parameters or features of the total population. The researcher distributed questionnaires and conduct questionnaire included construction companies in Saudi Arabia and the case study sample population comprised :Project Managers, contractor Managers, Site Supervisors and logistic manager

3.5 Data Sources and Types

Two types of data were utilized: major and minor data. The major data is the basic information gathered by the researcher for a certain goal and minor data is information gathered by others. For study design and study methodology stated above, the major and minor data sources have utilized. The primary data comprises survey ; However, minor data sources have obtained from recent studies data existed in books, published papers and publication that have adopted to develop data.

3.6 Data Collection Procedures

This study adopted major data that were gathered utilizing questionnaires.

To achieve the data collections, questionnaire (the major method for gathering the major quantitative data that include, age, education level, experience years and job position) was employed and the scale measure was the 5-point Likert type.

-For the degree of influence (very affecting = 5, affecting = 4, neutral = 3, not affecting = 2, not affecting at all = 1)

-For the degree of probability of occurrence (very likely = 5, likely = 4, infrequent = 3, not occurring = 2, not occurring at all = 1)

-For risk mitigation strategies (very affected = 5, affected = 4, neutral = 3, not affected = 2, not affected at all = 1)

3.7 Reliability Test

Reliability indicates the degree to which your collection of data methods or analysis will yield consistent results (Trizano-Hermosilla, and Alvarado, 2016)

This research utilized Chronbach's alpha to evaluate the inner consistency of variables in the study tool. Chronbach's alpha is a of reliability coefficient utilized to size the inner scale consistency .

Cronbac's Alpha (α); it is the most popular criteria of scale reliability. The Alpha value varies from a at least zero to a maximum of 1.0 for a perfect score, a good criteria of the alpha should achieve 0.70 or more .According to (Trizano-Hermosilla, and Alvarado, 2016)

$\alpha \geq 0.9$ the measure is excellent

$0.9 > \alpha \geq 0.8$ the measure is good

$0.8 > \alpha \geq 0.7$ the measure is accepted

$0.7 > \alpha \geq 0.6$ the measure is questionable

$0.6 > \alpha \geq 0.5$ the measure is poor

$\alpha < 0.5$ the measure is unacceptable

3.8 Data analysis

After the survey is implemented before analysis, the questionnaire sufficient examined for reliability , modifying , coding and tabulation were performed .

The outcomes gained were analyzed and explained by utilizing descriptive analysis comprise utilization of frequencies, means and percentile. The data were put in the form of tables, frequency, mean and percentages with description. The data collected were analyzed and explained in correlation to the theoretical suggestion thus , average scores of each risk is computed

All outcomes are computed using SPSS Statistics software, that symbolize for Statistical Package for the Social Sciences. This program is a broadly used software for statistical analysis . SPSS is mainly developed to analyze statistical data, and consequently , it provides a huge variety of charts, techniques and graphs.

Chapter Four

Results and discussion

4.1 Introduction

This chapter provides the outcomes of this study by explaining ; presenting and analyzing the collected data and discusses the outcomes.

The survey adopted questionnaire and in gathering data on supply chain hazards in the construction industry

The questions in the questionnaire were set depend on experts on construction sector and supply chain management in addition to the literature review addressed in chapter two.

4.2 Respondent

Out of 65 copy of questionnaires given away, only 46 of them were answered by respondents.

The number of returned questionnaire was enough adequate to conduct analysis.

4.3 Demographic information of the respondents

Both of Table 4.1 and Fig 4.1 illustrate frequencies and percentages of respondents according to gender, where all respondents approximately are from males and the percentage of participants from males 89.13% while the females were only 10.87%.

Table 4.1 Statistical analysis of gender respondents

gender	Frequency	percentage
Male	41	89.13
Female	5	10.87
Total	46	100

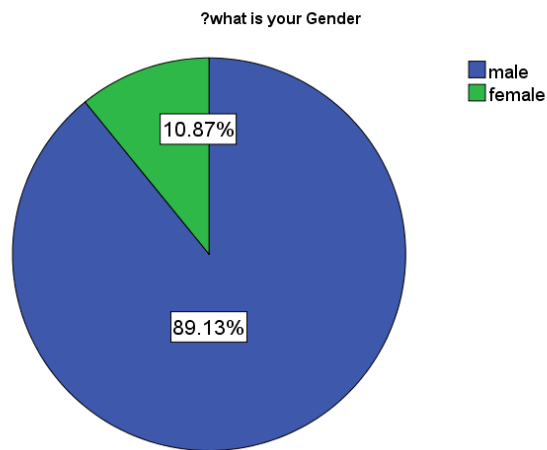


Figure 4.1 percentages of gender respondents

Also, Table 4.2 and Fig4.2 shows the respondents include all age groups from 25 years to more than 45 years, and the largest percentage of respondents from the age group over 45 years was 32.61%.

Table 4.2 Frequencies of respondent's age

Age	Frequency	Percentage
25-30 years	7	15.22
31-35 years	7	15.22
36-40 years	10	21.74
41-45 years	7	15.22
Above 45 years	15	32.61
Total	46	100

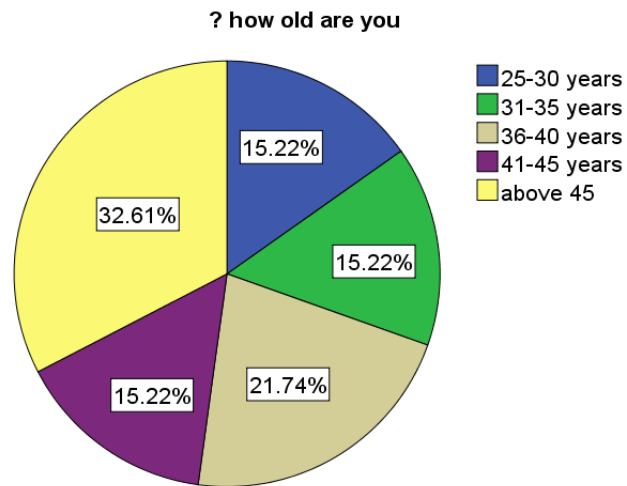


Figure 4.2 percentages of respondents age

The largest percentage of respondents, according to the number of years of experience, ranged from 5 to 10 years of experience and reached 50%. Figure 4.3 and Table 4.3 show the percentages and frequencies years of experience for the various categories mentioned.

Table 4.3 Frequencies of year's experience of respondent's

YEAR'S experience	Frequency	Percentage
5-10 years	23	50
11-15 years	7	15.22
16-20 years	5	10.87
21-25 years	5	10.87
Above 25 years	6	13.04
Total	45	100

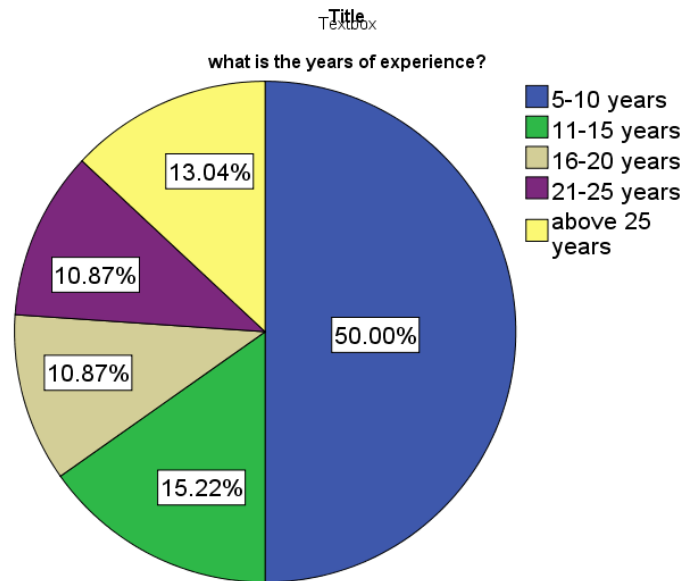


Figure 4.3 percentages of year's experience of respondent's

The selected sample included all levels of education, as shown in Table 4.4 and Figure 4.4. The largest percentage of respondents who hold a bachelor's degree was 56.52%, followed by the percentage who obtained a master's degree, amounting to 28.26%.

Table 4.4 Frequencies of educational level of respondents

Educational level	Frequency	Percentage
Less than Bachelor	1	2.17
Bachelor	26	56.52
Master	13	28.26
Diploma	4	8.7
PHD	2	4.35
Total	46	100

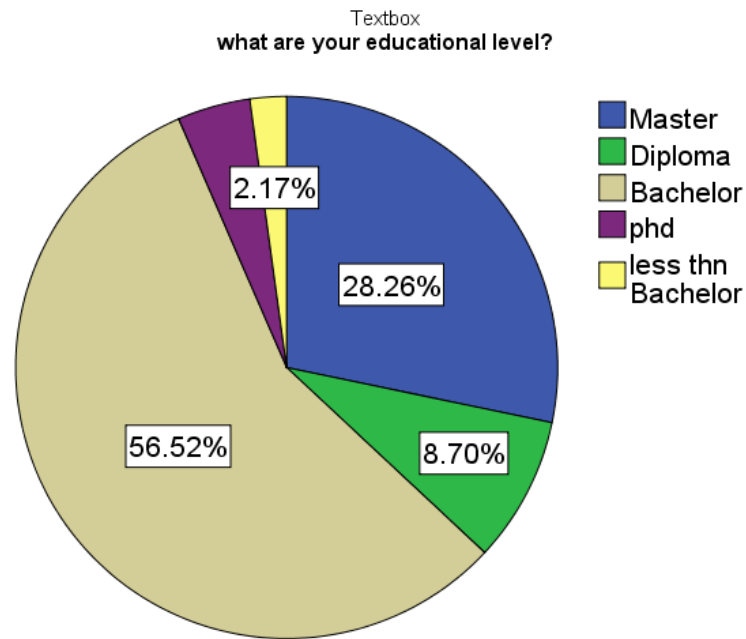


Figure 4.4 percentages of educational level of respondents

Most of the respondents were project managers, with a percentage of 63.07%, while the percentage of logistic managers reached 15.22%. The lowest percentage was for site supervisors and contractors, as their percentage reached 13.04% and 8.7%, respectively.

Table 4.5 frequencies of Job position of respondents

Job position	Frequency	Percentage
Logistic manager	7	15.22
Site supervision	6	13.04
Project manager	29	8.7
Contractor	4	63.04
Total	46	100

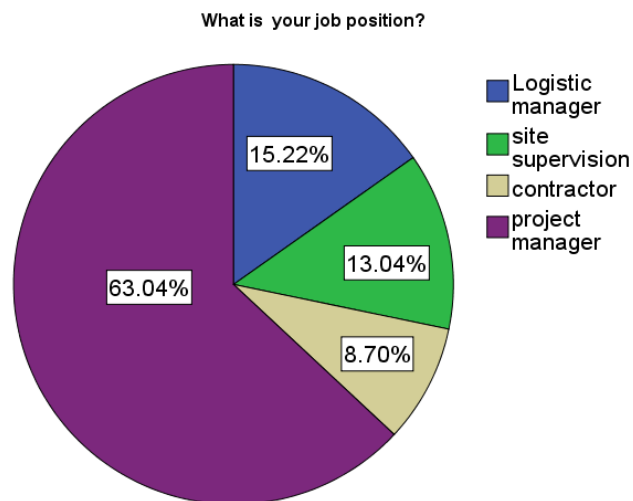


Figure 4.5 percentages of Job position of respondents

4.4 Reliability analysis

The analysis included conducting reliability by calculating Alpha's Cronbach coefficient. Table 4.6 shown value of calculated Alpha's Cronbach coefficient. It can be noted that Alpha's cronbach equals 0.96 and according to (Trizano-Hermosilla, and Alvarado, 2016)

IF $\alpha \geq 0.9$ the measure is considered .excellent.

Table 4.6 the calculated Alpha's cronbach coefficient

Reliability Statistics	
Cronbach's Alpha	N of Items
0.960	81

4.5 Results of the study

After the risks the risks were identified by dividing them four major categories (External ,Management, Technical and organizational), all determined hazards were analyzed by giving points of each risk from 1 to 5 with respect to their potential and influence on the construction project. Further more, risk score was computed by multiplying both mean of potential and influence for each risk and all risks of the supply chain were ordered and classified depend on their risk score supply chains to determine the most dangerous risks affects on construction supply chains.

lastly, the final step is response and control. This step utilized actions as transfer, lessen , and avoid for reducing risks in construction project.

4.5.1 Risk Identification

The risk determined that were surveyed in the research were classified into four categories:

Table 4.7 shows the risks determined related management in construction projects

Category	Identified Risk	symbol
Management	insufficient cost assess	M1
	insufficient program scheduling	M2
	insufficient period scheduling	M3
	shortage of collaboration among project team	M4
	workers dispute	M5
	Uncertain supply and demand	M6
	rise insurance budget	M7
	rise transport budget	M8

Table 4.8 shows the risks determined related management in construction projects

Category	Identified Risk	symbol
Technical	No consider in priority of material supply	T1
	Transport material is unsafe	T2
	shortage of suitable vehicle	T3
	Transport vehicle break down	T4
	shortage of adequate skilled labor	T5
	lack experience of labors and personnel	T6
	shortage of access to improved technology	T7
	shortage of access to suitable materials	T8
	procurement depend on schedule	T9
	No consider the priority of material procurement according to schedule	T10

Table 4.9 shows the risks determined related management in construction projects

Category	Identified Risk	symbol
ORGANIZATIONAL	shortage of adequate skilled administer procurement	O1
	Financing challenges	O2
	delay in supplying material	O3
	Delay in construction and implementing tasks	O4
	Delay owing to route disruption	O5
	No consider in geographical situation	O6

Table 4.10 shows the risks determined related management in construction projects

Category	Identified Risk	symbol
EXTERNAL	Supplier concentration risk	E1
	Unexpected natural disasters accidents	E2
	Price volatility of construction materials	E3
	Delays in delivery materials	E4
	High labor cost	E5
	High cost fuel	E6
	Supplier bankruptcy	E7
	Unpredicted changes in demand	E8
	Lack of raw materials	E9
	Regulation changes	E10

4.5.2 Risk analysis

After identifying risk, risks are analyzed. In this study potential and influence matrix is utilized to evaluate data, that illustrates findings on a matrix table depend on threat rate on project. This method is one of the suitable ways to analyze data in comparison to quantitative methods. Probability and impact method prioritizes identified risks based on calculated risk scores. As a result, average risk scores of each risk were calculated.

4.5.2.1 Risk score results

The following risk scores were calculated

Table 4.11 Ranking the construction supply chain risks in Saudi Arabia

Symbol	Statement	Category	Average potential	Average impact	Average risk score	Rank
M1	insufficient cost assess	Management	3.9783	4.4565	17.72921	2
M2	insufficient program scheduling		3.9348	4.4348	17.44991	3
M3	insufficient period scheduling		3.9348	4.4348	17.44991	3
M4	shortage of collaboration among project team		3.8913	4.6739	18.18762	1
M5	workers dispute		3.6739	4.4130	16.21314	4
M6	Uncertain supply and demand		3.5870	4.0217	14.4258	7
M7	rise insurance budget		3.7391	3.8913	14.55009	6
M8	rise transport budget		3.9565	4.0217	15.9121	5
T1	No consider in priority of material supply	TECHNICAL	3.8478	4.1739	16.06049	5
T2	Transport material is unsafe		3.7826	4.0217	15.21267	6

T3	shortage of suitable vehicle		3.4783	4.0435	14.06427	10
T4	Transport vehicle break down		3.6739	3.9130	14.37618	8
T5	shortage of adequate skilled labor		4.1304	4.3696	18.0482	1
T6	lack experience of labors and personnel		3.8478	4.3696	16.81333	2
T7	shortage of access to improved technology		3.6739	3.8478	14.13658	9
T8	shortage of access to suitable materials		3.6957	4.3696	16.14839	4
T9	procurement depend on schedule		3.7174	4.0435	15.03119	7
T10	No consider the priority of material procurement according to schedule		3.8478	4.3478	16.72968	3

O1	shortage of adequate skilled administer procurement	Organizational	3.8261	4.4565	17.05104	4
O2	Financing challenges		4.2609	4.5870	19.54442	1
O3	delay in supplying material		4.1087	4.4783	18.39981	2
O4	Delay in construction and implementing tasks		4.0435	4.5217	18.28355	3
O5	Delay owing to route disruption		3.9130	4.2826	16.75803	5
O6	No consider in geographical situation		3.7391	4.1522	15.52552	6
E1	Supplier concentration risk	External	3.7609	3.9783	14.96172	9
E2	Unexpected natural disasters accidents		3.7174	4.0217	14.95038	10
E3	Price volatility of construction materials		4.0000	3.9783	15.91304	4

E4	Delays in delivery materials		4.0435	4.2609	17.22873	2
E5	High labor cost		4.0217	4.3261	17.39839	1
E6	High cost fuel		3.8696	4.1304	15.98299	3
E7	Supplier bankruptcy		3.6739	4.1739	15.33459	5
E8	Unpredicted changes in demand		3.7609	4.0217	15.12524	7
E9	Lack of raw materials		3.6087	4.1957	15.14083	6
E10	Regulation changes		3.6522	4.1304	15.08507	8

Table 4.11 represents the risks resulting from the construction supply chains in the Kingdom of Saudi Arabia. It can be seen that the risk score for the risks mentioned in Table 4.11 ranges from 14 to 19. According to the map in Table 2.3, which determines the degree of risk by colors, we find that most of the values are within the red area that It represents a major threat to construction projects in terms of quality, cost and time. Therefore, it can be said that construction supply chains in the Kingdom of Saudi Arabia constitute a serious threat to the success of construction projects.

4.5.3 Mitigation strategies of construction Supply chain Risks

A list was prepared shown in Table 4.12 that includes strategies to mitigate the risk of construction supply chains. This list was prepared by benefiting from previous studies and by consulting experts in the field of construction. Then, the arithmetic average was calculated for each strategies and arranged to find out the most effective strategies to mitigate the risks of construction supply chains

Table 4.12 Mitigation Strategies of Construction supply chain risks.

Mitigation Strategies		Mean	Rank
S1	rising awareness about risk and solutions	4.2826	1
S2	Supplier ability evaluation and qualification examination practices	4.2609	2
S3	Optimize workplace safety	4.2391	3
S4	Prioritize communication	4.1739	4
S5	Budgeting for construction material price increases	4.1087	5
S6	Automate with technology"	4.0652	6
S7	Conduct check-up on supplier and subcontractor stability	4.0435	7
S8	Sustainable cooperative relationship practices"	4.0217	8
S9	adopting variety of materials, services, and suppliers	4.0217	9
S10	planning strategies of Supply chain contingency	4.0217	10
S11	strategies of transmitting Supply chain hazards via Insurance	4.0000	11
S12	Insure and ensure your raw material sources."	3.9565	12
S13	extra stock organizing practices	3.9348	13
S14	utilizing data to administer supply chain risk	3.9348	14
S15	Adopting artificial intelligence techniques"	3.7826	15

It can be noted from Table 4.12 that the arithmetic mean values are greater than 3.75, which indicates the effectiveness of the methods that have been proposed to mitigate the risks of construction supply chains.

Chapter Five

Conclusion and recommendation

5.1 Summary

This study aimed to determine construction supply chains risks in Saudi Arabia. Moreover, several solutions has been suggested to avoid and mitigate these risks. The study adopted questionnaire

survey method to achieve the research goal .The sample size selected includes several construction projects in Saudi Arabia by asking project managers ,contractors, Site supervisions and logistic managers. then , Data of questionnaire has been analyzed using SPSS software I order to discus and interpret the results.

5.2 Conclusions

5.2.1 construction supply chain risks

After the risks facing the construction supply chains were identified in Tables 4.7, 4.8, 4.9, and 4.10, The data were analyzed to arrange the risks according to their severity in terms of the degree of probability of their occurrence and the degree of severity of their impact, and after calculating the degree of risk for the risks, they were arranged according to the severity of the risk from the most dangerous to the least dangerous as shown in Table 4.11

As for the risks related to management, it was noted that all the mentioned risks have a negative impact on the construction supply chains in the Kingdom of Saudi Arabia

One of the most influential risks is the lack of correct evaluation of the cost of the project and the lack of appropriate scheduling for the project, in addition to the lack of experience in determining the time for completion of the project.

As for the risks related to technical risks, it was the lack of skilled labor, the lack of experience of skilled labor, and the lack of priority in purchasing materials in conjunction with the scheduling of the project.

According to the risks resulting from the organization, financial difficulties, delay in supplying materials, delay in construction and implementation of tasks, and lack of experience in purchasing management were among the most important risks to which construction projects are exposed.

Finally, the external risks that threaten the safety of construction supply chains were classified, which are: high labor costs, delays in material delivery, high fuel costs, sudden price fluctuations, and supplier bankruptcy.

All these risks affects negatively on construction projects leading to cost overrun , time delay and lack in project quality.

5.2.2 Mitigation Strategies of construction supply chain risks

Table 4.12 identified the most important and effective strategies used to avoid and reduce the risks of construction supply chains. Although the strategies used were found to be effective and important ways to mitigate the risks of construction chains, it was found that raising awareness and knowledge about the risks of construction chains and appropriate solutions is very important to avoid these risks. Evaluating the provider's ability by conducting tests to .3assess efficiency is very important in avoiding risks. It has also been emphasized that securing the safety of the site and giving priority to communication, in addition to setting a special budget to face price fluctuations are among the important strategies to mitigate

5.3 RECOMMENDATIONS

Here are the following suggested points for future works

- 1- Positive risks that also be addressed.
- 2- addressing construction firms in survey that have more profound supply chain practices.
- 3- have a complete image of the SC risk management practices of the total SC grid including all SC members be dealt better

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