

Impact of Risk management strategies on performance of Industrial Companies: "Sankyu Company as Case Study

Team Leader

Eng: Othman Algarni

ID:233001399

Participants:

Eng: Abdullah Adel Jumeh

ID:233001327

Year 2024-2025

Table of content

Section NO.	Section name	Page number
-	Abstract	Ix
Chapter one		
1.1	Introduction	1
1.2	Problem Statement	2
1.3	Theoretical Premises of the study	2
1.4	Research Significance	3
1.5	Research Objective	3
1.6	Research Question	4
Chapter two		
2.1	Introduction	5
2.2	Theoretical framework	5
2.2.1	Risk	5
2.2.2	Risk Management	5
2.2.3	Risk Management Tools	6
2.2.4	Identifying Objectives and context	8
2.2.5	risks Identification	9
2.2.6	risk Analyzation	9
2.2.7	Assessment the risk	9
2.2.8	The risk Treatment	10

2.3	Literature review of (Operational,manufacturing ,health,financial, compliance) Risks in industrial firms	10
2.4	Beneficial contributions of Evaluating the effectiveness of risk management in industrial companies .	11
2.5	Beneficial Contributions of Investigating the Effectiveness of Risk Management in Industrial Companies .	16
Chapter three		
3.1	Introduction	18
3.2	Research Design	18
3.3	Research Method	19
3.4	Study Population	19
3.5	Data Collection resources:	20
3.6	Study Tools	20
3.7	Dependent and Independent variables	20
3.8	Statistical methods	21
3.8.1	Standard linear regression Analysis	21
3.8.2	Delphi Technique	22
Chapter four		
4.1	Introduction	23
4.2	Risk Identification and assessment in Sankyu company	23
4.3	impact of potential risks on cost and quality of production in Sankyu company	25
4.3.1	Impact of operational risks on cost and quality of production in Sankyu company	26
4.3.2	Impact of health risks on cost and quality of production in Sankyu company	31

4.3.3	Impact of financial risks on cost and quality of production in Sankyu company	34
4.3.4	Impact of strategic risks on cost and quality of production in Sankyu company	38
4.3.5	Impact of compliance risks on cost and quality of production in Sankyu company	42
4.4	Impact of Risk management strategies on cost and quality of production in Sankyu company	46
4.5	Risk Evaluation Using Delphi Method	47
4.51	DELPHI TECHNIQUE RESULTS (ROUND ONE)	47
4.5.2	DELPHI TECHNIQUE RESULTS (ROUND Two)	50
Chapter five		
5.1	Summary	58
5.2	Conclusions	58
5.3	Recommendations	60
-	References	61
-		66

List of Tables

Table No	Table name	Page number
Table2.1	Risk Matrix	9
Table2.2	Review of Operational risks in Industrial Companies	12
Table2.3	Review of Health risks in Industrial Companies	13
Table2.4	Review of financial risks in Industrial Companies	14

Table2.5	Review of strategic risks in Industrial Companies	14
Table2.6	Review of compliance risks in Industrial Companies	15
Table2.7	Review of risk mitigation strategies in industrial companies	16
Table4.1	risk matrix in Sankyu Company	23
Table4.2	Operational Risks Identification in Sankyu company.	23
Table4.3	Health Risks Identification in Sankyu company.	24
Table4.4	financial Risks Identification in Sankyu company.	24
Table4.5	strategic Risks Identification in Sankyu company.	25
Table4.6	Compliance Risks Identification in Sankyu company	25
Table4.7	7 cost data By Sankyu company according to each risk category	26
Table4.8	Costs prediction due to Operational Risks	27
Table4.9	Data coding of operational risks , cost overrun % , quality % corresponded to risks occurred	27
Table4.10	Table 4.10 Model 1 Summary ^b	28
Table4.11	Table 4.11 ANOVA details of Model 1	28
Table4.12	Table 4.12 standard regression coefficients of Model 1	29
Table4.13	4.13 Regression Model 2	29
Table4.14	ANOVA details of Model 1	30
Table4.15	Regression Coefficients of Model 2	30
Table4.16	Costs prediction due to Health Risks	31
Table4.17	Data coding of health risks , cost overrun % , quality % corresponded to risks occurred	31
Table4.18	Regression Model 3	32
Table4.19	ANOVA details of Model 3	32

Table4.20	Regression Coefficients of Model 3	33
Table 4.21	Regression Model 4	33
Table 4.22	ANOVA details of Model 4	33
Table 4.23	Regression Coefficients of Model 4	34
Table 4.24	Data coding of financial risks , cost overrun % , quality % corresponded to risks occurred	34
Table 4.25	ANOVA details of Model 5	35
Table 4.26	Regression Model 5	35
Table 4.27	Regression Coefficients of Model 5	36
Table 4.28	Regression Model 6	37
Table 4.29	ANOVA details of Model 6	37
Table 4.30	Regression Coefficients of Model 6	38
Table 4.31	Costs prediction due to strategic Risks	38
Table 4.32	Data coding of strategic risks , cost overrun % , quality % corresponded to risks occurred	39
Table 4.33	Regression Model 7	39
Table 4.34	ANOVA details of Model 7	40
Table 4.35	Regression Coefficients of Model 7	40
Table 4.36	Regression Model 8	41
Table 4.37	ANOVA details of Model 8	41
Table 4.38	Regression Coefficients of Model 8	41
Table 4.39	Costs prediction due to compliance Risks	42
Table 4.40	Data coding of strategic risks , cost overrun % , quality % corresponded to risks occurred	43
Table 4.41	Regression Analysis Model 9	43
Table 4.42	ANOVA details of Model 9	43

Table 4.43	Regression Coefficients of Model 1	44
Table 4.44	Regression Model 10	44
Table 4.45	ANOVA Details of Model 10	45
Table 4.46	Regression Coefficients of Model 10	45
Table 4.47	risk Management strategies and their impacts of reducing cost in Sankyu Company	46
48	operational risks (first round of Delphi technique)	48
Table 4.49	health risks (first round of Delphi technique)	49
Table 4.50	financial risks (first round of Delphi technique)	49
Table 4.51	strategic risks (first round of Delphi technique)	50
Table 4.52	compliance risks (first round of Delphi technique)	50
Table 4.53	operational risks (second round of Delphi technique)	51
Table 4.54	health risks (second round of Delphi technique)	52
Table 4.55	financial risks (second round of Delphi technique)	53
Table 4.56	strategic risks (second round of Delphi technique)	55
Table 4.57	compliance risks (second round of Delphi technique)	56
Table 4.58	risk Management strategies using Delphi technique	57

List of Figures

Figure No.	Figure name	Page number
Figure1.1	BRM Development Since 1945(Mark,2021)	1
Figure 2.1	planned general legislation approach on risk management(IEC 2007)	6

Figure 2.2	Tools of Risk Management	7
Figure 2.3	The procedures life cycle of hazards management (Paul and Willlliam,2018).	7
Figure 2.4	Risk Management Procedures	8
Figure 2.5	Risk Treatment	10
Figure 2.6	Risk Identification by (Islam and Tedford,2012)	12
Figure 3.1	5*5 risk matrix	19
Figure 3.2	Dependent and Independent variables	21
Figure 4.1	Impact of mitigation strategies in cost reduction	47
Figure 4.2	Impact of mitigation strategies in quality enhancement%	47

Abstract

This study had been executed to address impact of potential risks in Sankyu company. In addition, impact of risks management strategies on quality and cost of production using have

been studied obtaining data by Sankyu company. This study based on data obtained and collected from Sankyu company .This data comprises the strategy planning of the company to manage potential risks. The study addressed at first the potential risks in the company that had been classified into five categories: compliance risks, strategic risks, operational risks, health risks and financial risks. After addressing risks identification and assessment, linear regression models have been used to study impact of each risk category in cost and quality of production in Sankyu company .In order to do the regression analysis, data have been collected during 2023 comprise the risks and information illustrates if each risk occur every month or not .As for data related to cost overrun , cost overrun % have been calculated based on the difference between actual cost and initial budget monthly. Moreover , quality reduction % had been obtained by company assessment monthly according to the risks occurred. After that , data had been coded and entered to SPSS to execute regression analysis. The next stage comprised using Delph technique adopting two rounds to obtain more extensive risks in industrial companies .In addition ,risk index had been established based on risk matrix and the risks had been evaluated in round two of Delphi technique. Also, Experts in Delphi technique identified all strategies to mitigate risks in industrial companies and these results compared to literature review. The results showed that all risks categories that include operational risks, health risks, financial risks, strategic risks and compliance risks have significant influence on cost overrun of production and reduction in quality .Also , The risk mitigation strategies that Sankyu company adopts proved that are efficient to reduce cost and enhance quality of production .ALSO , Delphi technique could provide comprehensive guide in potential risks and mitigation strategies in the field of industrial companies that can be generalized on the industrial companies in KSA .

Keywords: industrial firms-risk-mitigation strategies-operational-compliance-financial-strategic

Chapter one

1.1 Introduction

Each firm encounter hazards that could constitutes threats to its productivity . Risk is the potential of an action and its effects. managing is the practice of utilizing operations, techniques and tools to manage these hazards. It concentrates on determining what could occur wrong, assessing which hazards should be processed with and executing practices and procedures to address those hazards (Kádárová and Durkáčová, 2012). Industrial firms accustomed to

encounter several events that can result in adverse influence, positive influence, or both. Actions or accidents with a adverse influence presents hazards, that can prevent creating value or gnaw current value. Actions or accidents with positive influence can offset negative influences or presents chances. Chances are the potential that an action will happen and positively influence the fulfilment of goals. Hazards are the potentials that actions will happen and negatively influence the fulfilment of goals. Enterprise risk management (ERM) addresses hazards and potentials influencing value creation or preservation, consequently should be a central portion of any their strategic administer. In general, it is a strategic operation that assists and supports making decision at both strategic and operational levels in a firm. Improved understanding and management of all risks potential to influence the firm will result in better performance and competitive benefits, in particular when risks and threats are determined , and the hazards evaluated and controlled, in the same way as for chances and incentives (Mark,2021).

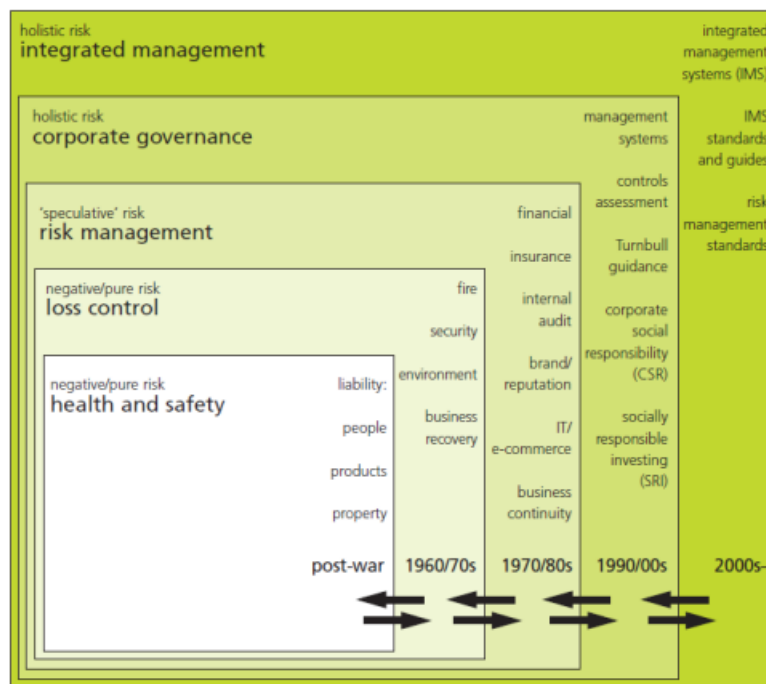


Figure 1.1 BRM Development Since 1945(Mark,2021)

This study addresses identifying potential risks in Industreial companies in Saudi Arabia in addition to develop risk management guidelines can be beneficial contribution of Industrial sector in Saudi Arabia to set emergency plan response of potential risks in the Saudi Industrial Companies and upgrade the risk management strategies in Saudi industrial Companies.

1.2 Problem Statement

The industrial companies is considered the basis of any country's economy and thus should be take interest to a high degree of standard to be robust, self-sustaining, and self-reliant. (Oduoza,2020) Nowadays, the manufacture is encountering numerous limitations due to competition, regulations, international standards, globalisation and technology development (Naradda et al.,2020) . Industrial companies demand to be flexible to react rapidly to incessant client requirements and respond to a dynamic production ecology .In order to attain the mentioned goals, the manufacturing field should require to have awareness and enough knowledge of a broad variety of dangers particular correlated to risks correlated in manufacturing, operating and maintenance in industrial companies(Ghouri, et al.,2020). Risk management consequently, could constitute a great limitation for business directors in particular in the industrial engineering field, and if not proactively controlled may result in poor performance and sometimes hindering activities for some firm. It is popular that poorly managed hazards can have an negative impact on performance while proactive and systematic control of major hazard variables in a business ecology could develop successful results(Oduoza,2020).

All manufacturing and operating companies encounter unfavourable and undesirable setback in daily operations. These are indicated by operational troubles in this study. The disturbances set the company at production, economic and occupational hazards and consequently this study targets Saudi industrial companies in the field of manufacturing, maintaining and operating mechanical mechanisms since the Saudi nation considers the most that depends on manufacturing and seeks to improve engineering industry and to achieve the goal of this study, establishing risk management guidelines in the field of engineering industries related to manufacture ,operating and maintenance field is mandatory to define all potential hazards in addition to establish response management plan to respond potential risks.

Sankyu Company was selected as a case study in Saudi Arabia because it represents the largest companies in various engineering services, especially in the areas of manufacturing, maintenance and operation of heavy equipment and machinery (Islam & Tedford,2012).

This study processes the research gaps by establishing risk management plan can be generalized on industrial Saudi companies in The field of manufacturing, operating and maintenance of plants and equipment in the field of engineering services in order to upgrade performance of Saudi industrial Companies and enhance industrial production

1.3 Theoretical Premises of the study

The theoretical premises of the study comprise the following Hypothesis:

- 1- Operational risks negatively affect the quality and cost of Saudi products in the engineering industry
- 2- Health risks negatively affect the quality and cost of Saudi products in the engineering industry
- 3- Compliance risks negatively affect the quality and cost of Saudi products in the engineering industry
- 4- Operational risks negatively affect the quality and cost of Saudi products in the engineering industry
- 5- Financial risks negatively affect the quality and cost of Saudi products in the engineering industry

- 6- Adopting efficient risk management plan positively affect the quality and cost of Saudi products in the engineering industry

1.4 Research Significance

Having awareness the influence of risk management on performance of industrial companies consider critical from academic and practical Aspect:

-Academic Aspect by support the Literature and academic research on risk management in industrial firms by adding beneficial contribution via discovering and ordering factors that impact risk management. It assists to develop a strong awareness of risk management strategies and their consequences.

determining the most significant potential risks impacting risk management, as operating hazards, maintenance hazards and manufacturing hazards according to several aspects comprise environmental aspects, financial aspects in addition to other factors. These visions can add academic research discussions and establish a basis for further research.

-Practical Aspect:

Upgrading enterprise Performance in which the efficient risk management positively influence performance of industrial companies. strategies as danger reduction, identification, evaluation , and controlling achieve a great role in attaining better results.

Reducing Risks: By understanding risk factors, companies can develop strategies and policies to reduce risks. This immediately influences their financial profit, operational effectivity, and productivity .Also, In the field of project management, adopting risk management strategies upgrade performance of project by reducing probable dangers. establishing efficient risk management enable the industrial companies to make decisions that can utilize risk management practices and allocate resources efficiency, and enhance the total performance of industrial companies.

Consequently, the importance of this study from a theoretical standpoint is to enrich the academic side with evidence about all the risks resulting from manufacturing, operation and maintenance in industrial companies in the Kingdom of Saudi Arabia, in addition to finding the necessary solutions and measures to mitigate the risks.

This study is also useful from an applied perspective to inform heavy equipment and machinery maintenance companies of the potential risks during operation, maintenance and manufacturing.

1.5 Research Objective

This study aims to evaluate the effectiveness of risk management in Saudi industrial companies specialized in the maintenance, operation, and manufacturing of heavy equipment and machinery, as it is one of the specializations that most faces many risks that negatively affect the quality and cost of the studied and implemented projects. This study also aims to achieve a number of sub-objectives, which are:

- 1- Identifying operational risks, financial risks, strategic risks and health risks that faces industrial companies in Saudi Arabia
- 2- Assessment risks that are identified previously in order to investigate the severity and magnitude of the risks.

- 3- Suggesting strategic solutions in each field to treat and process the potential risks in case study company.
- 4- Addressing impact of risks that will be identified on the cost and quality products in the industrial companies.

1.6 Research Question

In order to study impact of risk management on performance of industrial companies ,this study answers the following questions:

- 1-what are the potential risks that can be identified in Saudi Industrial companies?
- 2- What are the most significant risks that affect Saudi industrial companies?
- 3- To what extent the suggested risk management techniques reduce potential risks?
- 4- How can risk management strategies influence the performance of industrial companies?

Chapter Two

Theoretical Framework and Literature Review

2.1 Introduction

This chapter offers extensive theoretical framework of potential risks definition in addition risk management concept and explains risk mitigation techniques. Also, This chapter discuss the prior contributions of researcher in risk management in industrial companies. Moreover, this chapter provide extensive review of potential risks in industrial companies from the following several aspects: operational risks, health risks, financial risks, strategic risks and compliance risks.

2.2 Theoretical framework

2.2.1 Risk

Enterprises encounter a wide scope of hazards every day that can influence their capacity to fulfil specific business goals and preserve their business. Risk evaluation is a significant and developed operation utilized to evaluate an organization's hazards so that it can lessen and reduce hazards to an acceptable degree. Risk indicates the uncertainty that surrounds future accidents and results. It is expressed of the potential and influence of an event with the potential to impact the fulfilment of an enterprise's goals (Uzorh, 2017)

2.2.2 Risk Management

Two several safety management concepts can be noted: safety management based on consequence supposes that the most potential events at an installation should not include consequences external specific limits, and therefore design regimes under safety to insure this. Risk management that means risk based safety management insure that the remaining hazards must be analysed both with respect to the potential and the risk nature, and thus inform for more risk reduction. This means that unexpected events may be tolerated. Risk management is not novel instrument and a lot of legislations and guidelines are obtainable (ACT 2004, AZ/NZS 2004, Committee 2004). It is an integral part of good management and making decisions at all organization levels. All organization departments manage hazard regularly whether they recognized it or not, sometimes more rigorously and systematically, sometimes less. Risk management happens most clearly in those sections whose basic function is to preserve the ecology and public health and safety. currently, an additional generic legislation on hazard management is prepared as a popular ISO/IEC standard (IEC 2007) explaining a approach top down in addition a functional bottom up systemic as illustrated in Fig. 2.1) This legislation aims to support current industry.

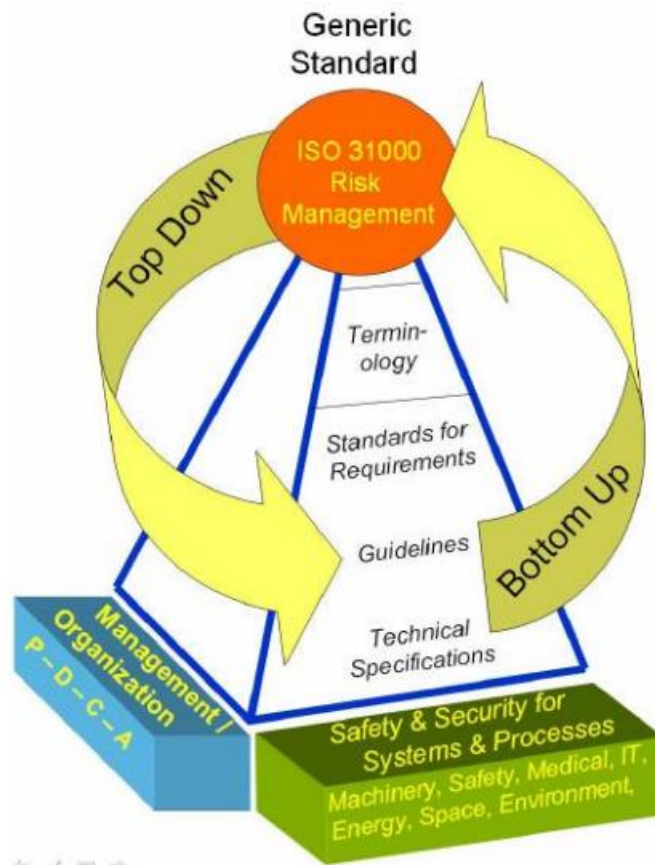


Figure 2.1 planned general legislation approach on risk management(IEC 2007)

2.2.3 Risk Management Tools

The procedures risk management as illustrated in Fig. 2.2 are:

1. identifying objectives and context such as the risk ecology),
2. defining hazards,
3. Analysing the defined hazards,
4. hazards evaluation
5. Processing or administering the hazards,
6. Monitoring and reviewing the risks and the risk environment continuously, and
7. regular communication, consulting with stakeholders and reporting. Some tools of the risk management are explained in (IEC 2008) and (Oehmen 2005).

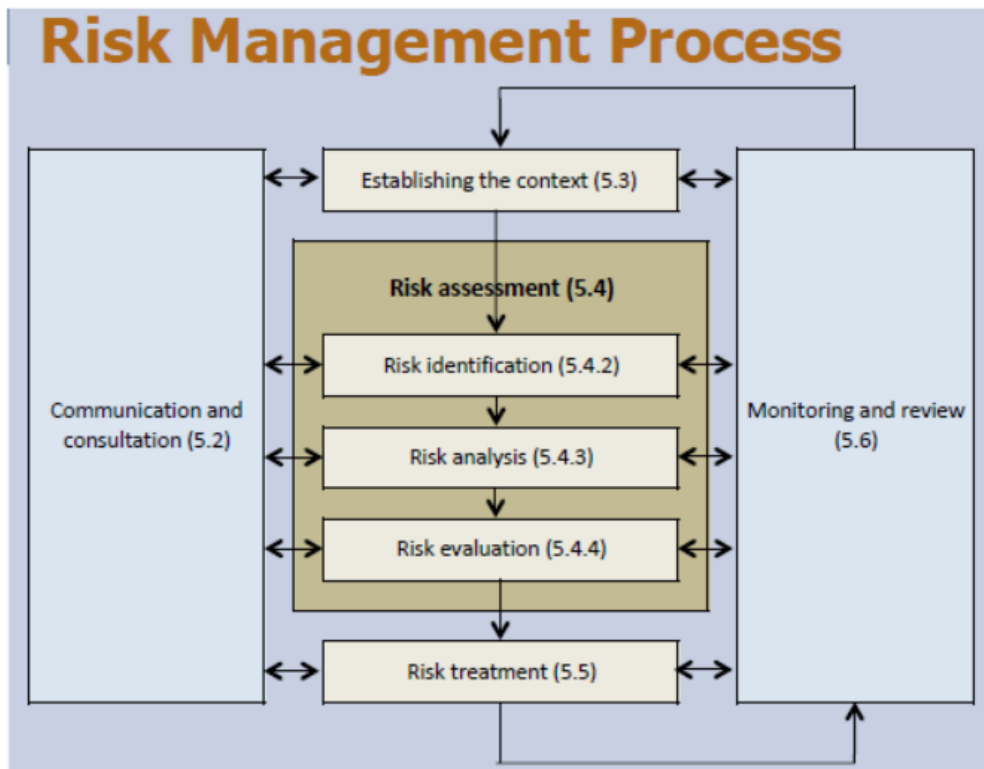


Figure 2.2 Tools of Risk Management

The procedures of risk management requires several steps are illustrated in Figure 2.3

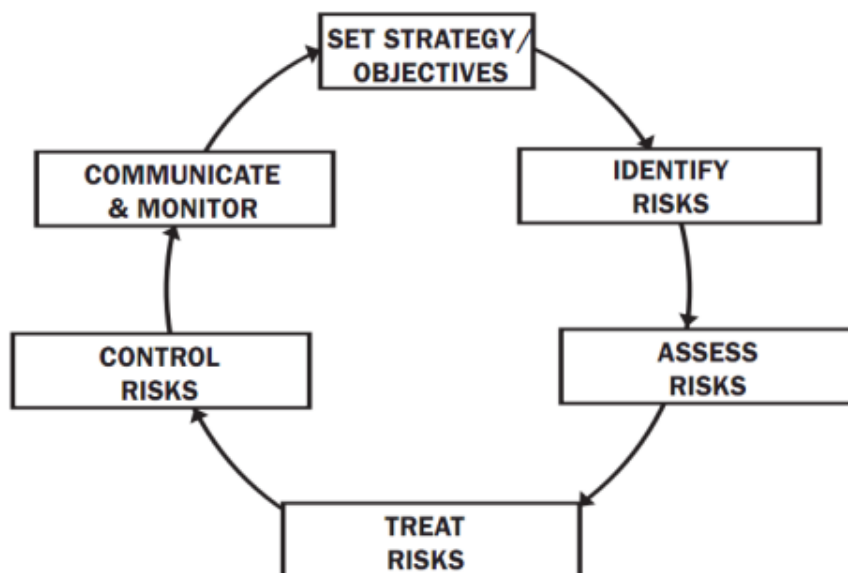


Figure 2.3 The procedures life cycle of hazards management (Paul and William,2018).

This procedures include identification, assessment and control, in addition to monitor process, audit and review stages common to all efficient management systems.

Figure 2.4 shows the organization's strategic objective through risk assessment that include :Risk assessment, Risk evaluation, Risk reporting and monitoring

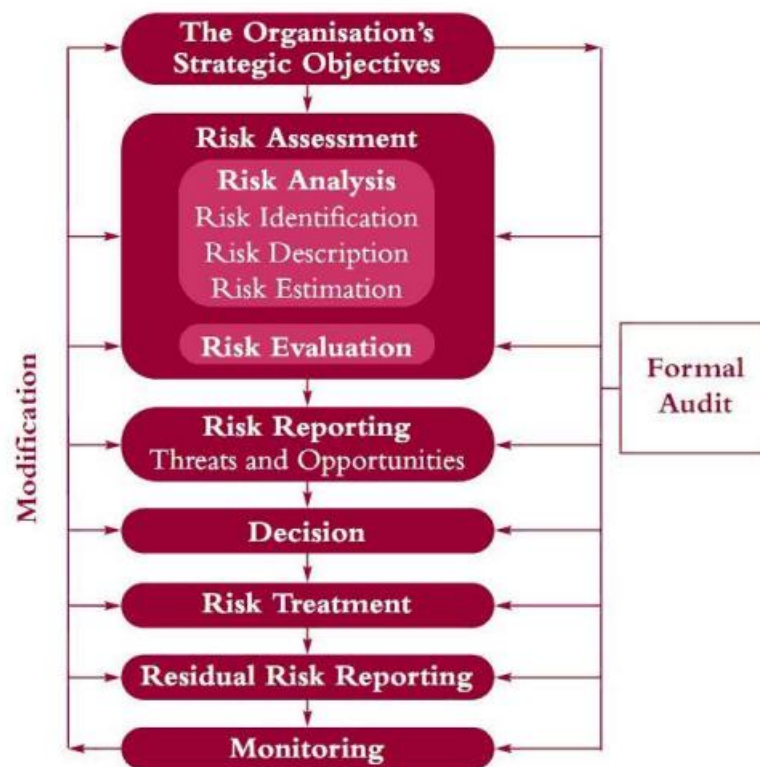


Figure 2.4 Risk Management Procedures

To create this efficient management system, all sections of the firm contribute basic views: Senior executives identify the degree of risk a firm can stand. They express their risk desire in concrete terms like profits fluctuation and possible losses of capital, equity or assets; The risk organization, in cooperation with line managers, continuously examines the possible influence of several hazards (such as strategic, business, financial and operational hazards) on the enterprise (RIGBY, D. – BILODEAU, 2009). They make a decision whether to avoid the exposure fully, efficiently reduce it (for instance, via a transform to another party) or utilize the firm hazard perspective and risk management abilities as a chance to create more profit from the exposure; Line managers embed risk management concepts into everyday business decisions and activities; Managers separate risk-taking and risk monitoring responsibilities to prevent possible conflicts of interest.

Risks results from manufacturing and operating in industrial companies are categorized into the following types: strategic risks, financial risks, operational risks and compliance risks.

2.2.4 Identifying Objectives and context

This step can give knowledge of the ecology in which the respective organization operates, which indicates to comprehensive understand the exterior ecology and the interior organization culture.

The analysis is executed via:

- identifying the strategic, organizational and risk management of the enterprise, and
- defining the limitations and chances of the operating ecology.

2.2.5 risks Identification

The proper risk determination technique will be based on the area of utilization (activities nature and the

hazard set), the project nature, the project stage, resources, legislation and client demands as to goals, desired result and the demanded level of details.

The following tools utilization and methods might further help the determination of hazards:

- Potential risk resources identification,
- List of probable business risks and cheat hazards,
- Typical hazards in phases of the procurement operation,
- Planning of Scenario as a hazard evaluation instrument,
- Process mapping, and
- Documentation, relevant audit reports, program evaluations and / or research reports.

2.2.6 risk Analyzation

Risk analysis requires taking into account the risk source, the effects and probability to evaluate the inherent. In addition, It requires determination of the controls, an assessment of their effectiveness and the resultant degree of hazard with controls in place. Often qualitative methods can be utilized for investigating hazards while more hazards are being exposed to more expensive quantitative methods as demanded. Risks can be evaluated in qualitative and quantitative method utilizing instruments as hazard matrices, hazard graphs, hazard matrices. Utilizing the hazard matrix, it is demanded to identify for each hazard its profile utilizing probability and consequences standard. Typical definitions of the likelihood and consequence are contained in the risk matrix are illustrated in Table 2.1

Table 2.1 Risk Matrix

Risk Rating Matirx					
Likelihood					
Impact	Rare	Unlikely	Possible	Likely	Almost certain
Catastrophic	moderate	moderate	high	critical	critical
Major	low	moderate	moderate	high	critical
Moderate	low	moderate	moderate	moderate	high
Minor	very low	low	moderate	moderate	moderate
Insignificant	very low	very low	low	low	moderate

2.4 Assessment the risk

As soon as the hazards have been analysed, they can be compared versus the documented earlier and accepted tolerable hazard standard. When utilizing hazard matrices this tolerable risk is generally documented with the hazard matrix. If the protected hazard be higher than the

tolerable hazard than the certain hazard requires more control procedures or enhancements in the effectiveness of the current controls.

2.2.7 The risk Treatment

An unacceptable hazard demands treatment. The goal of this phase of the hazard evaluation operation is to develop cost efficient option for addressing the hazards.

Treatment options (as illustrated in Fig. 2.5),which are not necessarily mutually exclusive or appropriate in all conditions, are depends on results that comprise:

- the risk avoidance,
- the risk reduction
- Transferring (sharing) the risk, and
- approving the risk.

the risk avoidance is not executing the activity that is probable to occur the hazard.

Mitigating the risk - controlling the likelihood of the risk occurring, or controlling the influence of the results if the risk happened.

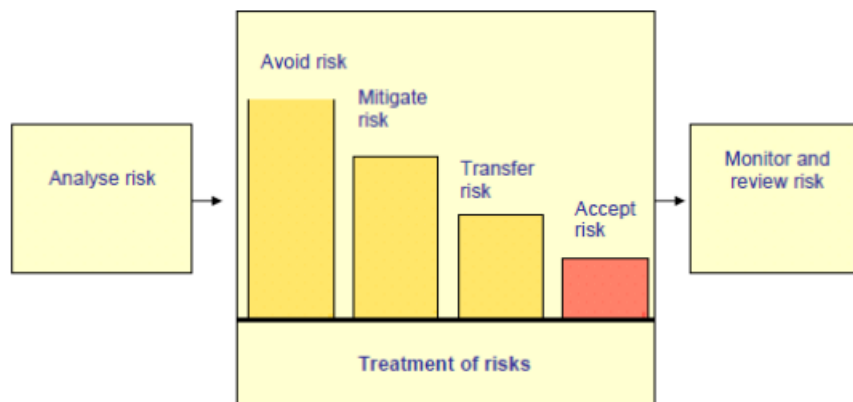


Figure 2.5 Risk Treatment

2.3 Literature review of (Operational,manufacturing ,health,financial, compliance) Risks in industrial firms

Numerous researches have been addressed the potential risk in industrial companies:

Tupa et al., (2017) mentioned the hazards correlated to manufacturing process management that addresses information risk correlated with missing data, lack of safety and obtainable information. the risks in the field of maintenance comprise with availability and data safety correlated to maintenance. As for Operation techniques and tools utilized the most risks can be noted are mistakes data processing. Machinery and manufacturing techniques that comprise risks related to Sensitivity and vulnerability of data—trouble correlated to cyber-attacks. As for human resources, it is affected by low number of skilled labor. Machine environments: Attacks from Internet network, issues correlated to electromagnetic compatibility and electromagnetic emissions impacting fabricating equipment.

Elfaki & Tayfor, (2023) listed all financial risks that affect on industrial performance of companies and these risks are Fire ,Business Interruption, Loss of Reputation, Physical

Business ,Failure to Change Employee, Environmental Risk ,Product Liability ,Computer Crime .

Moktadir et al., (2018) identified the risks faces industrial sector and these strategies include: poor of data security, High investment, shortage technological infrastructure, Unstable communication between firms, reducing job opportunity, shortage strategy towards Industry, Environmental side-impacts, Complexity in reconfiguring of production pattern, shortage skilled management team, Complexity in integrating IT and OT.

Moelf et al.,(2020) verified the risks that faces construction industry and found that main danger is the shortage of experience in in manufacture sector. It was found that industrial companies were poorly prepared with competence in support functions. The second danger is the short-term planning of industrial firms. The third danger defined is the technological improvement speed, that carries the danger of obsolescence of an investment in technology.

2.4 Beneficial contributions of Evaluating the effectiveness of risk management in industrial companies .

In the fields of risk management in industrial organizations, several studies conducted researches in order to evaluate the effectiveness of risk management in industrial companies in addition to upgrade risk management in industrial companies:

Uzorh et al., (2017) carried out a study to explain the several procedures in the risk management operation that techniques are utilized in the several stages, and introduces some instances for hazard and control measures. In this study, Trelleborg AB has been selected as case study to show the challenges that can be found regarding to risk management in a large firm huge with several business fields. In this study, Trelleborg AB has been selected as case study to show the limitations that can be found regarding to risk management in a huge firm with many business fields. One typical challenges is accessing the staff. Another typical limitation is no system existed to control and follow up on the findings of the risk analysis that has been executed.

Nevertheless, not only manufactures but also governmental enterprises, institutes and hospitals are presently providing risk management . the findings found that the outcomes of technical hazard evaluation are one section of an overall risk or safety evaluation of an enterprise or company.

(Islam and Tedford,2012) implemented study in order to develop a conceptual model which explains the general method of risk evaluation and determines the limitations in the evaluation steps that can prevent the successful execution of risk management. An empirical verification with several examples in New Zealand has been performed to verify the model. Finally, a comprehensive framework is improved for successful execution of risk management in industry companies.

(Kádárová and Durkáčová,2012) identified the risk that occurs in industrial companies and categorized them into four types: operational risk, financial risk, strategic risk and compliance risk as illustrated in Figure 2.6

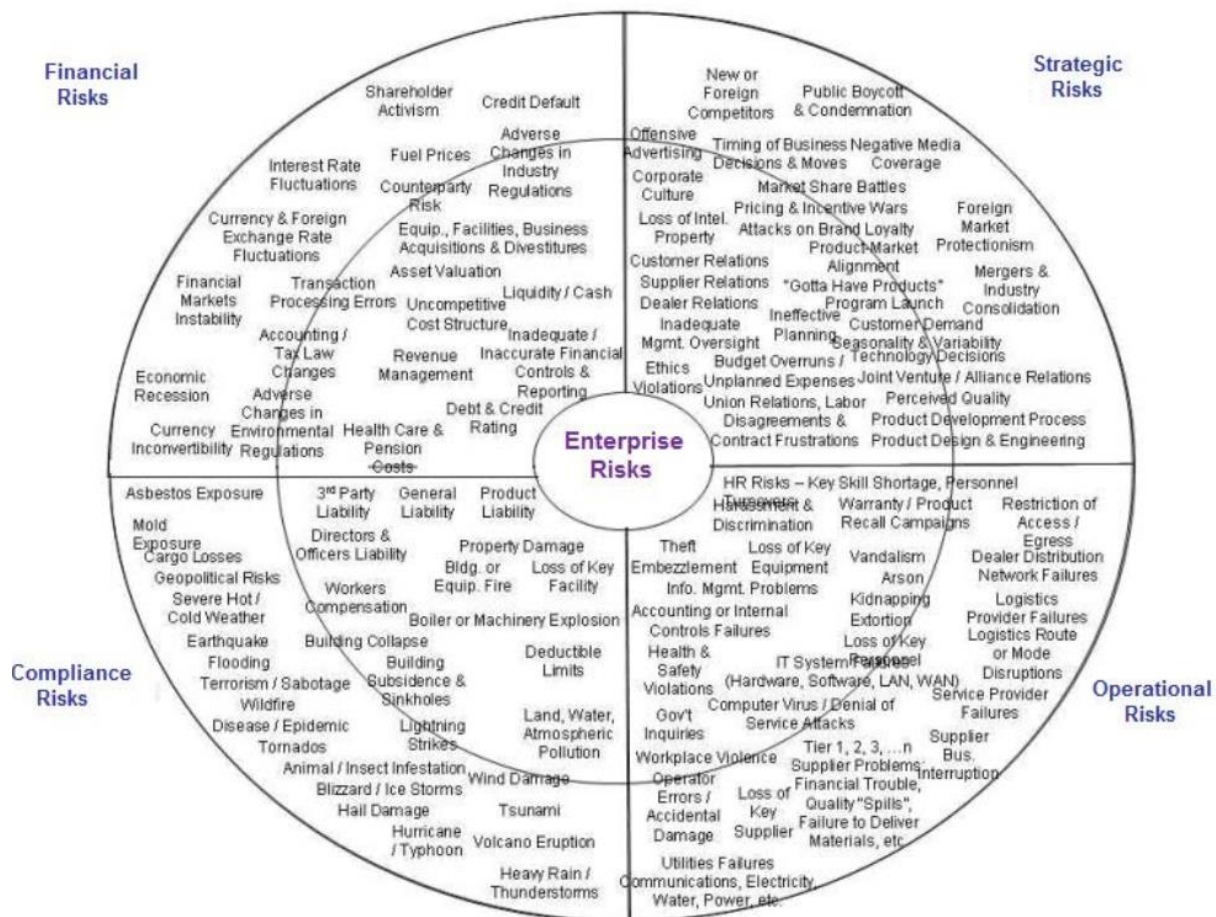


Figure 2.6 Risk Identification by (Islam and Tedford,2012)

The study identified the potential risk that may occur according to each type of risks Moreover , several methods to identify and analyze company hazards were suggested .

Oduoza,(2020) created a planning for risk management suitable for utilization particular by small and medium size companies in the fabricating field. Utilizing an integration of Bayesian Belief Network (BBN) and Analytical Hierarchical Process (AHP) search algorithms, enabled to determine major hazards indicators that can affect on business performance.

Table 2.2 provides comprehensive literature review of the Operational risks in industrial companies

Table 2.2 Review of Operational risks in Industrial Companies

CODE	Opaerational risks	Author
O1	Failure equipment	(Santos& Oliveira, 2019),(McDonald,2017), (Islam, & Tedford, 2012),(Gander et al.,2011),(Pandey et al.,2020),(Asghar et al.,2019),(Corallo et al.,2020),(Bai et al.,2021),(Feria et al.,2016),(
O2	Lack of skilled maintenance team	
O3	Operational errors such as incorrectly set-up of machines or mixing of materials.	
O4	Inadequate supervision	

O5	Cyber attacks that may disrupt operational systems	Kwiatkowski et al.,2021),(Czajkowska & Ingaldi,2021),(Murphy, 2017),(Gorlenko,& Murzin,2019),(Reason,2016), (Birkel et al.,2019),(Olsen et al.,2015),(Burns,2019),(Penelas et al.,2021),(Ablieieva et al.,2021)
O6	Product spillage.	
O7	Emission of Fumes and Smoke.	
O8	Scaffolding collapse.	
O9	Fire accidents	
O10	loss of raw materials	
O11	High leak of pressure.	
O12	Lack of energy sources	
O13	Damage Production/Process lines and pipes.	

Table 2.3 provides comprehensive literature review of the Health risks in industrial companies

Table 2.3 Review of Health risks in Industrial Companies

CODE	Health risks	Author
H1	Continuous exposure to high levels of noise	(Hays et al.,2017),(santos et al.,2019),(Abduladeem & Masood, 2023),(Gander et al.,2019),(Karpov et al.,2021),(Vaz,2015),(Benson et al.,2021),(Popov et al.,2016),(Agarwal et al.,2018),(Al-Omari & Okasheh,2017),(Tsang et al.,2018),(Gášová et al.,2017),(
H2	Exposure to continuous vibrations	
H3	Weak and Strong lighting	
H4	Exposure to radiation	
H5	Exposure to harmful chemicals	
H6	Exposure to toxic vapors and gases	
H7	Working in extremely cold environments can cause hypothermia, frostbite, and circulatory problems.	
H8	Lifting heavy loads or performing repetitive movements can cause muscle and joint stress and injuries	

H9	Working in uncomfortable positions or using inappropriate tools	
----	---	--

Table 2.4 provides comprehensive literature review of the financial risks in industrial companies

Table 2.4 Review of Financial risks in Industrial Companies

CODE	Financial Risks	Author
F1	Raw material price fluctuations	(Nikonenko et al.,2022),(Ribeiro& Tereso,2016),(Lee & Malerba,2017),(Black & Kohser, 2017),(Trianni et al.,2016),(Godwin et al,2022),(Scheibe & Blackhurst,2018),(Zonta et al.,2020),(Mohd et al.,2022),(Rivera et al.,2016),(Birkel etal.,2019),(Amoatey et al.,2015)
F2	Failure to keep up with technology	
F3	Faults in fabricating processes	
F4	Energy cost	
F5	Overstocking or understocking	
F6	Supply chain disruption	
F7	Regular Maintenance Costs	
F8	Unexpected equipment breakdowns	
F9	Using old equipment	
F10	Conflict information	
F11	Delay on paying to suppliers	
F12	Pricing exceeding internal estimates	
F13	Deteriorating standards of quality	
F14	Non-qualified manpower	

Table 2.5 provides comprehensive literature review of the strategic risks in industrial companies

Table 2.5 Review of Strategic risks in Industrial Companies

CODE	Strategic Risks	Author
S1	Disability to adequate to technology development	(Smith et al.,2018),(Porter et al.,2018),(McDonald ,2017),(Stark et al.,2014)
S2	Concentrating on one product or market	
S3	Failure to achieve operational efficiency	
S4	Failure to manage the lifecycle of equipment	
S5	Failure to integrate maintenance plans with production schedules	
S5	Lack of technical skills and competencies in maintenance teams	
S7	Delay to send timesheet and leaves on time	
S8	Delay to provide the requested documents of (Office, accommodation)	
S9	Lack of support in emergencies	
S10	Request for unplanned resources	

Table 2.4 provides comprehensive literature review of the compliance risks in industrial companies

Table 2.6 Review of Compliance risks in Industrial Companies

CODE	Compliance Risks	Author
C1	Failure to comply with regulations related to gas emissions and water pollution	(Zofío & Prieto, 2001),(Shi et al.,2021),(Pathak & Srivastava,2017),(Amponsah et al,2016),(Anttila, & Jussila, 2017),
C2	Improper management of industrial waste can cause legal liability.	
C3	Failure to comply with health and safety standards	
C4	Failure to comply clients needs and expectation	
C5	Fail to implement ISO standards	

C6	lack of employees that follow the policy and labor law.	
----	---	--

2.5 Beneficial Contributions of Investigating the Effectiveness of Risk Management in Industrial Companies .

Carvalho & Rabechini Junior, (2015) executed study aimed to illustrate the relationship between risk management and project success, taking into account the contingent impact of project complexity. This methodological method required an extensive review of literature to support the conceptual framework and a surveying study for empirical verification, utilizing structural equation modelling. The assumptions were examined depend on a surveying study participating 263 projects distributed among eight manufactures. The fieldwork comprised interviews with project directors and risk managers and an analysis of internal company documents about the projects' performance. The structural model executed offers a method for correlating the hard and soft aspects of risk management with project success, understanding the moderating impact of project complexity.

AHMED, (2021) utilized the descriptive analytical technique in executing this study and adopted questionnaire designation as the major tool to collect data, This study found that there is a positive relationship between risk management and the company performance where the research revealed that risk management strategies are applied in moderate proportions by the leaders and personnel of the Sudanese industrial companies and dominated by the reactive technique more than proactive.

Mu et al.,(2009) aimed to strength the knowledge of risk management and its utilizations to companies and to know the causes that resulted in the failure and faltering of the performance of these companies in addition finding suitable solutions .The author utilized the descriptive analytical technique in executing this study and designed a questionnaire as the major tool to collect data, This study develops through the assumption that there is a positive relationship between risk management and the fitm's performance where the study revealed that risk management practices are applied in moderate proportions by the leaders and employees of the Sudanese industrial companies and dominated by the reactive method rather than proactive.

Table 4.7 provides comprehensive literature review of the risk mitigation strategies in industrial companies

Table 2.7 Review of risk mitigation strategies in industrial companies

No.	Mitigation Strategy	Author
1	Identify all electrical wires and sign the locations	(Can et al.,2021),(Suwanda, 2024),(Tarei et al.,2020),(Kusrini & Handayani, 2020),(Reim et al.,2016),(Taghipour et al.,2018)
2	Frequent review of client needs and strategy	
3	Ensure following company rules	
4	develop closer relationships with key suppliers	
5	Awareness and training should be planned for all the employees.	

6	Regular monitoring & checking for the leakage.	
7	measuring & monitoring of Water consumption via BMS.	
8	Minimize the consumption of natural resources.	
9	Safe handling techniques shall be employed during such operations.	
10	Operation and maintenance as per manufacturers instructions.	
11	Ensure Scaffold or Platform are safe.	
12	Provide safety personal equipment for staff and labor	
13	Continuous investment in research and development (R&D) and adoption of new technology.	
14	conduct comprehensive market studies and develop effective marketing strategies.	
15	Strict adherence to regulations	
16	Adopt proactive maintenance strategies and update equipment periodically	
17	Develop integrated maintenance programs that align with production schedules	
18	Effective supply chain management	
19	Conduct regular internal audits to verify compliance and identify any potential issues.	
20	Raise awareness among all employees about the importance of compliance and the potential consequences of non-compliance.	

Chapter Three

Study Methodology

3.1 Introduction

This chapter describes the methodology that address practical aspects of the present study, that assists to attain the study's objective. It comprises the methods, and the steps for investigating impact of potential risks and their mitigation strategies on cost and quality of production in industrial companies. Finally, it provides the statistical techniques adopted in processing data collection and the sample population utilized and the analysis.

3.2 Research Design

This study is based on conducting a comparative analysis by defining all risks associated with manufacturing, operation and maintenance of industrial companies through a review of the literature in this regard.

After identifying all potential risks, a key risk index will be developed by obtaining data from Sankyu company that includes the number of times risks occur during a certain period of time using documents existed in the company in addition to the severity of their impact and comparing it with the risks that have been defined in the literature in order to evaluate the potential risks.

Performance indicators will also be created by obtaining data that includes the expected cost and the calculated cost during the time period studied, in addition to a quality performance indicator to evaluate the company's performance. The data will be analyzed to determine the impact of risks in the company on the company's performance through statistical analysis using the SPSS program.

After evaluating the potential risks, a literature review will be conducted of all strategies used to manage the risks of industrial companies in the field of operation, maintenance, and manufacturing of engineering products. Then the Delphi method will be applied to experts in the field of risk management of industrial companies, and the method will include two rounds.

The first round includes asking the experts to identify the potential risks in industrial companies in order to get comprehensive guide of the potential risks in industrial companies in KSA. In addition the expert will be asked about the most important strategies used to manage the risks of industrial companies. After the first round is compared with the literature, round two of delphi technique will be executed to assess the potential risks based on 5*5 risk matrix illustrated in Figure 3.1 establishing risk index based on severity of risk and risk probability by giving risk level ranges from 1 to 5 in which level one indicates the least impact and least probability to occur while level 5 indicates the highest impact and highest probability.

Enter your sub headline here		Consequence How severe could outcomes be if the risk event occurred?				
		Insignificant 1	Minor 2	Significant 3	Major 4	Severe 5
Likelihood What's the chance of the risk occurring?	5 Almost certain	Medium 5	High 10	Very high 15	Extreme 20	Extreme 25
	4 Likely	Medium 4	Medium 8	High 12	Very high 16	Extreme 20
	3 Moderate	Low 3	Medium 6	Medium 9	High 12	Very high 15
	2 Unlikely	Very low 2	Low 4	Medium 6	Medium 8	High 10
	1 Rare	Very low 1	Very low 2	Low 3	Medium 4	Medium 5

Figure 3.1 5*5 risk matrix

3.3 Research Method

This research adopts the descriptive analytical method using quantitative approach to attain its goals and aim, that is considered one of the advanced statistical techniques used in the field of study. The importance of this methods is due to its capacity to describe the research gap precisely in two methods: by detecting the most risks result in cost over-run and reduction in quality be to correlating these risks with cost over-run, and reduction in quality using quantitative approach by introducing a numerical. The descriptive analytical technique based on processing the problem of the research based on data collection from actual case study resources and experts, analyzing it and testing hypothesis to attain the outcomes, and conclude convenient recommendations.

3.4 Study Population

This study adopts case study present SANKYU company for engineering services in the field of manufacturing, maintenance and operating equipment, plants and mechanical machines. This field of industry results in a lot of threats and risks that affects on company performance.

Also, the sample of the study will comprise numerical data obtained from documents and files in the company related to risks identified and assessed by the company based on risk index and risk matrix. Also, the sample will include numerical data present sample during 2023 about the cost overrun and reduction in quality according to each risk category. Moreover, Data will be obtained comprise strategic risks and solutions and the percentages value of reduction in cost and enhancement in quality according to each strategy.

Next, ten experts and professionals in industrial companies will be selected for two round of Delphi method in order to prepare guidance comprise comprehensive potential risks and risk mitigation strategies as emergency response plan.

3.5 Data Collection resources:

The research based on two sources to gather the data and that are adopted for verifying the purposes and objectives of the study. These sources are classified into two parts, as follows:

1) Secondary Resources:

Data that obtained using literature review comprise extensive review of the recent studies identified potential risks in industrial countries and strategic solutions to manage these risks.

2) Main Resources

Main sources were obtained using data provided from Sankyu company comprise the potential risks in the company and their assessment Data collected in 2023 by Sankyu company comprise the risks occurs monthly and the correlated values in cost overrun and quality reduction evaluated monthly .Moreover , data related to risk mitigation strategies applied monthly and the correlated values of reduction in cost a quality enhancement.

Delphi technique questionnaire also has been used to identify comprehensive risks in industrial companies and their strategies solutions to reduce these risks.

3.6 Study Tools

The study tools comprise the following:

1. Primary data using comprehensive literature review comprise potential risks and risk mitigation strategies.
2. Key risk index to measure and evaluate the risks in the case study company.
3. Key performance index based on quality and cost of products to measure and evaluate the risks in the case study company selected.
4. Regression analysis to study impact of the potential risks on performance of SANKYU company.
5. Delphi technique using two rounds to determine to most significant risks and management strategies to mitigate risks in Saudi industrial companies.

3.7 Dependent and Independent variables

Independent variables: operational risks, financial risks, strategic risks, compliance risks ,health risks and risk management strategi will be considered as independent variables

Dependent variables: product cost and product quality

And the following scheme will depict the correlation between dependent and independent variables.

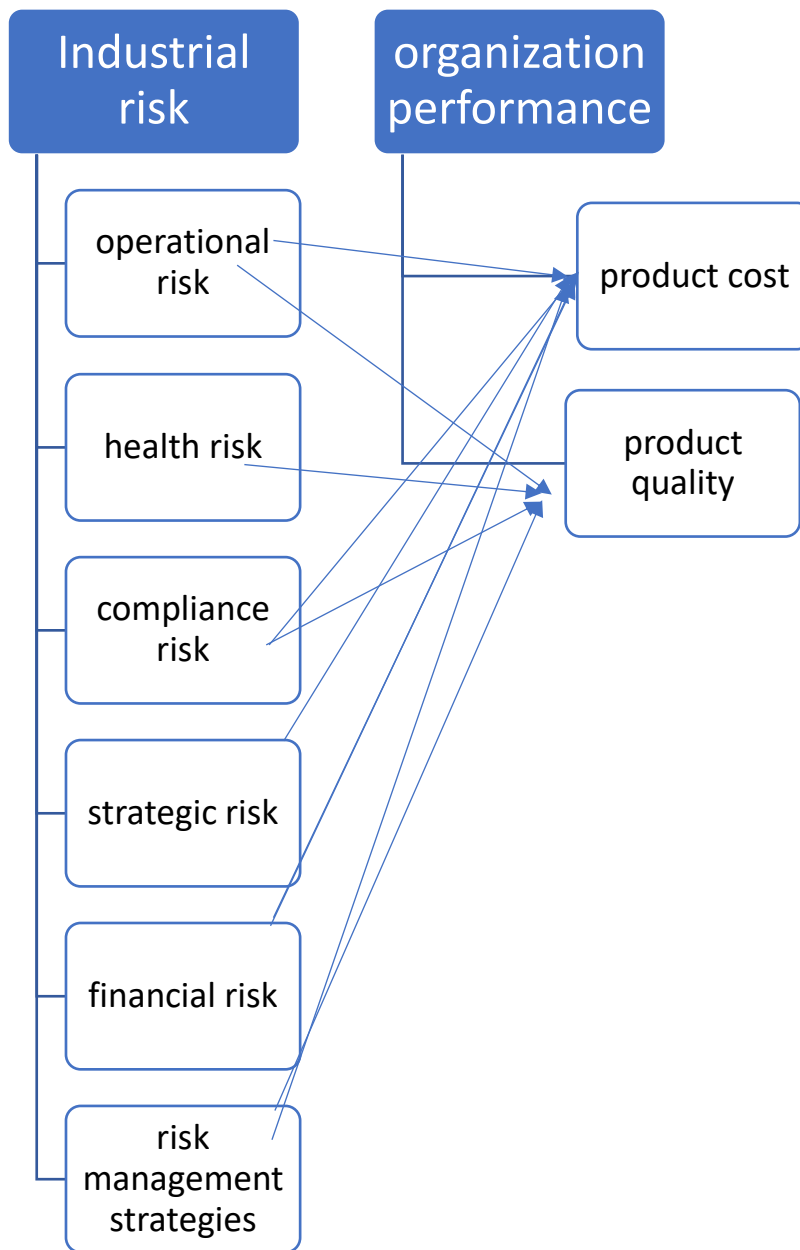


Figure 3.2 Dependent and Independent variables

3.8 Statistical methods

3.8.1 Standard linear regression Analysis

multiple linear regression model was applied to the group of historical data obtained by Samkyu company to investigate the evolution of quality and cost over-run model in which a regression coefficient for each independent variable. the regression model form (Darlington & Hayes, 2017):

$$Y = a_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + e \dots \dots \dots (3.1)$$

where Y is as dependent variable for instance percentage of cost over-run and quality reduction

a0: constant value refers to the intersect with Y axis,

bn: fractional regression coefficients,

Xn: independent variables,

e: error value

The model suggested is to predict the value of a notable amount $Y = f(X)$ related to a group of quantitative variables $X = (X_1, X_2, X_3, \dots, X_n)$, and study the function (f) between Y and X . The relationship f was developed on the basis of an integration of reasonable premises suggested from the researchers experience in public construction projects relating to the data being analyzed. The Advantages of the multiple regression analysis were judged utilizing the multiple correlation coefficients. moreover, it was tested performance of the regression model utilizing Pearson's correlation coefficients.

3.8.2 Delphi Technique

the Delphi technique was utilized since it characterize to assess risks in industrial companies and provide guide in risk mitigation strategies . Delphi method can be adopted resolute issues of getting information about any phenomena and that there is lack of knowledge about it (Adler and Ziglio, 1996), (Delbeq, et al,1975). Via this method information can be developed from the subjective views of professionals and experts on a collective foundation and this method is suitable investigating troubles that are not suitable themselves precise analytical techniques (Adler and Ziglio, 1996). Therefore, Delphi technique can provide comprehensive knowledge and awareness of to assess risks in industrial companies and provide guide in risk mitigation strategies.

The Delphi method included two rounds of questionnaires where the 2.nd questionnaire was formulation from the questions and professionals' opinions revealed from the 1.st questionnaire round. The questionnaire 's objective in the first round was to identify comprehensive potential risks in industrial companies and risk mitigation strategies in order to compare the first-round results with literature conducted in the relevant topic. In the second round of the Delphi, the items determined from the first round were listed and assessed according to the number of professionals who determined each item adopting risk index and risk 5*5 risk matrix express the severity of risk and probability of risk adopting 5 risk level for each factor (severity of risk and risk probability) and the risk index is given by the following relation:

Risk Index= severity of risk*risk probability.....(3.2)

Chapter Four

Results and Discussion

4.1 Introduction

This chapter discuss the results of identifying potential risks in Sankyu company .Also, This chapter describes of regression analysis to study impact of potential risks on cost and quality of production and Sankyu company .Moreover ,Delphi techniques with two rounds has been used to obtain extensive potential risks in industrial companies addition to measure it using risk index. Finally , risk mitigation strategies have been suggested using literature and experts in round one of Delphi technique.

4.2 Risk Identification and assessment in Sankyu company

This section includes the significant step to provide efficient risk management strategies in industrial companies of Saudi Arabia where risk identification process has been executed by literature review executed in addition to the risks data obtained by Sankyu company that comprise the risks that the company have been identified in its plan.

The following mentioned illustrates an extensive risk identifications related to the manufacturing, operating and maintenance categorized into the following categories:

Operational risk, health risk ,compliance risk ,strategic risk and financial risks.

The company has assessed the potential risks according to risk matrix illustrated in Table 4.1

Table 4.1 risk matrix in Sankyu Company

		Impact		
Probability		L	M	H
	3	L3	M3	H3
	2	L2	M2	H2
	1	L1	M1	H1

Table 4.2 presents the operational risk identified in Sankyu company plan in addition to assessment level of each risk according to risk matrix of Sankyu company that depends on the opportunity to occur and severity of impact.

Table 4.2 Operational Risks Identification in Sankyu company.

Code	Operational Risk	Assessment
O1	Falling lifted object	4

O2	Damage Production/Process lines and pipes.	3
O3	Release (Passing) Chemicals or hazardous material into atmosphere.	3
O4	Product spillage.	2
O5	Emission of Fumes and Smoke.	2
O6	Scaffolding collapse.	3
O7	Electrical shock	2
O8	Electrical hazards	2
O9	Oil escape from equipment during maintenance or service.	2
O10	High leak of pressure.	4

Table 4.3 presents the Health risk identified in Sankyu company plan in addition to assessment level of each risk according to risk matrix of Sankyu company that depends on the opportunity to occur and severity of impact.

Table 4.3 Health Risks Identification in Sankyu company.

Code	Health Risk	Assessment
H1	Consumption of water for toilets facilities & cleaning of kitchen utensils in office and project sites,due to damage pipe	2
H2	Spillage of hazardous chemicals	2
H3	High Noise.	2
H4	Vibration & Shaking	3

Table 4.4 presents the financial risk identified in Sankyu company plan in addition to assessment level of each risk according to risk matrix of Sankyu company that depends on the opportunity to occur and severity of impact

Table 4.4 financial Risks Identification in Sankyu company.

Code	financial Risk	Assessment
F1	Unclear request specifications	2
F2	Delay in technical evaluation	2
F3	Conflict information	2
F4	Delay on paying to suppliers	2
F5	Pricing exceeding internal estimates	2
F6	Deteriorating standards of quality	2
F7	Non-qualified manpower	2

F8	Delay on providing suppliers and materials.	2
----	---	---

Table 4.5 presents the strategic risk identified in Sankyu company plan in addition to assessment level of each risk according to risk matrix of Sankyu company that depends on the opportunity to occur and severity of impact.

Table 4.5 strategic Risks Identification in Sankyu company.

Code	strategic Risk	Assessment
S1	Delay to send timesheet and leaves on time	3
S2	Delay to provide the requested documents of (Office, accommodation)	2
S3	Lack of support in emergencies	2
S4	Request for unplanned resources	2

Table 4.6 presents the Compliance risk identified in Sankyu company plan in addition to assessment level of each risk according to risk matrix of Sankyu company that depends on the opportunity to occur and severity of impact.

Table 4.6 Compliance Risks Identification in Sankyu company.

Code	Compliance Risk	Assessment
C1	Failure to comply clients needs and expectation	3
C2	Fail to implement ISO standards	2
C3	Some of employees don't follow the policy and Saudi labor law.	2
C4	not following company rules	2

4.3 impact of potential risks on cost and quality of production in Sankyu company

In order to study impact of risks identified by Sankyu company on cost production, the company introduces file illustrate the additional costs due to the risks occurred in the company during 2023 each month and in order to evaluate the potential cost according to each risk evaluated ,the following equation had been used:

$$\text{Potential cost} = \text{Total cost} * \text{risk probability} \dots\dots\dots \text{eq 4.1}$$

The cost file obtained by Sankyu company has been categorized to illustrate the total cost according to risk categories: operational, compliance, strategic ,financial ,health as illustrated in Table 4.7

Table 4.7 cost data By Sankyu company according to each risk category

No.	Risk category	Total Cost (Dollar)
1	operational	150000
2	compliance	125000
3	strategic	300000
4	financial	200000
5	health	250000

The risk probability has been expressed in equation 4.1 as percentage value as follows:

risk probability=1  Risk % =25%

risk probability=2  Risk % =50%

risk probability=3  Risk % =75%

risk probability=4  Risk % =1%

After evaluating the cost based of the risk probability, standard linear regression model have been suggested in order to study impact of each risk category on cost and quality of products.

To execute this , Data obtained from Sankyu company comprise data related to each risk occurred monthly and the increasing percentage in cost by calculating the difference between the initial budget and the actual budget .Als, the reduction in product quality according to the risks occurred have been provided .illustrated in Appendix A.

After obtaining required data , SPSS software had been used in order to study impact of each risk category on product and quality of products and in order to express data in SPSS, each risk occurred coded in SPSS “yes=1” and if the risk not happen the code in SPSS “No=0” in addition ,the cost overrun and reduction in quality have expressed as percentage value % and the data coding of each risk category are illustrated in Table 4. 8, Table 4. 16, Table 4. 23, Table 4.31 , Table 4. 39.

4.3.1 Impact of operational risks on cost and quality of production in Sankyu company

In order to evaluate the impact of operational risk on cost production and predict the cost of each risk identified in the operational risk category ,equation 4.1 have been used and the results listed in table 4.8

Table 4.8 Costs prediction due to Operational Risks

Code	Operational Risk	Total cost	Risk probability	Risk %	Cost prediction
O1	Falling lifted object	150000	4	100	150000
O2	Damage Production/Process lines and pipes.	150000	3	75	112500
O3	Release (Passing) Chemicals or hazardous material into atmosphere.	150000	3	75	112500
O4	Product spillage.	150000	2	50	75000
O5	Emission of Fumes and Smoke.	150000	2	50	75000
O6	Scaffolding collapse.	150000	3	75	112500
O7	Electrical shock	150000	2	50	75000
O8	Electrical hazards	150000	2	50	75000
O9	Oil escape from equipment during maintenance or service.	150000	2	50	75000
O10	High leak of pressure.	150000	4	100	150000

Table 4.8 shows that risks related to O1,O10 result in high costs by percentages 100% followed by operational risks related to O2,O3,O3 and the least impact of operational risks on increasing cost are O4,O5,O7,O8,O9.

Also, data obtained from Sankyu company includes information about operational risks occurred each month during 2023 in addition the percentage value of cost overrun and percentage value of reduction in quality resulted in these risks illustrated in Table 4.9

Table 4.9 Data coding of operational risks , cost overrun % , quality % corresponded to risks occurred

Month	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	Cost overrun%	Quality%
January	1	1	1	1	1	1	1	1	0	0	0.5	0.4
February	1	0	1	1	1	0	1	0	1	1	0.1	0.11
March	0	0	0	1	0	0	0	1	0	1	0.24	0.22
April	1	1	1	0	1	1	0	1	0	1	0.18	0.15
May	0	1	1	1	1	1	1	1	1	1	0.32	0.31
June	0	0	1	0	0	0	0	1	0	0	0.12	0.11
July	1	1	1	1	1	0	1	1	1	1	0.18	0.2
August	1	0	1	1	1	1	0	1	0	1	0.35	0.3
September	1	0	0	1	1	1	1	0	1	1	0.29	0.23
October	0	0	0	0	1	0	1	0	1	0	0.12	0.09

November	1	1	0	1	1	0	1	1	1	1	0.25	0.23
December	1	1	1	1	1	1	0	1	0	0	0.03	0.02

After data analysis shown in Table 4.9 , regression analysis model depicted in Table 4.10 illustrates that there is a strong correlation of operational risks of Sankyu company with cost overrun of production% in which Adjusted R Square =0.999 indicated to high strong correlation.

Table 4.10 Model 1 Summary^b

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000 ^a	1.000	.999	.00343

a. Predictors: (Constant), High leak of pressure., Electrical hazards, Scaffolding collapse., Falling lifted object , Electrical shock, Release (Passing) Chemicals or hazardous material into atmosphere., Product spillage., Emission of Fumes and Smoke., Damage Production/Process lines and pipes., Oil escape from equipment during maintenance or service.

b. Dependent Variable: cost

It can be noted that the significant value in Table 4.11 is 0.02 that is smaller than 0.05 which indicated that there a significant impact of operational risks identified by Sankyu company on cost overrun

Table 4.11 ANOVA details of Model 1

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.185	10	.019	1572.967	.020 ^b
	Residual	.000	1	.000		
	Total	.185	11			

a. Dependent Variable: cost

b. Predictors: (Constant), High leak of pressure., Electrical hazards, Scaffolding collapse., Falling lifted object , Electrical shock, Release (Passing) Chemicals or hazardous material into atmosphere., Product spillage., Emission of Fumes and Smoke., Damage Production/Process lines and pipes., Oil escape from equipment during maintenance or service.

Table 4.12 Shows Substandard and standard regression coefficients additionally t and sig - values for each of the model 1 were derived illustrates in Table 4.12. the relative sig of each variable is shown in column 6. The regression coefficients expressed the variation in the percentage of cot over-run in units of its standard deviation. It was revealed that for Model 1, the variable Electrical shock (beta = 0.047) had the larger impact on the Percentage of cost over-run followed by Electrical hazards (beta = 0.301) and Oil escape from equipment during maintenance or service (beta = 0.294) in which the coefficients beta illustrated in column 2 illustrated the extend contribution of each sub- operational risk on cost overrun%.

Table 4.12 standard regression coefficients of Model 1

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.116	.006		19.977	.032
	Falling lifted object	.011	.004	.042	2.771	.220
	Damage Production/Process lines and pipes.	.217	.005	.875	45.919	.014
	Release (Passing) Chemicals or hazardous material into atmosphere.	.066	.003	.250	25.695	.025
	Product spillage.	.047	.003	.165	14.517	.044
	Emission of Fumes and Smoke.	.061	.007	.182	8.865	.072
	Scaffolding collapse.	.126	.004	.507	35.667	.018
	Electrical shock	.470	.005	1.866	96.893	.007
	Electrical hazards	.301	.006	1.049	47.339	.013
	Oil escape from equipment during maintenance or service.	.294	.007	1.185	43.771	.015
	High leak of pressure.	.103	.003	.390	31.468	.020

Also , regression analysis model 2 shown in Table 4.13 demonstrates that there is a very strong correlation of operational risks of Sankyu company with reduction quality % of production in which Adjusted R Square =1 indicated to high strong correlation.

Table 4.13 Regression Model 2

Model Summary ^b				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000 ^a	1.000	1.000	.00171

a. Predictors: (Constant), High leak of pressure., Electrical hazards, Scaffolding collapse., Falling lifted object , Electrical shock, Release (Passing) Chemicals or hazardous material into atmosphere., Product spillage., Emission of Fumes and Smoke., Damage Production/Process lines and pipes., Oil escape from equipment during maintenance or service.

b. Dependent Variable: quality

It can be realized that the significant value in Table 4.14 is 0.12 that is smaller than 0.05 which indicated that there a significant impact of operational risks identified by Sankyu company on quality reduction %

Table 4.14 ANOVA details of Model 1

		ANOVA ^a				
Model		12	df	Mean Square	F	Sig.
1	Regression	.127	10	.013	4332.350	.012 ^b
	Residual	.000	1	.000		
	Total	.127	11			

a. Dependent Variable: quality

b. Predictors: (Constant), High leak of pressure., Electrical hazards, Scaffolding collapse., Falling lifted object , Electrical shock, Release (Passing) Chemicals or hazardous material into atmosphere., Product spillage., Emission of Fumes and Smoke., Damage Production/Process lines and pipes., Oil escape from equipment during maintenance or service.

Table 4.15 Shows Substandard and standard regression coefficients additionally t and sig -values for each of the model 2 were derived illustrates in Table 4.15. the relative sig of each variable is shown in column 6. The regression coefficients expressed the variation in the percentage of quality reduction in units of its standard deviation. It was revealed that for Model 2, the variable Damage Production/Process lines and pipes. (beta = 0.856) had the larger impact on the Percentage of cost over-run followed by High leak of pressure. (beta = 0.474) and Electrical shock (beta = 0.18) in which the coefficients beta illustrated in column 2 illustrated the extend contribution of each sub- operational risk on quality reduction% where all the sub-operational risks impact in quality reduction since all significant values illustrated in column 6 are lower that 0.05

Table 4.15 Regression Coefficients of Model 2

		Unstandardized Coefficients		Standardized Coefficients Beta	t	Sig.
Model		B	Std. Error			
1	(Constant)	.122	.003		42.242	.015
	Falling lifted object	.024	.002	.112	12.107	.052
	Damage Production/Process lines and pipes.	.176	.002	.856	74.502	.009
	Release (Passing) Chemicals or hazardous material into atmosphere.	.032	.001	.147	25.006	.025

Product spillage.	.026	.002	.111	16.140	.039
Emission of Fumes and Smoke.	.050	.003	.180	14.545	.044
Scaffolding collapse.	.087	.002	.422	49.333	.013
Electrical shock	.380	.002	1.818	156.678	.004
Electrical hazards	.265	.003	1.112	83.248	.008
Oil escape from equipment during maintenance or service.	.218	.003	1.057	64.760	.010
High leak of pressure.	.104	.002	.474	63.568	.010

4.3.2 Impact of Health risks on cost and quality of production in Sankyu company

In order to evaluate the impact of health risk on cost production and predict the cost of each risk identified in the operational risk category ,equation 4.1 have been used and the results listed in Table 4.16

Table 4.16 Costs prediction due to Health Risks

Code	Health Risk	Total cost	Risk probability	Risk %	Cost prediction
H1	Consumption of water for toilets facilities & cleaning of kitchen utensils in office and project sites,due to damage pipe	125000	2	50	62500
H2	Spillage of hazardous chemicals	125000	2	50	62500
H3	High Noise.	125000	2	50	62500
H4	Vibration & Shaking	125000	3	75	93750

In addition, data obtained from Sankyu company includes information about health risks occurred each month during 2023 in addition the percentage value of cost overrun and percentage value of reduction in quality resulted in these risks illustrated in Table 4.17

Table 4.17 Data coding of health risks , cost overrun % , quality % corresponded to risks occurred

Month	O1	O2	O3	O4	Cost overrun%	Quality%
January	1.00	1.00	1.00	1.00	.95	.90
February	1.00	.00	1.00	.00	.15	.08
March	.00	1.00	.00	1.00	.22	.25
April	1.00	.00	1.00	.00	.15	.17
May	1.00	1.00	1.00	.00	.35	.31
June	.00	1.00	1.00	.00	.15	.17

July	1.00	.00	1.00	.00	.15	.17
August	1.00	.00	1.00	1.00	.23	.26
September	1.00	.00	.00	1.00	.27	.29
October	.00	.00	.00	1.00	.02	.05
November	1.00	1.00	.00	1.00	.25	.23
December	.00	1.00	1.00	1.00	.85	.75

After data analysis shown in Table 4.17 , regression analysis model illustrated in Table 4.18 illustrates that there is a correlation of health risks of Sankyu company with cost overrun of production% in which Adjusted R Square =0.649 indicated to strong correlation.

Table 4.18 Regression Model 3

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.881 ^a	.776	.649	.17037

a. Predictors: (Constant), Vibration & Shaking, Spillage of hazardous chemicals, Consumption of water for toilets facilities & cleaning of kitchen utensils in office and project sites,due to damage pipe, High Noise.

It can be noted that the significant value in Table 4.19 is 0.02 that is smaller than 0.05 which indicated that there a significant impact of operational risks identified by Sankyu company on cost overrun

Table 4.19 ANOVA details of Model 3

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.706	4	.176	6.079	.020 ^b
	Residual	.203	7	.029		
	Total	.909	11			

a. Dependent Variable: cost

b. Predictors: (Constant), Vibration & Shaking, Spillage of hazardous chemicals, Consumption of water for toilets facilities & cleaning of kitchen utensils in office and project sites,due to damage pipe, High Noise.

Table 4.20 Shows Substandard and standard regression coefficients additionally t and sig - values for each of the model 3 were derived illustrates in Table 4.20. the relative sig of each variable is shown in column 6. The regression coefficients expressed the variation in the percentage of cost over-run in units of its standard deviation. It was revealed that for Model 3, the variable *Vibration & Shaking* (beta =0.771) had the larger impact on the Percentage of cost over-run followed by *High Noise* (beta = 0.73) and *Spillage of hazardous chemicals* (beta = 0.476)

in which the coefficients beta illustrated in column 2 illustrated the extend contribution of each sub- operational risk on cost overrun%.

Table 4.20 Regression Coefficients of Model 3

		Coefficients^a				
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	-.422	.173		-2.437	.045
	Consumption of water for toilets facilities & cleaning of kitchen utensils in office and project sites,due to damage pipe	.102	.116	.175	.880	.408
	Spillage of hazardous chemicals	.262	.107	.476	2.441	.045
	High Noise.	.426	.134	.730	3.187	.015
	Vibration & Shaking	.430	.127	.771	3.378	.012

a. Dependent Variable: cost

Also, regression analysis model 4 illustrated in Table 4.21 illustrates that there is a correlation of health risks of Sankyu company with quality of production% in which Adjusted R Square =0.665 indicated to correlation.

Table 4.21 Regression Model 4

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.887 ^a	.787	.665	.14941

a. Predictors: (Constant), Vibration & Shaking, Spillage of hazardous chemicals, Consumption of water for toilets facilities & cleaning of kitchen utensils in office and project sites,due to damage pipe, High Noise.

It can be noted that the significant value in Table 4.22 is 0.017 that is smaller than 0.05 which indicated that there a significant impact of health risks identified by Sankyu company on quality production.

Table 4.22 ANOVA details of Model 4

ANOVA^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.577	4	.144	6.462	.017 ^b
	Residual	.156	7	.022		

Total	.733	11			
-------	------	----	--	--	--

a. Dependent Variable: quality

b. Predictors: (Constant), Vibration & Shaking, Spillage of hazardous chemicals, Consumption of water for toilets facilities & cleaning of kitchen utensils in office and project sites,due to damage pipe, High Noise.

Table 4.23 illustrates Substandard and standard regression coefficients additionally t and sig - values for each of the model 4 were derived illustrates in Table 4.23. the relative sig of each variable is shown in column 6. The regression coefficients expressed the variation in the percentage of cot over-run in units of its standard deviation. It was revealed that for Model 4, the variable **Vibration & Shaking** (beta = 0.814) had the larger impact on the Percentage of quality reduction followed by **High Noise** (beta = 0.723) and **Spillage of hazardous chemicals** (beta = 0.458) in which the coefficients beta illustrated in column 2 illustrated the extend contribution of each sub- health risk on quality production%.

Table 4.23 Regression Coefficients of Model 4

Model		Coefficients ^a		Standardized Coefficients Beta	t	Sig.
		Unstandardized Coefficients B	Std. Error			
1	(Constant)	.360	.152		2.372	.049
	Consumption of water for toilets facilities & cleaning of kitchen utensils in office and project sites,due to damage pipe	.088	.102	.169	.870	.413
	Spillage of hazardous chemicals	.226	.094	.458	2.403	.047
	High Noise.	.379	.117	.723	3.235	.014
	Vibration & Shaking	.408	.112	.814	3.653	.008

a. Dependent Variable: quality

4.3.3 Impact of financial risks on cost and quality of production in Sankyu company

In order to evaluate the impact of financial risk on cost production and predict the cost of each risk identified in the operational risk category ,equation 4.1 have been used and the results listed in Table 4.24

Table 4.24 Costs prediction due to financial Risks

Code	financial Risk	Total cost	Risk probability	Risk %	Cost prediction
F1	Unclear request specifications	300000	2	50	150000

F2	Delay in technical evaluation	300000	2	50	150000
F3	Conflict information	300000	2	50	150000
F4	Delay on paying to suppliers	300000	2	50	150000
F5	Pricing exceeding internal estimates	300000	2	50	150000
F6	Deteriorating standards of quality	300000	2	50	150000
F7	Non-qualified manpower	300000	2	50	150000
F8	Delay on providing suppliers and materials.	300000	2	50	150000

Table 4.24 shows that all sub-financial result in costs by percentages 50% .

In addition, data obtained from Sankyu company includes information about financial risks occurred each month during 2023 in addition the percentage value of cost overrun and percentage value of reduction in quality resulted in these risks illustrated in Table 4.25

Table 4.25 Data coding of financial risks , cost overrun % , quality % corresponded to risks occurred

F1	F2	F3	F4	F5	F6	F7	F8	Cost overrun%	Quality%
1	0	1	1	0	0	1	1	0.15	0.13
1	1	0	0	1	0	1	0	0.14	0.09
0	0	0	1	0	0	1	1	0.13	0.1
1	0	1	0	1	1	0	1	0.15	0.16
0	1	0	1	0	1	0	0	0.16	0.14
0	0	1	0	0	0	0	1	0.18	0.19
0	1	1	0	1	0	1	1	0.19	0.17
1	0	1	1	0	1	0	1	0.14	0.15
1	0	0	1	1	0	1	0	0.16	0.14
0	0	0	0	1	0	1	0	0.12	0.1
1	1	0	1	1	0	1	1	0.18	0.15
1	1	0	0	0	1	0	1	0.1	0.07

After data analysis shown in Table 4.25 , regression analysis model depicted in Table 4.26 illustrates that there is a strong correlation of financial risks of Sankyu company with cost overrun of production% in which Adjusted R Square =0.916 indicated to high strong correlation.

**Table 4.26 Regression Model 5
Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.989 ^a	.977	.916	.00760

a. Predictors: (Constant), Delay on providing suppliers and materials., Delay on paying to suppliers, Deteriorating standards of quality, Delay in technical evaluation, Unclear request specifications, Pricing exceeding internal estimates, Conflict information, Non-qualified manpower

It can be noted that the significant value in Table 4.26 is 0.022 that is smaller than 0.05 which indicated that there a significant impact of financial risks identified by Sankyu company on cost overrun

Table 4.26 ANOVA details of Model 5

		ANOVA ^a				
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.007	8	.001	16.073	.022 ^b
	Residual	.000	3	.000		
	Total	.008	11			

a. Dependent Variable: cost

b. Predictors: (Constant), Delay on providing suppliers and materials., Delay on paying to suppliers, Deteriorating standards of quality, Delay in technical evaluation, Unclear request specifications, Pricing exceeding internal estimates, Conflict information, Non-qualified manpower

Table 4.27 Shows Substandard and standard regression coefficients additionally t and sig - values for each of the model 5 were derived illustrates in Table 4.27. the relative sig of each variable is shown in column 6. The regression coefficients expressed the variation in the percentage of cot over-run in units of its standard deviation. It was revealed that for Model 5, the variable **Non-qualified manpower** (beta = 1.205) had the larger impact on the Percentage of cost over-run followed by **Deteriorating standards of quality** (beta = 1.151) and **Delay on paying to suppliers** (beta = 0.867) and **Pricing exceeding internal estimates suppliers** (beta = 0.867) in which the coefficients beta illustrated in column 2 illustrated the extend contribution of each sub- operational risk on cost overrun%.

Table 4.27 Regression Coefficients of Model 5

		Coefficients ^a				
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.146	.010		15.211	.001
	Unclear request specifications	-.014	.005	-.279	-2.718	.073
	Delay in technical evaluation	.029	.005	.573	5.584	.011
	Conflict information	.035	.007	.678	5.282	.013

Delay on paying to suppliers	.044	.006	.867	7.389	.005
Pricing exceeding internal estimates	.041	.007	.816	5.934	.010
Deteriorating standards of quality	.061	.010	1.151	5.913	.010
Non-qualified manpower	.062	.011	1.205	5.424	.012
Delay on providing suppliers and materials.	-.001	.006	-.019	-.153	.888

a. Dependent Variable: cost

Regression analysis model depicted in Table 4.28 illustrates that there is a strong correlation of financial risks of Sankyu company with quality reduction of production% in which Adjusted R Square =0.972 indicated to high strong correlation.

Table 4.28 Regression Model 6

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.996 ^a	.992	.972	.00596

a. Predictors: (Constant), Delay on providing suppliers and materials., Delay on paying to suppliers, Deteriorating standards of quality, Delay in technical evaluation, Unclear request specifications, Pricing exceeding internal estimates, Conflict information, Non-qualified manpower

It can be noted that the significant value in Table 4.29 is 0.004 that is smaller than 0.05 which indicated that there a significant impact of financial risks identified by Sankyu company on quality reduction

Table 4.29 ANOVA details of Model 6

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.014	8	.002	48.925	.004 ^b
	Residual	.000	3	.000		
	Total	.014	11			

a. Dependent Variable: quality

b. Predictors: (Constant), Delay on providing suppliers and materials., Delay on paying to suppliers, Deteriorating standards of quality, Delay in technical evaluation, Unclear request specifications, Pricing exceeding internal estimates, Conflict information, Non-qualified manpower

Table 4.30 Shows Substandard and standard regression coefficients additionally t and sig - values for each of the model 5 were derived illustrates in Table 4.30. the relative sig of each

variable is shown in column 6. The regression coefficients expressed the variation in the percentage of quality reduction in units of its standard deviation. It was revealed that for Model 6, the variable **Non-qualified manpower** (beta = 1.365) had the larger impact on the Percentage of quality reduction followed by **Deteriorating standards of quality** (beta = 0.931) and **Pricing exceeding internal estimates** (beta = 0.853) and **Delay on paying to suppliers** (0.793) in which the coefficients beta illustrated in column 2 illustrated the extend contribution of each sub-financial risk on cost overrun%.

Table 4.30 Regression Coefficients of Model 6

		Coefficients^a				
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.138	.008		18.312	.000
	Unclear request specifications	.022	.004	.311	5.259	.013
	Delay in technical evaluation	.014	.004	.203	3.433	.041
	Conflict information	.048	.005	.696	9.393	.003
	Delay on paying to suppliers	.054	.005	.793	11.705	.001
	Pricing exceeding internal estimates	.058	.005	.853	10.740	.002
	Deteriorating standards of quality	.068	.008	.931	8.281	.004
	Non-qualified manpower	.095	.009	1.365	10.641	.002
	Delay on providing suppliers and materials.	.003	.005	.047	.674	.548

a. Dependent Variable: quality

4.3.4 Impact of strategic risks on cost and quality of production in Sankyu company

In order to evaluate the impact of strategic risks on cost production and predict the cost of each risk identified in the strategic risk category ,equation 4.1 have been used and the results listed in Table 4.31

Table 4.31 Costs prediction due to strategic Risks

Code	strategic Risk	Total cost	Risk probability	Risk %	Cost prediction
------	----------------	------------	------------------	--------	-----------------

S1	Delay to send timesheet and leaves on time	200000	3	75	150000
S2	Delay to provide the requested documents of (Office, accommodation)	200000	2	50	100000
S3	Lack of support in emergencies	200000	2	50	100000
S4	Request for unplanned resources	200000	2	50	100000

Table 4.31 shows that S1 result in high cost by percentages 75% followed by sub-strategic risks related to S2,s3,s4 result in cost by percentage 50%.

In addition, data obtained from Sankyu company includes information about strategic risks occurred each month during 2023 in addition the percentage value of cost overrun and percentage value of reduction in quality resulted in these risks illustrated in Table 4.32

Table 4.32 Data coding of strategic risks , cost overrun % , quality % corresponded to risks occurred

S1	S2	S3	S4	Cost overrun%	Quality%
1	0	1	1	0.2	0.19
1	1	0	1	0.1	0.08
0	0	0	1	0.14	0.11
0	1	1	0	0.14	0.13
1	0	0	1	0.16	0.12
1	0	0	1	0.17	0.16
0	0	1	1	0.15	0.13
1	0	0	1	0.13	0.14
1	0	1	1	0.21	0.19
0	1	1	0	0.15	0.13
1	0	0	1	0.17	0.15
1	1	0	0	0.17	0.11

regression analysis model depicted in Table 4.33 illustrates that there is a strong correlation of strategic risks of Sankyu company with cost overrun of production% in which Adjusted R Square =0.682 indicated to high strong correlation.

Table 4.33 Regression Model 7

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.893 ^a	.798	.682	.01685

a. Predictors: (Constant), Request for unplanned resources, Lack of support in emergencies, Delay to send timesheet and leaves on time, Delay to provide the requested documents of (Office, accommodation)

It can be noted that the significant value in Table 4.34 is 0.014 that is smaller than 0.05 which indicated that there a significant impact of strategic risks identified by Sankyu company on cost overrun

Table 4.34 ANOVA details of Model 7

		ANOVA ^a				
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.008	4	.002	6.897	.014 ^b
	Residual	.002	7	.000		
	Total	.010	11			

a. Dependent Variable: cost

b. Predictors: (Constant), Request for unplanned resources, Lack of support in emergencies, Delay to send timesheet and leaves on time, Delay to provide the requested documents of (Office, accommodation)

Table 4.35 Shows Substandard and standard regression coefficients additionally t and sig -values for each of the model 7 were derived illustrates in Table 4.35. the relative sig of each variable is shown in column 6. The regression coefficients expressed the variation in the percentage of cost over-run in units of its standard deviation. It was revealed that for Model 7, the variable **Delay to provide the requested documents of (Office, accommodation)** (beta = 1.061) had the larger impact on the Percentage of cost over-run followed by **Request for unplanned resources** (beta = 0.894) and **Delay to send timesheet and leaves on time** (beta = 0.675) and **Lack of support in emergencies**(beta = 0.557) which the coefficients beta illustrated in column 2 illustrated the extend contribution of each sub- strategic risks on cost overrun%.

Table 4.35 Regression Coefficients of Model 7

		Coefficients ^a				
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.183	.024		7.657	.000
	Delay to send timesheet and leaves on time	.041	.012	.675	3.295	.013
	Delay to provide the requested documents of (Office, accommodation)	.064	.018	1.061	3.505	.010
	Lack of support in emergencies	.032	.011	.557	2.814	.026
	Request for unplanned resources	.059	.021	.894	2.766	.028

a. Dependent Variable: cost

Moreover, regression analysis model depicted in Table 4.36 illustrates that there is a strong correlation of strategiv risks of Sankyu company with quality reduction of production% in which Adjusted R Square =0.809 indicated to high strong correlation.

Table 4.36 Regression Model 8

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.937 ^a	.878	.809	.01412

a. Predictors: (Constant), Request for unplanned resources, Lack of support in emergencies, Delay to send timesheet and leaves on time, Delay to provide the requested documents of (Office, accommodation)

It can be noted that the significant value in Table 4.37 is 0.003 that is smaller than 0.05 which indicated that there a significant impact of strategic risks identified by Sankyu company on quality reduction.

Table 4.37 ANOVA details of Model 8

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.010	4	.003	12.629	.003 ^b
	Residual	.001	7	.000		
	Total	.011	11			

a. Dependent Variable: quality

b. Predictors: (Constant), Request for unplanned resources, Lack of support in emergencies, Delay to send timesheet and leaves on time, Delay to provide the requested documents of (Office, accommodation)

Table 4.38 Shows Substandard and standard regression coefficients additionally t and sig - values for each of the model 8 were derived illustrates in Table 4. 38. the relative sig of each variable is shown in column 6. The regression coefficients expressed the variation in the percentage of cot over-run in units of its standard deviation. It was revealed that for Model 8, the variable **Delay to provide the requested documents of (Office, accommodation)** (beta = 0.944) had the larger impact on the Percentage of quality reduction followed by **Lack of support in emergencies** (beta = 0.709) and **Delay to send timesheet and leaves on time** (beta = 0.598) in which the coefficients beta illustrated in column 2 illustrated the extend contribution of each sub- operational risk on cost overrun%.

Table 4. 38 Regression Coefficients of Model 8

Coefficients ^a				
Model	Unstandardized Coefficients	Standardized Coefficients	t	Sig.

		B	Std. Error	Beta		
1	(Constant)	.142	.020		7.136	.000
	Delay to send timesheet and leaves on time	.039	.010	.598	3.762	.007
	Delay to provide the requested documents of (Office, accommodation)	.062	.015	.944	4.021	.005
	Lack of support in emergencies	.044	.010	.709	4.622	.002
	Request for unplanned resources	.040	.018	.558	-2.225	.061

a. Dependent Variable: quality

4.3.5 Impact of compliance risks on cost and quality of production in Sankyu company

In order to evaluate the impact of compliance risk on cost production and predict the cost of each risk identified in the compliance risk category, equation 4.39 have been used and the results listed in table 4.39

Table 4.39 Costs prediction due to compliance Risks

Code	Compliance Risk	Total cost	Risk probability	Risk %	Cost prediction
C1	Failure to comply clients needs and expectation	250000	3	75	187500
C2	Fail to implement ISO standards	250000	2	50	125000
C3	Some of employees don't follow the policy and Saudi labor law.	250000	2	50	125000
C4	not following company rules	250000	2	50	125000

Table 4.39 shows that risks related to C1 result in high costs by percentages 75% followed by sub-compliance risks related to O2, O3 that result in costs by percentages 50%

In addition, data obtained from Sankyu company includes information about compliance risks occurred each month during 2023 in addition the percentage value of cost overrun and percentage value of reduction in quality resulted in these risks illustrated in Table 4.40

Table 4.40 Data coding of strategic risks , cost overrun % , quality % corresponded to risks occurred

C1	C2	C3	C4	Cost overrun%	Quality%
1	1	1	1	0.25	0.23
1	1	0	1	0.17	0.18
0	0	1	0	0.13	0.1
1	0	1	0	0.12	0.13
1	1	0	0	0.15	0.16
1	0	1	0	0.14	0.15
0	1	1	0	0.13	0.11
1	0	0	1	0.14	0.12
1	1	1	0	0.19	0.17
1	0	1	0	0.13	0.12
0	1	0	1	0.15	0.14
0	1	1	0	0.16	0.13

After data analysis shown in Table 4.40 , regression analysis model depicted in Table 4.41 illustrates that there is a strong correlation of compliance risks of Sankyu company with cost overrun of production% in which Adjusted R Square =0.749 indicated to high strong correlation.

Table 4.41 Regression Analysis Model 9

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.917 ^a	.840	.749	.01793

a. Predictors: (Constant), not following company rules, Failure to comply clients needs and expectation, Fail to implement ISO standards, Some of employees don't follow the policy and Saudi labor law.

It can be noted that the significant value in Table 4.42 is 0.02 that is smaller than 0.05 which indicated that there a significant impact of compliance risks identified by Sankyu company on cost overrun

Table 4.42 ANOVA details of Model 9

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.012	4	.003	9.214	.006 ^b
	Residual	.002	7	.000		
	Total	.014	11			

a. Dependent Variable: cost

b. Predictors: (Constant), not following company rules, Failure to comply clients needs and expectation, Fail to implement ISO standards, Some of employees don't follow the policy and Saudi labor law.

Table 4.43 Shows Substandard and standard regression coefficients additionally t and sig - values for each of the model 9 were derived illustrates in Table 4.43. the relative sig of each variable is shown in column 6. The regression coefficients expressed the variation in the percentage of cost over-run in units of its standard deviation. It was revealed that for Model 9, the variable *Some of employees don't follow the policy and Saudi labor law.* (beta =0. 691) had the larger impact on the Percentage of cost over-run followed by *not following company rules* (beta = 0.684) and *Fail to implement ISO standards* (beta = 0.669) in which the coefficients beta illustrated in column 2 illustrated the extend contribution of each sub-compliance risk on cost overrun%.

Table 4.43 Regression Coefficients of Model 1

		Coefficients^a				
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.057	.018		3.111	.017
	Failure to comply clients needs and expectation	.030	.012	.419	2.629	.034
	Fail to implement ISO standards	.047	.011	.669	4.089	.005
	Some of employees don't follow the policy and Saudi labor law.	.050	.014	.691	3.531	.010
	not following company rules	.050	.014	.684	3.494	.010

a. Dependent Variable: cost

Furthermore, regression analysis model depicted in Table 4.44 illustrates that there is a strong correlation of compliance risks of Sankyu company with quality reduction of production% in which Adjusted R Square =0.788 indicated to high strong correlation

Table 4.44 Regression Model 10

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.930 ^a	.865	.788	.01660

a. Predictors: (Constant), not following company rules, Failure to comply clients needs and expectation, Fail to implement ISO standards, Some of employees don't follow the policy and Saudi labor law.

It can be noted that the significant value in Table 4.45 is 0.004 that is smaller than 0.05 which indicated that there a significant impact of compliance risks identified by Sankyu company on quality reduction.

Table 4.45 ANOVA Details of Model 10

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	.012	4	.003	11.225	.004 ^b
	Residual	.002	7	.000		
	Total	.014	11			

a. Dependent Variable: quality

b. Predictors: (Constant), not following company rules, Failure to comply clients needs and expectation, Fail to implement ISO standards, Some of employees don't follow the policy and Saudi labor law.

Table 4.46 Shows Substandard and standard regression coefficients additionally t and sig - values for each of the model 10 were derived illustrates in Table 4.46. the relative sig of each variable is shown in column 6. The regression coefficients expressed the variation in the percentage of quality reduction in units of its standard deviation. It was revealed that for Model 10, the variable *Failure to comply clients needs and expectation* (beta = 0.664) had the larger impact on the Percentage of quality reduction followed by *Fail to implement ISO standards* (beta = 0.661) and *not following company rules* (beta = 0.503) and *Some of employees don't follow the policy and Saudi labor law.* (beta = 0.453) in which the coefficients beta illustrated in column 2 illustrated the extend contribution of each sub- compliance risk on quality reduction%.

Table 4.46 Regression Coefficients of Model 10

Coefficients ^a						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	.051	.017		2.994	.020
	<i>Failure to comply clients needs and expectation</i>	.049	.011	.664	4.534	.003
	<i>Fail to implement ISO standards</i>	.046	.011	.661	4.395	.003
	<i>Some of employees don't follow the policy and Saudi labor law.</i>	.033	.013	.453	2.517	.040

not following company rules	.037	.013	.503	2.795	.027
-----------------------------	------	------	------	-------	------

a. Dependent Variable: quality

4.4 Impact of Risk management strategies on cost and quality of production in Sankyu company

In order to reduce risks and hazards that mentioned previously , the company applied several mitigation strategies in order to reduce cost and enhance quality .Table 4.47 Illustrates data obtained by Sankyu company express the percentage values reducing cost and enhance quality according to each strategy .

Table 4.47 risk Management strategies and their impacts of reducing cost in Sankyu Company

No.	Mitigation Strategy	Cost reduction%	Quality enhancement%
1	Identify all electrical wires and sign the locations	32	10
2	Frequent review of client needs and strategy	40	70
3	Ensure following company rules	62	56
4	develop closer relationships with key suppliers	57	61
5	Awareness and training should be planned for all the employees.	65	55
6	Regular monitoring & checking for the leakage.	42	15
7	measuring & monitoring of Water consumption via BMS.	5	-
8	Minimize the consumption of natural resources.	41	32
9	Safe handling techniques shall be employed during such operations.	40	35
10	Operation and maintenance as per manufacturers instructions.	35	25
11	Ensure Scaffold or Platform are safe.	11	9
12	Provide safety personal equipment for staff and labor	25	12

And the impact of these strategies on cost reduction is illustrated in Figure 4.1 and the impact of these strategies on quality enhancement is presented in Figure 4.2

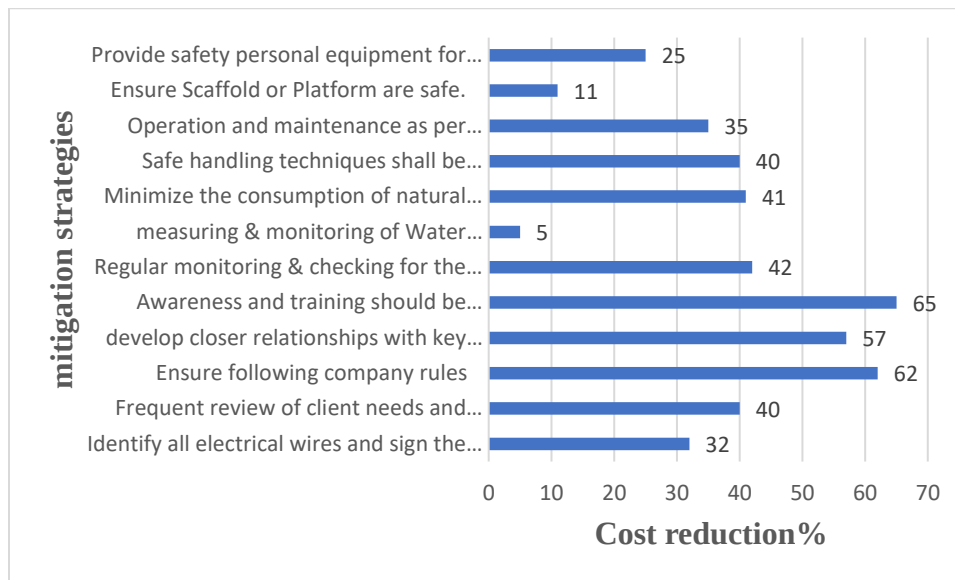


Figure 4.1 Impact of mitigation strategies in cost reduction

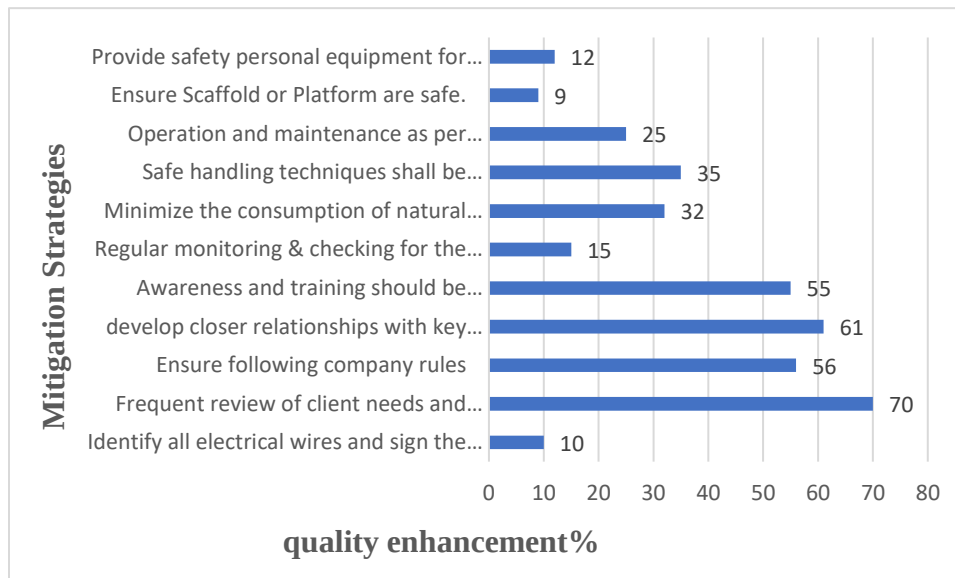


Figure 4.2 Impact of mitigation strategies in quality enhancement%

4.5 Risk Evaluation Using Delphi Method

4.5.1 DELPHI TECHNIQUE RESULTS (ROUND ONE)

Delphi methods were employed in order to detect more extensive risks impact industrial companies in KSA in addition provide comprehensive guideline of the most efficient mitigation strategies in industrial companies.

The round one of Delphi methods comprised the experts and professionals in industrial companies in KSA were asked the first round of the Delphi method comprised asking questions via a questionnaire illustrated in Appendix B that includes the following questions:

- 1- What are the operational risks facing industrial companies in the Kingdom of Saudi Arabia?

- 2- What are the health risks facing industrial companies in the KSA?
- 3- What are the financial risks facing industrial companies in the KSA?
- 4- What are the strategic risks facing industrial companies in the KSA?
- 5- What are the compliance risks facing industrial companies in KSA?
- 6- What are the most efficient strategies to mitigate risks in industrial companies in KSA?

Experts and professionals introduced their replies on relevant topics, and then the frequented replies were counted and ranked in the first round and compared with the literature in chapter Two.

The experts and professionals were asked to identify the risks in industrial companies and ten participators answered accordingly. Ten professionals answered the section A of Delphi-methods. Each expert responded according to his knowledge of the potentials risks occurred according to five categories : technical risks, compliance risks, health risks, operational risks, financial risks, strategic risks. Next, the replies of professionals were gathered by mentioning sub-risk category, along with mentioning the number of experts who indicted to each risk. Table 4.48 shows operational risks in industrial companies identified by experts and compared to literature according to round one of Delphi method.

Table 4.48 operational risks (first round of Delphi technique)

No.	Operational risk	replies
O1	Loss of IT system personnel	8
O2	Failure equipment	9
O3	Lack of skilled maintenance team	10
O4	Operational errors such as incorrectly set-up of machines or mixing of materials.	8
O5	Inadequate supervision	5
O6	Cyber attacks that may disrupt operational systems	6
O7	Product spillage.	7
O8	Emission of Fumes and Smoke.	5
O9	Scaffolding collapse.	7
O10	Electrical shock	6
O11	Fire accidents	3
O12	loss of raw materials	2
O13	High leak of pressure.	9
O14	Lack of energy sources	10

O15	Damage Production/Process lines and pipes.	9
-----	--	---

Table 4.49 Health risks (first round of Delphi technique)

No.	Health risk	replies
H1	Continuous exposure to high levels of noise	10
H2	Exposure to continuous vibrations	10
H3	Weak and Strong lighting	8
H4	Exposure to radiation	7
H5	Exposure to harmful chemicals	7
H6	Exposure to toxic vapors and gases	7
H7	Working in high temperatures can lead to heat stress, heat stroke, and dehydration.	8
H8	Working in extremely cold environments can cause hypothermia, frostbite, and circulatory problems.	8
H9	Lifting heavy loads or performing repetitive movements can cause muscle and joint stress and injuries	9
H10	Working in uncomfortable positions or using inappropriate tools	8

Table 4.50 Financial risks (first round of Delphi technique)

No.	financial risk	replies
F1	Raw material price fluctuations	9
F2	Failure to keep up with technology	10
F3	Faults in fabricating processes	8
F4	Energy cost	10
F5	Overstocking or understocking	7
F6	Supply chain disruption	8
F7	Regular Maintenance Costs	8
F8	Unexpected equipment breakdowns	9
F9	Using old equipment	7
F10	Delay in technical evaluation	8
F11	Conflict information	5

F12	Delay on paying to suppliers	9
F13	Pricing exceeding internal estimates	5
F14	Deteriorating standards of quality	6
F15	Non-qualified manpower	7

Table 4.51 strategic risks (first round of Delphi technique)

No.	strategic risks	replies
S1	Overexpansion in production without adequate market study	5
S2	Disability to adequate to technology development	6
S3	Concentrating on one product or market	4
S4	Failure to achieve operational efficiency	6
S5	Failure to manage the lifecycle of equipment	7
S6	Failure to integrate maintenance plans with production schedules	8
S7	Lack of technical skills and competencies in maintenance teams	9
S8	Delay to send timesheet and leaves on time	7
S9	Delay to provide the requested documents of (Office, accommodation)	9
S10	Lack of support in emergencies	9
S11	Request for unplanned resources	10

Table 4.52 compliance risks (first round of Delphi technique)

No.	compliance risks	replies
C1	Failure to comply with regulations related to gas emissions and water pollution	10
C2	Improper management of industrial waste can cause legal liability.	9
C3	Failure to comply with health and safety standards	7
C4	Failure to obtain the necessary licenses	8
C5	Failure to comply clients needs and expectation	7
C6	Fail to implement ISO standards	9
C7	lack of employees that follow the policy and labor law.	10

4.5.2 DELPHI TECHNIQUE RESULTS (ROUND Two)

In the second round of the Delphi technique, the questionnaire was re-administered to the experts, but they were asked to evaluate it through a risk index that was adopted by giving each risk two degrees, one of which expresses the severity of the risk and the second expresses the severity of the recurrence of the risk according to their personal opinion. They are arranged from number 1 to number 5, where number 1 represents the least influential or least recurring value, while number 5 represents the most influential or most intense value. Then the degree of risk is calculated for each respondent by multiplying the degree of recurrence by the degree of severity of the impact. For example :

The severity impact =3

The probability impact =2

Risk index = The severity impact* The probability impact

Risk index=3*2=6

Table 4.53 shows that experts assessed the operational hazards that they have identified in in Round one .It can be noted that that sub- operational risks that categorized from high risk to extreme are : Loss of IT system personnel, Failure equipment, Operational errors such as incorrectly set-up of machines or mixing of materials, Inadequate supervision, Cyber attacks that may disrupt operational systems, Product spillage, loss of raw materials, Lack of energy sources and Damage Production/Process lines and pipes.

Table 4.53 operational risks (second round of Delphi technique)

CODE	Round Two of Delphi Technique	Judge(j)										mean	Risk index
		1	2	3	4	5	6	7	8	9	10		
O1	Loss of IT system personnel	20	16	25	9	16	25	16	12	25	20	18.4	Extreme risk
O2	Failure equipment	16	12	12	2	16	20	8	20	16	25	14.7	Very high
O3	Lack of skilled maintenance team	6	4	6	12	9	4	12	2	6	1	6.2	medium
O4	Operational errors such as incorrectly set-up of machines or mixing of materials.	25	25	12	1	2	3	4	12	16	12	11.2	high
O5	Inadequate supervision	6	9	20	4	2	1	25	20	16	12	11.5	high
O6	Cyber attacks that may disrupt operational systems	16	20	9	25	16	25	12	20	16	9	16.8	Very high

O7	Product spillage.	25	20	16	16	12	25	12	6	16	20	16.8	Very high
O8	Emission of Fumes and Smoke.	2	4	2	12	8	6	16	6	12	16	8.4	medium
O9	Scaffolding collapse.	2	1	6	12	9	9	2	6	5	16	6.8	medium
O10	Electrical shock	9	9	4	4	2	1	1	1	12	1	4.4	Medium
O11	Fire accidents	9	12	9	9	4	1	2	1	12	2	6.1	Medium
O12	loss of raw materials	25	16	16	16	12	25	12	6	16	20	16.4	Very high
O13	High leak of pressure.	16	12	2	12	8	6	16	6	12	16	10.6	high
O14	Lack of energy sources	25	25	20	4	2	1	25	20	16	20	15.8	Very high
O15	Damage Production/Process lines and pipes.	12	9	9	16	20	12	20	25	20	25	16.8	Very high

Table 4.54 illustrates that experts assessed the health hazards that they have identified in Round one. It can be noted that sub- health risks that categorized from high risk to extreme are : Continuous exposure to high levels of noise, Exposure to continuous vibrations, Weak and Strong lighting, Weak and Strong lighting, Exposure to harmful chemicals, Working in high temperatures can lead to heat stress, heat stroke, and dehydration, Working in extremely cold environments can cause hypothermia, frostbite, and circulatory problems, Lifting heavy loads or performing repetitive movements can cause muscle and joint stress and injuries and Working in uncomfortable positions or using inappropriate tools.

Table 4.54 **Health risks (second round of Delphi technique)**

CODE	Round Two of Delphi Technique	Judge(j)										mean	Risk index
		1	2	3	4	5	6	7	8	9	10		
H1	Continuous exposure to high levels of noise	25	20	25	12	25	25	12	20	25	16	20.5	extreme
H2	Exposure to continuous vibrations	25	16	20	20	16	25	20	16	25	20	20.3	extreme
H3	Weak and Strong lighting	6	12	12	20	12	20	9	16	16	12	13.5	high

H4	Exposure to radiation	12	4	6	1	2	6	4	8	5	3	5.1	medium
H5	Exposure to harmful chemicals	16	16	20	8	16	9	25	20	12	3	14.5	Very high
H6	Exposure to toxic vapors and gases	9	8	9	9	6	1	2	6	9	3	6.2	medium
H7	Working in high temperatures can lead to heat stress, heat stroke, and dehydration.	20	20	25	25	9	12	16	6	20	25	17.8	Extreme
H8	Working in extremely cold environments can cause hypothermia, frostbite, and circulatory problems.	16	12	16	12	9	9	16	6	12	12	12	high
H9	Lifting heavy loads or performing repetitive movements can cause muscle and joint stress and injuries	25	25	20	25	16	12	20	25	16	25	20.9	Extreme
H10	Working in uncomfortable positions or using inappropriate tools	12	20	20	20	16	20	12	20	25	25	19	Extreme

Table 4.55 demonstrates that experts assessed the financial hazards that they have identified in in Round one .It can be noted that that sub- financial risks that categorized from high risk to extreme are : Raw material price fluctuations, Failure to keep up with technology, Energy cost, Overstocking or understocking, Supply chain disruption, Regular Maintenance Costs, Unexpected equipment breakdowns, Using old equipment, Delay in technical evaluation, Conflict information, Pricing exceeding internal estimates, Delay on paying to suppliers, Deteriorating standards of quality and Non-qualified manpower.

Table 4.55 **Financial risks (second round of Delphi technique)**

CODE	Round Two of Delphi Technique	Judge(j)										mean	Risk index
		1	2	3	4	5	6	7	8	9	10		
F1	Raw material price fluctuations	20	16	25	9	16	25	16	12	25	20	18.4	Extreme

F2	Failure to keep up with technology	20	16	12	2	16	16	8	20	16	25	15.1	Very high
F3	Faults in fabricating processes	6	4	6	12	9	4	12	2	6	1	6.2	medium
F4	Energy cost	25	25	12	1	2	3	20	20	16	12	13.6	Very high
F5	Overstocking or understocking	6	9	20	4	2	20	25	20	16	12	13.4	Very high
F6	Supply chain disruption	16	20	20	25	16	25	12	20	16	9	17.9	Very high
F7	Regular Maintenance Costs	16	20	16	20	12	25	25	25	25	20	20.4	Extreme
F8	Unexpected equipment breakdowns	25	16	2	20	25	9	16	12	16	20	16.1	Very high
F9	Using old equipment	20	12	9	16	9	9	12	8	9	12	11.6	high
F10	Delay in technical evaluation	16	20	16	4	16	12	9	2	12	1	10.8	high
F11	Conflict information	25	20	16	12	4	20	2	16	25	16	15.6	Very high
F12	Delay on paying to suppliers	9	12	16	12	16	25	16	20	12	16	15.4	Very high
F13	Pricing exceeding internal estimates	16	20	20	25	25	20	12	12	9	12	17.1	Very high
F14	Deteriorating standards of quality	12	16	12	4	6	3	12	9	16	12	10.2	high
F15	Non-qualified manpower	12	12	5	12	9	9	8	6	16	16	10.5	high

Table 4.56 shows that experts assessed the strategic hazards that they have identified in Round one. It can be noted that sub-strategic risks that categorized from high risk to extreme are : Overexpansion in production without adequate market study, Disability to adequate to technology development, Failure to achieve operational efficiency, Failure to manage the lifecycle of equipment, Failure to integrate maintenance plans with production schedules, Lack of technical skills and competencies in maintenance teams, Delay to send timesheet and leaves on time, Delay to send timesheet and leaves on time, Delay to provide the requested documents of (Office, accommodation) and Lack of support in emergencies

Table 4.56 **Strategic risks (second round of Delphi technique)**

CODE	Round Two of Delphi Technique	Judge(j)										mean	Risk index
		1	2	3	4	5	6	7	8	9	10		
S1	Overexpansion in production without adequate market study	2	3	9	9	16	9	16	20	16	20	12	high
S2	Disability to adequate to technology development	20	16	16	20	12	16	9	20	12	25	16.6	Very high
S3	Concentrating on one product or market	12	10	6	8	9	9	2	3	2	1	6.2	medium
S4	Failure to achieve operational efficiency	25	25	16	12	12	9	16	12	20	16	16.3	Very high
S5	Failure to manage the lifecycle of equipment	12	16	20	12	12	20	16	20	16	12	15.6	Very high
S6	Failure to integrate maintenance plans with production schedules	16	20	20	25	16	25	12	20	16	9	17.9	extreme
S7	Lack of technical skills and competencies in maintenance teams	16	20	12	20	20	25	16	16	20	20	18.5	extreme
S8	Delay to send timesheet and leaves on time	25	16	16	12	20	9	2	9	6	16	13.1	Very high
S9	Delay to provide the requested documents of (Office, accommodation)	20	12	9	9	20	12	9	8	9	12	12	high
S10	Lack of support in emergencies	20	16	16	12	16	12	16	20	12	10	15	Very high

S11	Request for unplanned resources	20	12	20	9	4	5	12	20	20	12	13.4	Very high
-----	---------------------------------	----	----	----	---	---	---	----	----	----	----	------	-----------

Table 4.57 shows that experts assessed the compliance hazards that they have identified in in Round one .It can be noted that that sub- compliance risks that categorized from high risk to extreme are : Improper management of industrial waste can cause legal liability, Failure to comply with health and safety standards, Failure to obtain the necessary licenses, Failure to comply clients needs and expectation, Fail to implement ISO standards, lack of employees that follow the policy and labor law

Table 4.57 **Compliance risks (second round of Delphi technique)**

CODE	Round Two of Delphi Technique	Judge(j)										mean	Risk index
		1	2	3	4	5	6	7	8	9	10		
C1	Failure to comply with regulations related to gas emissions and water pollution	2	6	12	12	8	6	16	4	12	16	9.4	medium
C2	Improper management of industrial waste can cause legal liability.	16	12	6	12	20	9	20	16	16	16	14.3	Very high
C3	Failure to comply with health and safety standards	12	9	9	12	16	12	12	9	12	9	11.2	high
C4	Failure to obtain the necessary licenses	6	9	20	4	2	20	25	20	16	12	13.4	very high
C5	Failure to comply clients needs and expectation	16	20	20	25	16	25	12	20	16	9	17.9	extreme
C6	Fail to implement ISO standards	12	12	5	12	9	9	8	6	16	16	10.5	high
C7	lack of employees that follow the policy and labor law.	20	16	16	12	16	12	16	20	12	10	15	Very high

4.6 Risk mitigation strategies using Delphi Method

Risk mitigation strategies have been suggested integrating literature and expert opinions in round one of Delphi technique. These strategies comprise extensive solutions to mitigate risks in industrial companies. These strategies are illustrated in Table 4.58.

Table 4.58 risk Management strategies using Delphi technique

No.	Mitigation Strategy	replies
1	Identify all electrical wires and sign the locations	10
2	Frequent review of client needs and strategy	9
3	Ensure following company rules	8
4	develop closer relationships with key suppliers	6
5	Awareness and training should be planned for all the employees.	10
6	Regular monitoring & checking for the leakage.	9
7	measuring & monitoring of Water consumption via BMS.	9
8	Minimize the consumption of natural resources.	10
9	Safe handling techniques shall be employed during such operations.	9
10	Operation and maintenance as per manufacturers instructions.	8
11	Ensure Scaffold or Platform are safe.	5
12	Provide safety personal equipment for staff and labor	10
13	Continuous investment in research and development (R&D) and adoption of new technology.	10
14	conduct comprehensive market studies and develop effective marketing strategies.	9
15	Strict adherence to regulations	6
16	Adopt proactive maintenance strategies and update equipment periodically	10
17	Develop integrated maintenance programs that align with production schedules	9
18	Effective supply chain management	10
19	Conduct regular internal audits to verify compliance and identify any potential issues.	10
20	Raise awareness among all employees about the importance of compliance and the potential consequences of non-compliance.	9

Chapter Five

Conclusions and Recommendations

5.1 Summary

This study had been executed to address impact of potential risks in Sankyu company. In addition, impact of risks management strategies on quality and cost of production using have been studied obtaining data by Sankyu company. This study based on data obtained and collected from Sankyu company .This data comprises the strategy planning of the company to manage potential risks. The study addressed at first the potential risks in the company that had been classified into five categories: compliance risks, strategic risks, operational risks, health risks and financial risks. After addressing risks identification and assessment, linear regression models have been used to study impact of each risk category in cost and quality of production in Sankyu company .In order to do the regression analysis, data have been collected during 2023 comprise the risks and information illustrates if each risk occur every month or not .As for data related to cost overrun , cost overrun % have been calculated based on the difference between actual cost and initial budget monthly. Moreover , quality reduction % had been obtained by company assessment .After that , data had been coded and entered to SPSS to execute regression analysis. The next stage comprised using Delph technique adopting two rounds to obtain more extensive risks in industrial companies .In addition ,risk index had been established based on risk matrix and the risks had been evaluated in round two of Delphi technique. Also, Experts in Delphi technique identified all strategies to mitigate risks in industrial companies and these results compared to literature review.

5.2 Conclusions

The study revealed numerous outcomes in the field of risk management strategies in industrial companies in Saudi Arabis .The study achieved the hypothesis of the study by the following :

- 7- operational risk negatively affect the quality and cost of Saudi products in the engineering industry:

Regression model analysis showed that there is a strong correlation between operational risks and cost and quality of production. Moreover, the significance value for all sub-operational risks gave value lower than 0.05 and consequently all operational risks in Sankyu company studied can cause cost overrun and reduction in quality

- 8- Health risks negatively affect the quality and cost of Saudi products in the engineering industry:

Regression model analysis showed that there is a strong correlation between health risks and cost and quality of production. Moreover, the significance value for all sub- health risks gave value lower than 0.05 except the risk “Consumption of water for toilets facilities & cleaning of kitchen utensils in office and project sites, due to damage pipe” which had been excluded from the model and consequently most health risks in Sankyu company studied can cause cost overrun and reduction in quality

- 9- financial risks negatively affect the quality and cost of Saudi products in the engineering industry:

- 10- Regression model analysis showed that there is a strong correlation between financial risks and cost and quality of production. Moreover, the significance value for all sub-financial risks gave value lower than 0.05 except the risk “Unclear request specifications” which had been excluded from the model”and consequently most

financial risks in Sankyu company studied can cause cost overrun and reduction in quality

- 11- strategic risks negatively affect the quality and cost of Saudi products in the engineering industry:

Regression model analysis showed that there is a strong correlation between financial risks and cost and quality of production. Moreover, the significance value for all sub- financial risks gave value lower than 0.05 and consequently all financial risks in Sankyu company studied can cause cost overrun and reduction in quality

- 12- compliance risks negatively affect the quality and cost of Saudi products in the engineering industry:

Regression model analysis showed that there is a strong correlation between compliance risks and cost and quality of production. Moreover, the significance value for all sub- compliance risks gave value lower than 0.05 and consequently all compliance risks in Sankyu company studied can cause cost overrun and reduction in quality

- 13- Adopting efficient risk management plan positively affect the quality and cost of Saudi products in the engineering industry

The study showed that mitigation strategies management adopted in Sankyu company can significantly reduce cost and enhance quality of production.

- 14- Also, The study developed equation to calculate cost overrun based on risk probability

Cost predicted =initial cost *risk probability %.

- 15- Delphi technique could provide assessment of extensive potential operational based on risk index in which it was noted that that sub- operational risks that categorized from high risk to extreme are : Loss of IT system personnel, Failure equipment, Operational errors such as incorrectly set-up of machines or mixing of materials, Inadequate supervision, Cyber attacks that may disrupt operational systems, Product spillage, loss of raw materials, Lack of energy sources and Damage Production/Process lines and pipes.

- 16- It was noted that that sub- health risks that categorized from high risk to extreme are : Continuous exposure to high levels of noise, Exposure to continuous vibrations, Weak and Strong lighting, Weak and Strong lighting, Exposure to harmful chemicals, Working in high temperatures can lead to heat stress, heat stroke, and dehydration, Working in extremely cold environments can cause hypothermia, frostbite, and circulatory problems, Lifting heavy loads or performing repetitive movements can cause muscle and joint stress and injuries and Working in uncomfortable positions or using inappropriate tools.

- 17- It was noted that that sub- financial risks that categorized from high risk to extreme are : Raw material price fluctuations, Failure to keep up with technology, Energy cost, Overstocking or understocking, Supply chain disruption, Regular Maintenance Costs, Unexpected equipment breakdowns, Using old equipment, Delay in technical evaluation, Conflict information, Pricing exceeding internal estimates, Delay on paying to suppliers, Deteriorating standards of quality and Non-qualified manpower.

- 18- It was noted that that sub- strategic risks that categorized from high risk to extreme are : Overexpansion in production without adequate market study, Disability to adequate to

technology development, Failure to achieve operational efficiency, Failure to manage the lifecycle of equipment, Failure to integrate maintenance plans with production schedules, Lack of technical skills and competencies in maintenance teams, Delay to send timesheet and leaves on time, Delay to send timesheet and leaves on time, Delay to provide the requested documents of (Office, accommodation) and Lack of support in emergencies

- 19- It was noted that that sub- compliance risks that categorized from high risk to extreme are : Improper management of industrial waste can cause legal liability, Failure to comply with health and safety standards, Failure to obtain the necessary licenses, Failure to comply clients needs and expectation, Fail to implement ISO standards, lack of employees that follow the policy and labor law.
- 20- Delphi Technique integrating with literature could provide an extensive guidelines of risk mitigation strategies can be adopted to mitigate risks in industrial companies.

5.3 Recommendations

Based on the results of the study that have been inferred in the field on risk mitigation strategies in industrial companies, the study recommends the following:

- 1- Further studies should conduct control chart and capability analysis to evaluate cost and quality of production before and after applying mitigation strategies in industrial companies during certain period.
- 2- Further studies should conduct more in depth studies in specific manufactures to determine accurately risks and could mitigate them.
- 3- Due to the beneficial contributions of risk mitigation strategies ,It is recommended to adopt risk mitigation planning in all industrial companies and government should suggest restrict punishment when no adopting these risk mitigation strategy planning.

References

1. Adler, M. and Ziglio, E. (1996). Gazing into the oracle: The Delphi Method and its application to social policy and public health. London: Jessica Kingsley Publishers.
2. Amponsah-Tawiah, K., & Mensah, J. (2016). Occupational health and safety and organizational commitment: Evidence from the Ghanaian mining industry. *Safety and health at work*, 7(3), 225-230.
3. Anttila, J., & Jussila, K. (2017). ISO 9001: 2015—a questionable reform. What should the implementing organisations understand and do?. *Total Quality Management & Business Excellence*, 28(9-10), 1090-1105.
4. AHMED, Y. A. A. (2021). Study of the effect of risk management application on the performance of giad industrial group. *Journal of Karary University for Engineering and Science*.
5. Abduladeem, A. A., & Masood, M. A. (2023). Occupational Health and Safety, Risk Assessment, and Management in the Machinery Sector. *African Journal of Advanced Pure and Applied Sciences (AJAPAS)*, 187-198.
6. AZ/NZS 4360 2004. Risk Management. Standards Australia International Ltd, Sydney
Basel Committee on Banking Supervision 2003. Trends in Risk Integration and Aggregation, Basel, August 2003
7. Al-Omari, K., & Okasheh, H. (2017). The influence of work environment on job performance: A case study of engineering company in Jordan. *International Journal of Applied Engineering Research*, 12(24), 15544-15550.
8. Amoatey, C. T., Ameyaw, Y. A., Adaku, E., & Famiyeh, S. (2015). Analysing delay causes and effects in Ghanaian state housing construction projects. *International Journal of Managing Projects in Business*, 8(1), 198-214.
9. Ablieieva, I., Plyatsuk, L., Trunova, I., Burla, O., & Krasulia, B. (2022). Scientific and methodological approaches to assessing the safety of oil production complexes as potentially dangerous objects.
10. Agarwal, P., Goyal, A., & Vaishnav, R. (2018). Chemical hazards in pharmaceutical industry: An overview. *Asian J. Pharm. Clin. Res*, 11, 27-35.
11. Asghar, M. R., Hu, Q., & Zeadally, S. (2019). Cybersecurity in industrial control systems: Issues, technologies, and challenges. *Computer Networks*, 165, 106946.
12. ACT Insurance Authority 2004. Risk Management Toolkit. February 2004.
13. Birkel, H. S., Veile, J. W., Müller, J. M., Hartmann, E., & Voigt, K. I. (2019). Development of a risk framework for Industry 4.0 in the context of sustainability for established manufacturers. *Sustainability*, 11(2), 384.
14. Benson, C., Dimopoulos, C., Argyropoulos, C. D., Mikellidou, C. V., & Boustras, G. (2021). Assessing the common occupational health hazards and their health risks among oil and gas workers. *Safety science*, 140, 105284.
15. Barrero, L. H., Cifuentes, M., Rodríguez, A. C., Rey-Becerra, E., Johnson, P. W., Marin, L. S., ... & Dennerlein, J. T. (2019). Whole-body vibration and back pain-related work absence among heavy equipment vehicle mining operators. *Occupational and Environmental Medicine*, 76(8), 554-559.
16. Bai, C., Gao, W., & Sarkis, J. (2021). Operational risks and firm market performance: Evidence from China. *Decision Sciences*, 52(4), 920-951.

17. Burns, M. G. (2019). Managing energy security: an all hazards approach to critical infrastructure. Routledge.
18. Birkel, H. S., Veile, J. W., Müller, J. M., Hartmann, E., & Voigt, K. I. (2019). Development of a risk framework for Industry 4.0 in the context of sustainability for established manufacturers. *Sustainability*, 11(2), 384.
19. Black, J. T., & Kohser, R. A. (2017). *DeGarmo's materials and processes in manufacturing*. John Wiley & Sons.
20. Corallo, A., Lazoi, M., & Lezzi, M. (2020). Cybersecurity in the context of industry 4.0: A structured classification of critical assets and business impacts. *Computers in industry*, 114, 103165.
21. Carvalho, M. M. D., & Rabechini Junior, R. (2015). Impact of risk management on project performance: the importance of soft skills. *International journal of production research*, 53(2), 321-340.
22. Czajkowska, A., & Ingaldi, M. (2021). Structural failures risk analysis as a tool supporting corporate responsibility. *Journal of Risk and Financial Management*, 14(4), 187.
23. Can Saglam, Y., Yildiz Çankaya, S., & Sezen, B. (2021). Proactive risk mitigation strategies and supply chain risk management performance: an empirical analysis for manufacturing firms in Turkey. *Journal of Manufacturing Technology Management*, 32(6), 1224-1244.
24. Darlington, R. B., & Hayes, A. F. (2016). *Regression analysis and linear models: Concepts, applications, and implementation*. Guilford Publications.
25. Delbeq, A., Van de Ven, A., and Gustafson, D. H. (1975). Group techniques for program planning: A guide to nominal group and Delphi processes. Glenview, USA: Scott, Foresman and Company.
26. Engr. Dr. Uzorh, A.C.(2017), Assessing and Controlling Risk in Industrial Organization , International Journal of Engineering Science Invention ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726 www.ijesi.org ||Volume 6 Issue 8|| August 2017 || PP. 68-79
27. Elfaki, I. O., & Tayfor, A. E. (2023). Concepts, Uncertainties, and Reaction to Financial Risk in the Sudanese Manufacturing Sector. *WSEAS Transactions on Business and Economics*, 20, 2289-2299.
28. Feria-Domínguez, J. M., Jiménez-Rodríguez, E., & Merino Fdez-Galiano, I. (2016). Financial perceptions on oil spill disasters: isolating corporate reputational risk. *Sustainability*, 8(11), 1090.
29. Ghouri, A. M., Mani, V., Khan, M. R., Khan, N. R., & Srivastava, A. P. (2020). Enhancing business performance through green human resource management practices: an empirical evidence from Malaysian manufacturing industry. *International Journal of productivity and Performance management*, 69(8), 1585-1607.
30. Godwin, H. C., Umeonwujiaku, I., Aguh, P., & Igbokwe, N. (2022). Development of the best optimal policy for Inventory control in a Small and Medium Enterprise. *International Journal of Engineering Science and Computing*.
31. Gášová, M., Gašo, M., & Štefánik, A. (2017). Advanced industrial tools of ergonomics based on Industry 4.0 concept. *Procedia engineering*, 192, 219-224.

32. Gander, P., Hartley, L., Powell, D., Cabon, P., Hitchcock, E., Mills, A., & Popkin, S. (2011). Fatigue risk management: Organizational factors at the regulatory and industry/company level. *Accident Analysis & Prevention*, 43(2), 573-590.
33. Gorlenko, N. V., & Murzin, M. A. (2019, December). Comparative analysis of fire risks in coal and oil and gas industries. In *IOP Conference Series: Materials Science and Engineering* (Vol. 687, No. 6, p. 066009). IOP Publishing.
34. Hays, J., McCawley, M., & Shonkoff, S. B. (2017). Public health implications of environmental noise associated with unconventional oil and gas development. *Science of the Total Environment*, 580, 448-456.
35. International Electrotechnical Commission (IEC) 2008. Draft IEC 31010 Ed. 1.0, Risk Management– Risk Assessment Techniques. May 2008
36. Islam, M. A., & Tedford, D. (2012). Implementation of risk management in manufacturing industry-An empirical investigation. *people*, 2(3), 258-267
37. Islam, A., & Tedford, D. (2012). Risk determinants of small and medium-sized manufacturing enterprises (SMEs)-an exploratory study in New Zealand. *Journal of Industrial Engineering International*, 8, 1-13
38. J. Kádárová* and M. Durkáčová,(2012), Risk management in industrial companies, SAMI 2012 , 10th IEEE Jubilee International Symposium on Applied Machine Intelligence and Informatics
39. Karpov, A. B., Takhaouov, R. M., Zerenkov, A. G., Semenova, Y. V., Bogdanov, I. M., Kazantceva, S. B., ... & Zablotska, L. B. (2021). Descriptive characteristics of occupational exposures and medical follow-up in the cohort of workers of the Siberian Group of Chemical Enterprises in Seversk, Russia. *International journal of radiation biology*, 97(6), 848-860.
40. Kwiatkowski, S., Polat, M., Yu, W., & Johnson, M. S. (2021). Industrial emissions control technologies: Introduction. *Air Pollution Sources, Statistics and Health Effects*, 477-511
41. Kusrini, E., & Handayani, S. (2020). Sustainable risk mitigation in manufacturing company. In *IOP Conference Series: Materials Science and Engineering* (Vol. 722, No. 1, p. 012066). IOP Publishing.
42. Lee, K., & Malerba, F. (2017). Catch-up cycles and changes in industrial leadership: Windows of opportunity and responses of firms and countries in the evolution of sectoral systems. *Research Policy*, 46(2), 338-351.
43. Mark,(2021),Business risk management getting health and safety firmly on the agenda [online]. Available at: Health and Safety Risk Management - Business Opportunity or Burden? (ecoonline.com)
44. Moktadir, M. A., Ali, S. M., Kusi-Sarpong, S., & Shaikh, M. A. A. (2018). Assessing challenges for implementing Industry 4.0: Implications for process safety and environmental protection. *Process safety and environmental protection*, 117, 730-741.
45. Moeuf, A., Lamouri, S., Pellerin, R., Tamayo-Giraldo, S., Tobon-Valencia, E., & Eburdy, R. (2020). Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs. *International Journal of Production Research*, 58(5), 1384-1400.
46. Mu, J., Peng, G., & MacLachlan, D. L. (2009). Effect of risk management strategy on NPD performance. *Technovation*, 29(3), 170-180.

47. Mohd Fateh, M. A., Mohamed, M. R., & Omar, S. A. (2022). The involvement of local skilled labour in Malaysia's construction industry. *Frontiers in Built Environment*, 8, 861018.
48. Min, J., Kim, Y., Lee, S., Jang, T. W., Kim, I., & Song, J. (2019). The fourth industrial revolution and its impact on occupational health and safety, worker's compensation and labor conditions. *Safety and health at work*, 10(4), 400-408.
49. McDonald, N. (2017). Organisational resilience and industrial risk. In *Resilience Engineering* (pp. 155-180). CRC Press.
50. Murphy, J. F. (2017). Safety considerations in the chemical process industries. *Handbook of Industrial Chemistry and Biotechnology*, 1805-1887.
51. Naradda Gamage, S. K., Ekanayake, E. M. S., Abeyrathne, G. A. K. N. J., Prasanna, R. P. I. R., Jayasundara, J. M. S. B., & Rajapakshe, P. S. K. (2020). A review of global challenges and survival strategies of small and medium enterprises (SMEs). *Economies*, 8(4), 79.
52. Nikonenko, U., Shtets, T., Kalinin, A., Dorosh, I., & Sokolik, L. (2022). Assessing the Policy of Attracting Investments in the Main Sectors of the Economy in the Context of Introducing Aspects of Industry 4.0. *International Journal of Sustainable Development & Planning*, 17(2).
53. Oduoza, 2020, Framework for Sustainable Risk Management in the Manufacturing Sector, / *Procedia Manufacturing* 51 (2020) 1290–1297
54. Olsen, E., Næss, S., & Høyland, S. (2015). Exploring relationships between organizational factors and hydrocarbon leaks on offshore platform. *Safety science*, 80, 301-309.
55. Porter, M. E., & Heppelmann, J. E. (2015). How smart, connected products are transforming companies. *Harvard business review*, 93(10), 96-114
56. Penelas, A. D. J., & Pires, J. C. (2021). Hazop analysis in terms of safety operations processes for oil production units: A case study. *Applied Sciences*, 11(21), 10210.
57. Popov, G., Lyon, B. K., & Hollcroft, B. D. (2016). *Risk assessment: A practical guide to assessing operational risks*. John Wiley & Sons.
58. Paul L. Walker, [CPA](#); William G. Shenkir, (2018), Enterprise risk management: tools and techniques for effective implementation, Institute of Management Accountants 10 Paragon Drive, Suite 1 Montvale, NJ, 07645
59. Pandey, S., Singh, R. K., Gunasekaran, A., & Kaushik, A. (2020). Cyber security risks in globalized supply chains: conceptual framework. *Journal of Global Operations and Strategic Sourcing*, 13(1), 103-128.
60. Pathak, P., & Srivastava, R. R. (2017). Assessment of legislation and practices for the sustainable management of waste electrical and electronic equipment in India. *Renewable and Sustainable Energy Reviews*, 78, 220-232..
61. Rivera-Gómez, H., Gharbi, A., Kenné, J. P., Montano-Arango, O., & Hernandez-Gress, E. S. (2016). Production control problem integrating overhaul and subcontracting strategies for a quality deteriorating manufacturing system. *International Journal of Production Economics*, 171, 134-150.
62. Ribeiro, E., & Tereso, A. P. (2016). The application of a decision model in the management of raw material costs.
63. Reason, J. (2016). *Managing the risks of organizational accidents*. Routledge.

64. Reim, W., Parida, V., & Sjödin, D. R. (2016). Risk management for product-service system operation. *International Journal of Operations & Production Management*, 36(6), 665-686.
65. RIGBY, D. – BILODEAU, B. 2009, : Management Tools and Trends 2009
66. Stark, A., McConnell, A., & Drennan, L. T. (2014). *Risk and crisis management in the public sector*. Routledge.
67. Scheibe, K. P., & Blackhurst, J. (2018). Supply chain disruption propagation: a systemic risk and normal accident theory perspective. *International Journal of Production Research*, 56(1-2), 43-59.
68. Santos, R. B., & de Oliveira, U. R. (2019). Analysis of occupational risk management tools for the film and television industry. *International Journal of Industrial Ergonomics*, 72, 199-211.
69. Shi, J., Huang, W., Han, H., & Xu, C. (2021). Pollution control of wastewater from the coal chemical industry in China: Environmental management policy and technical standards. *Renewable and Sustainable Energy Reviews*, 143, 110883.
70. Suwanda, S. (2024). Implementation of Risk Management Strategies in the Industrial Sector. *Jurnal Sosial Sains dan Komunikasi*, 2(2), 179-186.
71. Smith, R. O., Scherer, M. J., Cooper, R., Bell, D., Hobbs, D. A., Pettersson, C., ... & Bauer, S. (2018). Assistive technology products: a position paper from the first global research, innovation, and education on assistive technology (GREAT) summit. *Disability and Rehabilitation: Assistive Technology*, 13(5), 473-485.
72. Trianni, A., Cagno, E., & Farné, S. (2016). Barriers, drivers and decision-making process for industrial energy efficiency: A broad study among manufacturing small and medium-sized enterprises. *Applied energy*, 162, 1537-1551.
73. Tsang, Y. P., Choy, K. L., Wu, C. H., Ho, G. T., Lam, C. H., & Koo, P. S. (2018). An Internet of Things (IoT)-based risk monitoring system for managing cold supply chain risks. *Industrial Management & Data Systems*, 118(7), 1432-1462.
74. Taghipour, M., Vosough, A., Kazemi, N., & Ahitabar, P. (2018). Study of the application of risk management in the operation and maintenance of power plant projects. *International Journal of Business Management*, 3(3-2018), 98-110.
75. Tupa, J., Simota, J., & Steiner, F. (2017). Aspects of risk management implementation for Industry 4.0. *Procedia manufacturing*, 11, 1223-1230.
76. Tarei, P. K., Thakkar, J. J., & Nag, B. (2020). Benchmarking the relationship between supply chain risk mitigation strategies and practices: an integrated approach. *Benchmarking: An International Journal*, 27(5), 1683-1715.
77. Vaz, P. (2015). Radiological protection, safety and security issues in the industrial and medical applications of radiation sources. *Radiation Physics and Chemistry*, 116, 48-55.
78. Zonta, T., Da Costa, C. A., da Rosa Righi, R., de Lima, M. J., da Trindade, E. S., & Li, G. P. (2020). Predictive maintenance in the Industry 4.0: A systematic literature review. *Computers & Industrial Engineering*, 150, 106889.
79. Zofío, J. L., & Prieto, A. M. (2001). Environmental efficiency and regulatory standards: the case of CO₂ emissions from OECD industries. *Resource and Energy Economics*, 23(1), 63-83.

Appendix A

Data obtained by Sankyu company illustrates that if risk occurs it expresses “yes” and “No” if the risk not occur during each month in 2023. Also, the column “cost %” indicates to the difference between initial budget expected in each month and the actual budget

Cost % = initial budget - actual budget

While “quality %” indicates the percentage reduction in quality of product according to each risk .

Operational risks

Month	O1	O2	O3	O4	O5	O6	O7	O8	O9	O10	Cost%	Quality %
January	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	No	0.5	0.4
February	Yes	No	Yes	Yes	Yes	No	Yes	No	Yes	Yes	0.1	0.11
March	No	No	No	Yes	No	No	No	Yes	No	Yes	0.24	0.22
April	Yes	Yes	Yes	No	Yes	Yes	No	Yes	No	Yes	0.18	0.15
May	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	0.32	0.31
June	No	No	Yes	No	No	No	No	Yes	No	No	0.12	0.11
July	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	0.18	0.2
August	Yes	No	Yes	Yes	Yes	Yes	No	Yes	No	Yes	0.35	0.3
September	Yes	No	No	Yes	Yes	Yes	Yes	No	Yes	Yes	0.29	0.23
October	No	No	No	No	Yes	No	Yes	No	Yes	No	0.12	0.09
November	Yes	Yes	No	Yes	Yes	No	Yes	Yes	Yes	Yes	0.25	0.23
December	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No	No	0.03	0.02

Health Risks

Month	O1	O2	O3	O4	Cost%	Quality%
January	Yes	Yes	Yes	Yes	0.95	0.9
February	Yes	No	Yes	No	0.15	0.08
March	No	Yes	No	Yes	0.22	0.25
April	Yes	No	Yes	No	0.15	0.17
May	Yes	Yes	Yes	No	0.35	0.31
June	No	Yes	Yes	No	0.15	0.17
July	Yes	No	Yes	No	0.15	0.17
August	Yes	No	Yes	Yes	0.23	0.26
September	Yes	No	No	Yes	0.27	0.29
October	No	No	No	Yes	0.02	0.05
November	Yes	Yes	No	Yes	0.25	0.23
December	No	Yes	Yes	Yes	0.85	0.75

Financial Risks

Month	F1	F2	F3	F4	F5	F6	F7	F8	Cost	Quality
January	yes	No	yes	yes	No	No	yes	yes	0.15	0.13
February	yes	yes	No	No	yes	No	yes	No	0.14	0.09
March	No	No	No	yes	No	No	yes	yes	0.13	0.1
April	yes	No	yes	No	yes	yes	No	yes	0.15	0.16
May	No	yes	No	yes	No	yes	No	No	0.16	0.14
June	No	No	yes	No	No	No	No	yes	0.18	0.19
July	No	yes	yes	No	yes	No	yes	yes	0.19	0.17
August	yes	No	yes	yes	No	yes	No	yes	0.14	0.15
September	yes	No	No	yes	yes	No	yes	No	0.16	0.14
October	No	No	No	No	yes	No	yes	No	0.12	0.1
November	yes	yes	No	yes	yes	No	yes	yes	0.18	0.15
December	yes	yes	No	No	No	yes	No	yes	0.1	0.07

Strategic Risks

Month	S1	S2	S3	S4	cost %	quality%
January	yes	No	yes	yes	0.2	0.19
February	yes	yes	No	yes	0.1	0.08
March	No	No	No	yes	0.14	0.11
April	No	yes	yes	No	0.14	0.13
May	yes	No	No	yes	0.16	0.12
June	yes	No	No	yes	0.17	0.16
July	No	No	yes	yes	0.15	0.13
August	yes	No	No	yes	0.13	0.14
September	yes	No	yes	yes	0.21	0.19
October	No	yes	yes	No	0.15	0.13
November	yes	No	No	yes	0.17	0.15
December	yes	yes	No	No	0.17	0.11

Compliance Risks

Month	C1	C2	C3	C4	cost	quality
January	yes	yes	yes	yes	0.25	0.23
February	yes	yes	No	yes	0.17	0.18
March	No	No	yes	No	0.13	0.1
April	yes	No	yes	No	0.12	0.13
May	yes	yes	No	No	0.15	0.16
June	yes	No	yes	No	0.14	0.15
July	No	yes	yes	No	0.13	0.11
August	yes	No	No	yes	0.14	0.12
September	yes	yes	yes	No	0.19	0.17
October	yes	No	yes	No	0.13	0.12
November	No	yes	No	yes	0.15	0.14
December	No	yes	yes	No	0.16	0.13

Appendix B

DELPHI QUESTIONNAIRE

Research topic: Impact of Risk management strategies on performance of Industrial Companies: "Sankyu Company as Case Study"

Researchers: **Othman Algarni ,Abdullah Adel Jumeih**

Preamble

This study sheds light on the potential risks in industrial companies according to several categories: operational risks, compliance risks, health risks, financial risks and strategic risks .Moreover, this study aims to assess these potential risks via risk index based on risk matrix.

Moreover, this study aims to suggest guidelines of the risk management strategies in industrial companies.

In this research, the Delphi method will be used to generate lists comprise the following:

- a. the first list contains identifying operational risks in industrial companies.
- b. the second list includes identifying compliance risks in industrial companies.
- c. the third list comprise identifying financial risks in industrial companies.
- d. the fourth list contains identifying strategic risks in industrial companies.
- e. the fifth list includes identifying health risks in industrial companies.

2- the final list comprise mentioning risk mitigation strategies in industrial companies.

The research data – i.e. opinions from experts in the industrial companies in KSA – will be collected by means of two rounds of questionnaires, which generates a series of qualitative and quantitative data for analysis. The analysis findings will then determine the form and content of subsequent questionnaires, and so on until the group opinion is formed and is stable.

The Delphi method will be conducted in two rounds, as outlined below.

ROUND 1: Brainstorming of lists

ROUND 2: Ranking the statements of lists

Participating in this Study

You have been selected as a member of the Delphi expert panel. Over the next few weeks, you will be asked to complete two rounds of questionnaires. At the end of this period, the results of the questionnaires will be made available to you as a token of gratitude for your contribution.

Your participation is on a voluntary basis. Below are the conditions of voluntary participation:

- • • Confidentiality.
- • • Anonymity.
- • • Not asked to divulge any business-sensitive information.

The 2-page questionnaire can be found overleaf. The questionnaire should take no more than 30 minutes to complete.

Kindly return the completed questionnaire within 7 days of receiving the questionnaire. Many thanks in advance for your time and contribution. If you have any questions about the research, please do not hesitate to contact the undersigned.

Kind regards,

Othman Algarni

Abdullah Adel Jumei

ROUND 1 – BRAINSTORMING

Please list at least 5 operational risks in industrial companies in KSA

O1: _____

O 2: _____

O 3: _____

O 4: _____

O 5: _____

other: _____

Please list at least 5 Health risks in industrial companies in KSA

H 1: _____

H 2: _____

H 3: _____

H 4: _____

H 5: _____

other: _____

Please list at least 5 financial risks in industrial companies in KSA

F 1: _____

F2: _____

F3: _____

F4: _____

F 5: _____

other: _____

Please list at least 5 Strategic risks in industrial companies in KSA

S 1:

S2:

S3:

S4:

S5:

other:

Please list at least 5 compliance risks in industrial companies in KSA

C 1:

C:

C3:

C4:

C 5:

other:

Please list at least 5 risk mitigation strategies in industrial companies in KSA

C 1:

C:

C3:

C4: _____

C 5: _____

other: _____

DELPHI QUESTIONNAIRE – ROUND 2

Research topic: **Impact of Risk management strategies on performance of Industrial Companies: "Sankyu Company as Case Study"**

Researcher: **Othman Algarni**

Abdullah Adel Jumei

ROUND 2 – Risk Assessment

Thank you for completing your Round 1 Delphi questionnaire.

In Round 2 Delphi we will review the results of Round 1 Delphi and attempt to assess the risk identified but they were asked to evaluate it through a risk index that was adopted by giving each risk two degrees, one of which expresses the severity of the risk and the second expresses the severity of the recurrence of the risk according to their personal opinion. They are arranged from number 1 to number 5, where number 1 represents the least influential or least recurring value, while number 5 represents the most influential or most intense value. Then the degree of risk is calculated for each respondent by multiplying the degree of recurrence by the degree of severity of the impact. For example :

The severity impact =3

The probability impact =2

Risk index = The severity impact* The probability impact

Risk index=3*2=6

. Kindly return the completed questionnaire within 7 days of receiving the questionnaire.

Many thanks in advance for your time and contribution. If you have any questions about the research, please do not hesitate to contact the undersigned.

Kind regards,

Othman Algarni

Abdullah Adel Jumeih

Round 1 Delphi Results

In Round 1 Delphi, the participants identified a number potential risks classified into five categories. These risk a correlate well with existing literature and research and are listed below.

Table 1 operational risks in industrial companies in KSA

CODE	Round Two of Delphi Technique	Risk Assessment	
		probability	severity
O1	Loss of IT system personnel		
O2	Failure equipment		
O3	Lack of skilled maintenance team		
O4	Operational errors such as incorrectly set-up of machines or mixing of materials.		
O5	Inadequate supervision		
O6	Cyber attacks that may disrupt operational systems		
O7	Product spillage.		
O8	Emission of Fumes and Smoke.		
O9	Scaffolding collapse.		
O10	Electrical shock		

O11	Fire accidents		
O12	loss of raw materials		
O13	High leak of pressure.		
O14	Lack of energy sources		
O15	Damage Production/Process lines and pipes.		

Table 2 health risks in industrial companies in KSA

CODE	Round Two of Delphi Technique	Risk Assessment	
		probability	severity
H1	Continuous exposure to high levels of noise		
H2	Exposure to continuous vibrations		
H3	Weak and Strong lighting		
H4	Exposure to radiation		
H5	Exposure to harmful chemicals		
H6	Exposure to toxic vapors and gases		
H7	Working in high temperatures can lead to heat stress, heat stroke, and dehydration.		
H8	Working in extremely cold environments can cause hypothermia, frostbite, and circulatory problems.		
H9	Lifting heavy loads or performing repetitive movements can cause muscle and joint stress and injuries		
H10	Working in uncomfortable positions or using inappropriate tools		

Table 3 financial risks in industrial companies in KSA

CODE	
------	--

	Round Two of Delphi Technique	Risk Assessment	
		probability	severity
F1	Raw material price fluctuations		
F2	Failure to keep up with technology		
F3	Faults in fabricating processes		
F4	Energy cost		
F5	Overstocking or understocking		
F6	Supply chain disruption		
F7	Regular Maintenance Costs		
F8	Unexpected equipment breakdowns		
F9	Using old equipment		
F10	Delay in technical evaluation		
F11	Conflict information		
F12	Delay on paying to suppliers		
F13	Pricing exceeding internal estimates		
F14	Deteriorating standards of quality		
F15	Non-qualified manpower		

Table 4 strategic risks in industrial companies in KSA

CODE	
------	--

	Round Two of Delphi Technique	Risk Assessment	
		probability	severity
S1	Overexpansion in production without adequate market study		
S2	Disability to adequate to technology development		
S3	Concentrating on one product or market		
S4	Failure to achieve operational efficiency		
S5	Failure to manage the lifecycle of equipment		
S6	Failure to integrate maintenance plans with production schedules		
S7	Lack of technical skills and competencies in maintenance teams		
S8	Delay to send timesheet and leaves on time		
S9	Delay to provide the requested documents of (Office, accommodation)		
S10	Lack of support in emergencies		
S11	Request for unplanned resources		

Table 5 compliance risks in industrial companies in KSA

CODE	Round Two of Delphi Technique	Risk Assessment

		probability	severity
S1	Failure to comply with regulations related to gas emissions and water pollution		
S2	Improper management of industrial waste can cause legal liability.		
S3	Failure to comply with health and safety standards		
S4	Failure to obtain the necessary licenses		
S5	Failure to comply clients needs and expectation		
S6	Fail to implement ISO standards		
S7	lack of employees that follow the policy and labor law.		

Thank you for completing the Round 2 Delphi questionnaire.

Please return the completed questionnaire to the following address.

Othman Algarni

Abdullah Adel Jumei

