

Research Title

**Impact of Risk Management Techniques on the
Financial aspects during Petrochemical Project
Planning**

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Abstract

This study has been executed to investigate impact of risk management strategies on financial aspects in petrochemical companies. To achieve this goal, the study comprised three steps, the first step based on executing surveying study adopting survey questionnaire targeting experts, specialists and labor in the field of petrochemical industries. The questionnaire survey comprised risk evaluation that have been identified according to several categories: operational risks, human risks, maintenance risks and environmental risks adopting extensive literature review. Also, questionnaire investigated evaluation of risk mitigation strategies in petrochemical industries that comprise risk retention, risk control, risk prevention and risk transfer. After data collection, statistical analysis using mean, I.R.R and risk index have been conducted to analyze data. Also, linear regression analysis has been used to study impact of risk mitigation strategies on financial aspects of petrochemical projects. Next, data obtained from Sankyu company have been analyzed using Minitab software. Data obtained comprise percentage of cost maintenance during 12 months where cost control charts and capability analysis have been used to analyze Sankyu company data before and after risk mitigation strategies to ensure that the maintenance costs are in within limits. The final step addressed qualitative analysis using structured interviews with three experts to ensure and investigate the results obtained .The results could develop comprehensive guide comprise extensive potential risks in petrochemical industries in the field of operation ,maintenance , environment and human errors .Also, comprehensive risk mitigation strategies categorized into risk retention ,risk control, risk prevention and risk transfer have been established to process these potential risks. Results of regression analysis showed that the suggested risk mitigation strategies could significantly impact risks and reduce maintenance costs and enhance financial aspects of petrochemical projects. Also, control charts and capability process showed that the suggested risk mitigation strategies could maintain cost within accepted limits. Moreover, structures interviews affirmed and proved the outcomes obtained in quantitative method

Chapter one

1.1 Introduction:

The Kingdom of Saudi Arabia is considered one of the first countries to export petrochemical products, as it relies on the production of crude oil and then refining it and converting it into oil derivatives and petrochemical products. It reflects significantly an upstream industry in which it aims to produce petrochemical products such as crude oil and gas from natural reservoir – and based greatly on raw fuel exports. Nevertheless, since the launch of the Saudi Vision 2030, the Saudi country seeks to produce more products in petrochemical field (Saudi Vision, 2030). In the KSA, the Saudi government stands all responsibilities related to promoting and developing standards and regulation of the industry and suggest punishment of those who are not adhering to these regulations. This means, the Saudi government presents the prosecution, judge and jury relating to all aspects of regulations and rules in the petrochemical industry in KSA. (Aljohani,2021).

For several years, industrial enterprises in the petrochemical field have experienced changes toward enhancing operational effectivity. To achieve this objective, it requires project development execution, that are beneficial to these firms, in addition the public economic and result in social advantages. Planning development projects is a complicated operation that demands multi-purpose analysis, that should supply adequate information permitting decision making whether or not to execute a specific project.

These decisions consider the most challenges between all economic decisions. The attainment of benefits in dependent of planning requires planning to the future unexpected conditions of firm processes, identified by exterior and interior factors (Bijańska & Wodarski, 2014). These factors are often in exchanged dependency, in particular difficult owing to the industries of petrochemical, that is distinguished by the production operation complexity and the variety of technical and technological techniques. Up to now, there are not known techniques enable to identify precisely of future conditions under which such petrochemical companies will maintain and operate. The risk correlated is with a probability of not receiving scheduled advantages or incurring unintended damages can be termed as a danger).

Hussain, (2024) mentioned the risks related to the maintenance and operating plants and petrochemical equipment as the following:

-Health and Safety Risks (Hussain,2024)

Petrochemical plants handle huge amounts of flammable materials comprise gases and fluids. These materials can significantly flame due to specific conditions, result in fires or explosions. The destructed effects of such accidents require decisive control procedures, comprising suitable storage, processing, and monitoring of combustible substances.

encounter the toxic chemicals via inhalation, ingestion, or skin contact constitute a huge danger to mankind health. executing decisive exposure controls and personal protective tools is mandatory to minimize these dangers.

-Mechanical and Structural dangers comprise the following issues: (Hussain,2024)

Petrochemical plants based on advanced machines and equipment. if these machines were not maintained in proper manner, this will result in calamitous faults. Pressure vessels, for instance, may explode if they are exposed to factors exceed their design limits, emitting

hazardous materials into the eco-system. continuous detection and monitoring, maintenance, and obligation to safety codes and measures are crucial to avoid these accidents.

The safety of conduits and pipelines regimes is critical to prevent seepage and leaks of dangerous substances. Failures may be due to erosion, physical destruction, or design defects, resulting in ecological pollution and probable fire dangers. Efficient monitoring regimes, along with fast emergency plans, are necessary to manage these hazards.

-Environmental Risk (Hussain,2024)

The r from petrochemical plants releases gases and pollutants, comprising volatile organic compositions, so₂, and nitrogen oxides, may greatly pollute quality of air. Moreover, effluents pumped into water bodies may pollute water resources, impacting mankind health and watery life. Executing pollution control techniques and obligating to ecological legislations are crucial to minimize these effects.

-Mankind Factor and Operational dangers (Hussain,2024)

mankind faults consider a great hazard factor in petrochemical equipment processes. Faults in making decision, non-adherence with measures, or shortage of training can result in dangerous actions.

Planting Health and safety culture, regular training, and decisive obligation to operational measures can reduce these risks.

The Possibility for illegal access or deliberately damage constitutes a security danger to petrochemical plants.

Such actions can lead to dangerous substances emissions or creating of catastrophic accidents. Security procedures, comprising controlling, access controls, and emergency response plans, are crucial for safeguarding versus these risks.

Risk should be managed in specific in planning project stage to attain the expected advantages while droppings and damages are accurately controlled. The goal of this study is to provision risk-management model in planning stage that can be applied in the planning of petrochemical development project.

1.2 Problem Statement

Petrochemical industry considers one of the most leading fields in which it contributes to KSA's economic. The field also occupy a leading place compared to other countries of the Gulf Cooperation Council (GCC). GCC area provide approximately 16 % of the petrochemical outcomes in the world and the KSA alone generates almost % 60 percent of the GCC's whole petrochemical production. KSA occupy 11th largest petrochemicals provider in the world (Akhtar, & Asif, 2017).

Despite the great progress of Saudi petrochemical industries companies in the field of petrochemical industry, these petrochemical factories incur significant financial losses due to insufficient planning for projects related to the maintenance of machinery and equipment, unforeseen emergency circumstances that arise, and sudden malfunctions during the operation of the equipment, which causes delays in projects, which results in an increase in costs and poor production quality. Therefore, risk management during the development of a maintenance and operation plan for the production of petrochemical products is necessary to avoid any financial losses and obtain the best financial performance for the company.

1.3 Study Significance

This study is considered of great importance in the field of petrochemical industry management, especially in petrochemical equipment operation and maintenance projects. The importance of this study is that it aims to integrate risk management techniques in the stage of preparing the equipment maintenance and operation plan, which provides a plan that contributes to providing the applied side with foundations and principles to avoid any risks resulting from Maintenance of petrochemical equipment. This study is also unique in the academic field that integrates risk management during the planning of maintenance projects for petrochemical equipment and mechanisms in addition it can be considered as a basis for more research and improvements in this field.

1.4 Study Objective

The general goal of the study is to identify the impact of risk management techniques on financial project performance of projects in petrochemical industries in the field of operation and equipment maintenance. This general objective can be derived to the following sub-goals:

- 1- To evaluate the current, operation and maintenance plan in petrochemical company in KSA and determine the challenge and limitations.
- 2- To integrate risk management techniques at project planning stage in petrochemical companies.
- 3- To study the impact of risk retention on financial project performance in KSA.
- 4- To detect how risk avoidance influence on financial performance of the projects in KSA.
- 5- To investigate the impact of risk control on financial performance of projects in KSA.
- 6- To Assess the impact of risk transfer on the financial performance of projects in KSA.

1.5 Research Questions:

- 1- What are the risks that impacts on maintenance and operation equipment during planning stage in petrochemical industries?
- 2- To what extent does risk retention impact the project's financial performance in KSA?
- 3- What is the impact of risk prevention on performance the project's financial performance in KSA?
- 4- How does risk control impact the project's financial performance in KSA?
- 5- What is the impact of risk transfer practice on the project's financial performance in KSA?

1.6 Study Hypothesis

- 1- There are challenges and defects in petrochemical equipment maintenance plans that cause poor financial performance of the maintenance Equipment Projects
- 2- There is a need to integrate risk management techniques during the planning stage of equipment maintenance and operation
- 3- There is no statistically significant effect at a significance level of less than 0.05 for the risk retention technique on the project's financial performance.
- 4- There is no statistically significant effect at a significance level of less than 0.05 for risk prevention technology on the financial performance of the project.
- 5- There is no statistically significant effect at a significance level of less than 0.05 for the risk control technique on the financial performance of the project.
- 6- There is no statistically significant impact at a significance level of less than 0.05 for the risk transfer technique on the project's financial performance.

1.7 Study Scope

The boundaries of the study represent human, spatial and temporal boundaries

- 1- Spatial boundaries: The study will be limited to Sankyu Company for the maintenance and operation of petrochemical equipment
- 2- Time limits: The study will be conducted in the second semester of 2024
- 3- Human limitations: The study sample is limited to Sankyu employees in the field of manufacturing and maintenance

1.8 Dependent and Independent variables

Independent variables: retention risks, transfer risks, control risks and prevention risks

Dependent variables: project cost and petrochemical product quality

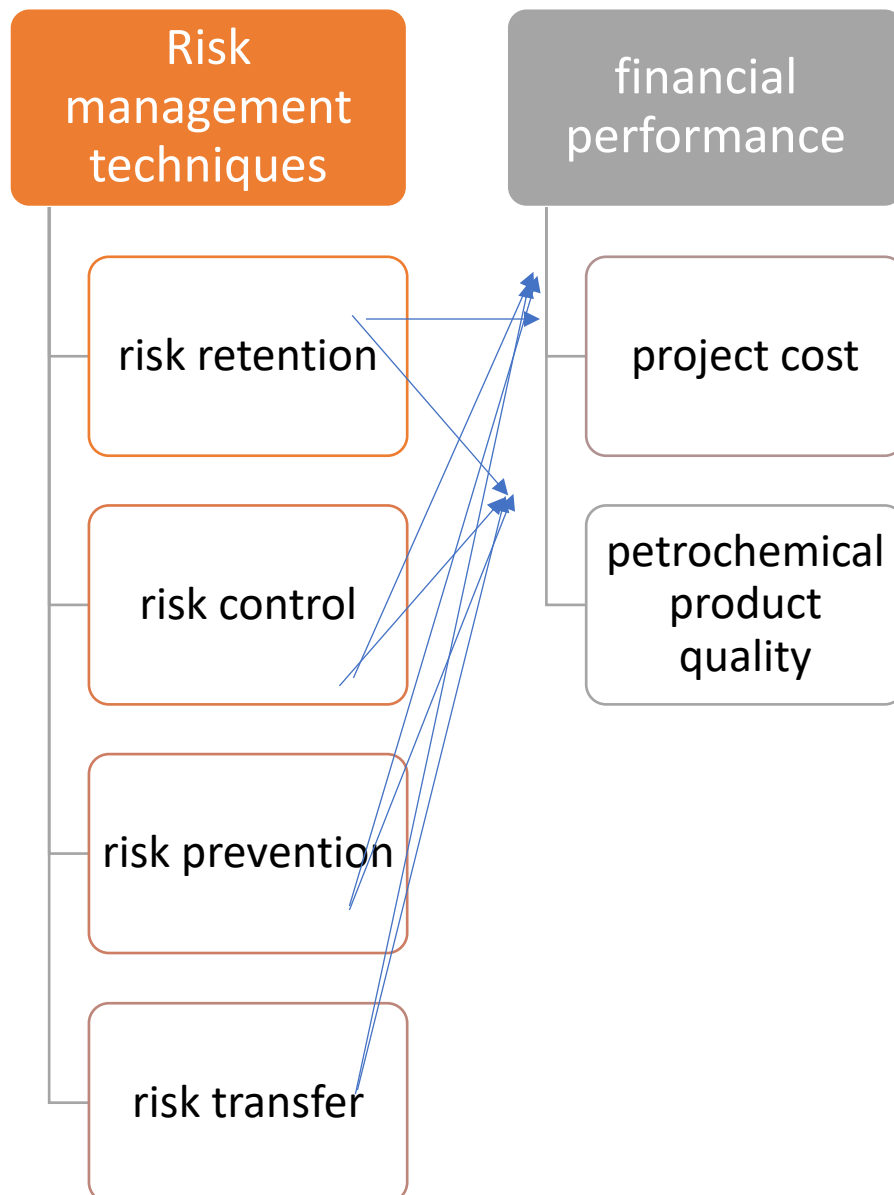


Figure 1.1 Dependent and in dependent variables

Chapter Two

Literature Review

2.1 Theoretical Framework

The theoretical framework of the study is based on mentioning all definitions and terms related to the study, including risk management, risk management techniques, and financial performance terms.

The study also includes a comprehensive literary review of all modern local, Arab and foreign studies that deal with risks related to petrochemical industry companies in the field of maintenance and operation of petrochemical equipment and mechanisms. The theoretical framework also includes a review of all risk management techniques related to the operation and maintenance of petrochemical plants and the most important theories adopted to study risk management. This framework also includes Theoretical covers the financial performance of companies and all financial aspects.

- In the fields of international engineering projects from a danger management view, Liu et al., (2017) presented a developed quantitative danger evaluation prototype to assist hazard directors to determine the immediate relationships among certain danger opportunities and decision variables of investment. Stress testing is also provided to evaluate the diverse influence of severe hazards. The novel model was used to an continues international petrochemical project to prove its application and verify its applicability and efficiency.

Kim et al., (2017) aimed to provide an analytical model that correlate the danger and cost of overseas plant construction projects and to improve a model tool for the risk and cost analysis in dependent on the prototype. Furthermore, a case study is executed utilizing this model to analyse its danger and cost. The major benefit of this research is as the following: 1) A model tool has been improved for an analysis that correlated the danger and cost 2) hazard factors have been studied for a case analysis element and their influence has been numerically assessed.

Murtaja & Al Wattar, (2016) carried out a study depends basically on extensive literature review executed from prior studies executed on Enterprise Risk Management. furthermore, a case-study was selected on the data supplied by a selected firm in the petrochemical companies in Qatar. The study found that risk management is a novel side to address and study within a firm, where most of the firms, where directors should analyze and predict each stage to manage and avoid failure probabilities.

Mollaalizadeh et al., (2021) directed a study concentrated on the seven crucial factors that presents principal impacts on the financial performance of the Persian Gulf Petrochemical firms.

surveying study based on 12 Experts and engineers of firms in Persian Gulf Petrochemical firm using sampling technique, in which 180 questionnaires have been applied. The confirmatory factor analysis (CFA) accepted the divergent validity of all favourable factors and comply to the survey. The nonparametric analysis illustrated the study's central assumption relating the efficiency of all under verification factors to comply the study objectives. By the Friedman ranking test, the interior operations and exterior environment of the firm provided the highest and the lowest rank of influence on the financial performance of the petrochemical firms.

2.2. Theoretical principles of the study

2.2.1 Enterprise Risk Management Theory

Nocco and Stulz (2006) defined Enterprise Risk Management (ERM) that is a theory of risk management motivators in order to suggest recommendations to measure and size of risk that can be noted encounter a given entity whole than the administer of each danger separately. It seeks basically is to integrate the hazard management silos in a company plan into one thorough framework. The ERM risk management guidance of administering danger confirms that senior firm executives and staff should actively be participate in hazard management process to analyze and respond to a comprehensive area of firm risks (Hallowell, Molenaar, & Fortunato, 2013). This principle motivates all the organization's members to be participated in the administer of dangers. Also, the ERM shed light on the significance of clear operation and regulations for administering dangers. Olson and Wu (2010) stated that the theory additionally confirms that if ten enterprises can adopt formal regulations that identify dangers appetite, strategic objectives, and structured operations then they can enhance their risk management ability of defining, analyzing, and handling of dangers. Moreover, the theory affirms on a developing of hazard management culture where all stakeholders are enabling and accountable to administer dangers. Cormican (2015) proposed that ERM practices involve increased competitive benefit, stakeholder confidence and sustainability of companies.

2.2.2 Risk Management Principle

Risk management (RM) is a principle that have become very common in several enterprises. Numerous firms often execute risk management in their projects to enhance financial performance and enhance profits in addition to enhance productivity (Ahmadi et al., 2017). Dangers and uncertainties consider of the most broadly utilized concepts in the literature of project management (Hopkinson, 2017; Qureshi et al., 2020)). Even though these definitions are significantly correlated, several writers characterize them (Lachapelle & Hundozi, 2018). It is also hard for labor at danger to determine and distinguish them. Risk management received great attention, as it considered as a technique to enhance cost, schedule, and technical performance of novel product improvement plans (Aven, 2016). Uncertainty is one of the most significant danger factors in projects that are as a random action of an action where the possibility is actually unknown, that means that the uncertainty is owing to the occurrence of a little-known event, except that it may occur. (Bazin, 2017). Nevertheless, it should be affirmed that risk management is not only an instrument that guarantee success but rather an instrument that assists to enhance the possibility of attaining success (Ahmadi et al., 2017).

2.3 Risk Management Techniques

2.3.1 Risk Identification

Risk identification is important as it impacts the sequences steps of the organization's work (Petrovic 2017). Similarly, strategies should be improved that can define dangers to expect the probabilities of their occurrence, similarly to several strategies suitable for handling with hazards as soon as explored (Potts and Ankrah 2008). Mhetre et al. (2016) thinks that it can display the hazards that a firm was priorly subjected to, ranked by its demands, from the most serious to the least serious, that assists the firm's personnel with knowing these hazards and simplifying their identification.

Potts and Ankrah (2008) emphasized that this operation is the most important in risk management and has measures and methods for collecting information and executing an exact database to gain the best outcomes. Numerous approaches for defining dangers comprise brainstorming, holding workshops, analyzing scenarios, analyzing historical data, analyzing

action plans (Klemetti 2006), and interviewing experts, that is the most useful method (Steyn 2018).

2.3.2 Risk Assessment

Saeidi et al. (2019) identified risk evaluation as “allowing a company to take into account the influence and probability of events and analyze danger utilizing quantitative and qualitative methods. It investigates the positive and adverse impacts of possible events all over the company. So, the second phase is the major strategy to investigate for analyzing and assessing dangers. Consequently, this operation aims to rank hazards (Rovins et al. 2015). Risk assessment is a high risk, and it should demand the management to run efficient tools to address efficiently these hazards. In addition, low risk should not be neglected, while, the quantity of control should be lower than for high dangers (Serpell et al. 2015).”

A—Qualitative method: It based on the utilization of interviews, brainstorming, the Delphi method, and checklists, the probability and impact of hazards can be used adversely or positively to a firm’s objective and expected results (Banaitiene and Banaitis 2012). One of the qualitative methods for evaluation is a “risk matrix”, as illustrated in Figure 1, that can be based on to make a decision the “possibility of danger” (Serraino 2014), in which the hazards are categorized into three levels: high danger, medium danger, and low danger (Petrovic 2017)

		Impact →				
		Negligible	Minor	Moderate	Significant	Severe
Likelihood ↑	Very Likely	Low Med	Medium	Med Hi	High	High
	Likely	Low	Low Med	Medium	Med Hi	High
	Possible	Low	Low Med	Medium	Med Hi	Med Hi
	Unlikely	Low	Low Med	Low Med	Medium	Med Hi
	Very Unlikely	Low	Low	Low Med	Medium	Medium

Figure 2.1 Risk Matrix

Quantitative method is considered more unbiased than qualitative techniques. The quantitative method based on data to determine the level of impact of each danger (low, medium, or high) and the possibility of its occurrence, which is why it is an important operation to decide the level of impact of a hazard on the firm (Serpell et al. 2015).

2.3.3 Risk Response

It is the operation of defining the essential measures to reduce the negative effects of dangers on the performance of firms and avail the chances that improve their success. Alhassan (2016) pointed that it determines dangers via the optimal utilize of resources and activities in the cost. several techniques can be run to mitigate the possibility of risk severity and the impact of dangers.

According to Petrovic (2017), there are 4 techniques to respond risk: (1) avoiding dangers by efficiently handling with the cause, (2) mitigating the risks by reducing the cost of risk via

using of emerging technology, (3) accepting the dangers, and (4) handling with dangers efficiently by planning an emergency case.

Figure 2 assists to make decision for the response to the possibility and impact of the risk based on two factors, the possibility of the danger and the danger effect, and the actions could be as follows:

- Avoid the risk; -Mitigate the risk.
- Transfer the risk; -Accept the risk.

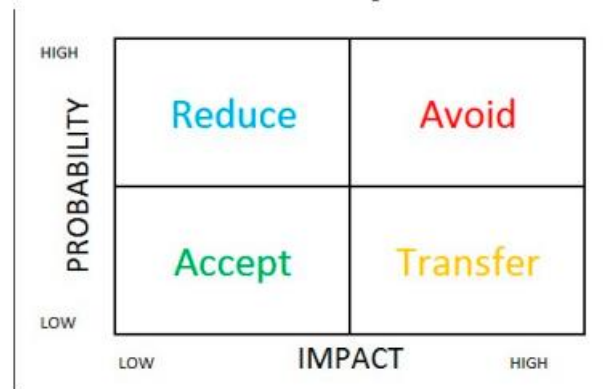


Figure 2. 2 selecting risk reactions from kinds of risk control procedures

2.3.4 Risk Monitoring

PMI (2017) stated that risk monitoring and control is the “operation of tracking defined dangers, defining and analyzing novel dangers, monitoring the execution of risk reaction plans, and evaluating the efficient of risk management operations during a project life cycle”.

2.4 Previous Studies:

Numerous studies in the field of study the impact of risk management on project performance have been executed:

-Winarto & Chariri, (2022) carried out research to analyze the impact of company risk management on financial performance of the company. Those factors comprise danger committee, risk map, COSO and ISO guide.

This research is conducted using quantitative method. the study based on secondary data to gather via annual report, Bloomberg Finance Laboratories and IDX website utilizing purposive sampling method. The sample population targeted in this study industrial firms which were 74 firm. The gained data then were detected by utilizing regression analysis. The outcomes of the research point the results show that ISO framework positively impact the company financial performance

- (Alsaadi & Norhayatizakuan,2021) aimed to execute risk management in construction sector to guarantee to deliver the construction with high quality on time and within specific cost. and the study showed that integrating risk management enhance the construction project performance greatly and the study recommended to employ project managers who has adequate experience in risk management and its major schedules.

- Butt et al., (2021) conducted study to prove that structured risk management technique via planning phase of the project is the optimal method. The study adopted quantitative technique. The study has successfully attained its goal to define the influence of risk definition.

the study showed that there is robust positive correlation between risk identification and performance of the project.

-Bijańska, J., & Wodarski, K. (2014) executed a study to provide risk management model it used during the development project planning of industrial companies. The model comprises techniques of risk definition, measurement and assessment of danger. The model was generated based on several years of study of the challenges of planning and assessment of the efficiency and hazards of the development projects execution in industrial firms.

- Ebrahimia et al.,(2012) carried out research to initiate a public framework to analyze risk management regulations of a company in petrochemical industries. It was noted that in the case that exterior resources or financial sources are higher costly to the projects comparing to interior financial how project decision makers should be ensured to have benefit of attractive interior investment probabilities. The significant note is not only to prevent dangers, but to identify the hazards computed by defining and administering them efficiently. Using efficient risk management framework, has assisted the making decisions in this project to utilize interior financing and consequently make them to change their supply chain management plan in a more efficient manner. It has been revealed that how the efficient risk management framework assisted them to change their suppliers to minimize their budget.

Savchina et al., (2021) aimed of this study is to analyse the financial condition, evaluate the prospects for development and enhance the activity of one of the highest systemically significant companies of the petrochemical manufacture in Russia - PJSC "SIBUR Holding". To execute the study, the authors have gathered financial information from the reports of financial outcomes and the budget sheets of the firm. They have chosen the key performance indices and solvency indices in specific, liquidity, profitability, solvency. the factors related to financial dangers were the impacting the probabilities for business expansion. Econometric modelling techniques were applied to identify the firm's development possibilities that are based on the interior regulation of cash flow management. study findings propose that the continuous cash flow, namely, the constitution of a regulation to manage accounts payable in the crisis, has a great influence on the further of the firm development.

Regarding the study of potential risks that industrial companies may face, all potential risks were reviewed through the latest previous studies in this regard. These risks were divided into several categories, namely: operational risks (Table 2.1), human risks (Table 2.2), maintenance risks (Table 2.3), and environmental risks (Table 2.4)

Table 2.1 presents overview of the operational risks in petrochemical companies that researcher and academics have been addressed in their studied.

Table 2.1 overview of the operational risks in petrochemical companies

Symbol	Operational Risk	Authors
O1	Chemical concentration inside vessel due to cleaning result in O2 deficiency	(Bahadori et al.,2014), (Ancione et al.,2020), (Vinnem & Røed,2015), (Bahadori,2020), (Groysman,2017), (Loganathan et al.,2018),
O2	Crane Lifting faults that cause deterioration in Production lines and pipes.	

O3	Crane Lifting faults that cause Falling lifted object.	(ABESI, 2017), (Μοσχογιάννη, 2023), (Jarvis, R., & Goddard,2017), (Boulamanti & Moya, 2017), (Ruqaishi, M., & Bashir, 2015), (Moktadir et aal.,2018), (Ahmad et al.,2016)
O4	Oil escape from equipment during service.	
O5	Production, storage and disposal of general waste result in pollution and fire	
O6	Corrosion in natural gas systems	
O7	Gasket damage/worn out result in Leakage of service fluid	
O8	failure of valve lead to fluid leakage, Increased gland packing wear and tear, Service fluid loss and fire hazard, Inconsistent process output	
O9	tube failure led to Intermixing of service fluid, Low flow, Loss of heat transfer	
O10	Lack of equipment	
O11	Equipment operating errors	
O12	energy waste	
O13	Delays of material supply	
O14	Lack of proper suppliers	
O15	Lack of supply chain management	

Table 2.2 presents overview of the Human risks in petrochemical companies that researcher and academics have been addressed in their studied.

Table 2.2 overview of the Human risks in petrochemical companies

Symbol	Human Risk	Authors
H1	Lack of skilled maintenance staff	(Zahiri et al.,2020), (Kangavari et al.,2015), (Morag et al.,2018), (Sweis et al.,2019), (Raut et al.,2017)
H2	Lack of skilled labor to operate plant, equipment and machines	
H3	Lack of supplying information	
H4	Lack of regular checks for machines and plants	

H5	Lack of communication result in shortage in inaccurate maintenance	
H6	Delay to make decision for maintenance processes	
H7	Poor knowledge of the original design of the equipment by the maintenance team	
H8	Lack of managerial processes	
H9	Lack of knowledge of operating machines and plants	
H10	Insufficient training	

Table 2.3 presents overview of maintenance risks in petrochemical companies that researcher and academics have been addressed in their studied.

Table 2.3 overview of the maintenance risks in petrochemical companies

Symbol	maintenance Risk	Authors
M1	Release Chemicals hazardous material into atmosphere as a result of Pipe lines Modification	(Bouafia et al.,2020), (Jafarinejad & Jiang,2019), (El-Borhamy et al.,2022), (Qi et al.,2024), (Narayanan et al.,2023), (Ekefre et al.,2024), (Jung et al.,2020), (Khahro et al.,2023), (Saloua et al.,2019), (Chen et al.,2019), (Duma et al.,2021), (Yolchuyeva et al.,2020),
M2	Filter Cleaning & Replacement result in Product spillage	
M3	Filter Cleaning & Replacement lead to Chemical powder inhalation.	
M4	Pump Strainer Cleaning result in Product splash	
M5	Reactor Cleaning & Inspection can lead to Fire & Explosion	
M6	Reactor Cleaning & Inspection can lead to lead to Emission of Fumes and Smoke.	
M7	Scaffolding collapse	
M8	Reactor Cleaning & Inspection can lead to lead to release hazardous material into atmosphere	
M9	Flying of welding Flash.	

M10	Valve Replacement led to Release Chemicals into atmosphere.	
M11	Electrocution	
M12	Fire & Explosion.	
M13	Exposing Ultraviolet or IR.	

Table 2.4 presents overview of environmental risks in petrochemical companies that researcher and academics have been addressed in their studied.

Table 2.4 overview of the environmental risks in petrochemical companies

Symbol	Compliance Risk	Authors
E1	Rain	(Rostami& Rahimpour,2023), (Rahmatmand et al.,2023), (Motahari et al.,2015), (Ragothaman & Anderson, 2017), (Hassani et al.,2017), (Ciucci et al.,2023)
E2	High temperature	
E3	storm	
E4	Wind speed	
E5	Earthquakes	
E6	Fire	

Regarding the study of risk management strategies that industrial companies to mitigate risks, all risk mitigation strategies were reviewed via the latest previous studies in this regard. These risks were divided into several categories, namely: risk retention (Table 2.5), risk control (Table 2.6), risk prevention (Table 2.7), and risk transfer (Table 2.8)

Table 2.5 presents overview of the risk retention in petrochemical companies that researcher and academics have been addressed in their studied.

Table 2.5 overview of the risk retention in petrochemical companies

Symbol	Risk Retention	Authors
RR1	Waste shall be stored securely	(Al Attar et al.,2015), (Li et al.,2019), (Hassani et sl.,2017), (Li,2016), (George et al.,2016), (Akbarpour et al.,2020), (Negara et al.,2021), (El-Sherif et al.,2016),
RR2	Minimize the consumption of natural resources	
RR3	Operation and maintenance as per manufacturer's instructions	

RR4	Introducing new technology	(Kangavari et al.,2016), (Huang et al.,2016), (Kozhemyatov & Bulauka,2019)
RR5	Training and awareness Programs.	
RR6	Ensure following company rules	
RR7	Regular intervals workshop and program shall be organized	
RR8	Proper grounding.	
RR9	Management consider and calculate risk management during the initial project planning	
RR10	Equipment High Temperature Detection and using Cooling System	
RR11	Control Fatigue Gas Detection, Oil Detection, Overpressure Detection	

Table 2.6 presents overview of risk control in petrochemical companies that researcher and academics have been addressed in their studied.

Table 2.6 overview of the risk control in petrochemical companies

Symbol	Risk control	Authors
RC1	Regular monitoring & checking for the leakage.	(Shu et al.,2017), (Bahadori, 2020), (Clancy et al.,2018), (DeRosa & Allen,2015), (Hosseinnia et al.,2021), (Van et al.,2017), (Al-Shatti et al.,2021), (Gholami et al.,2015), (Groysman, 2017), (Dong & Chen, 2016), (Jaderi et al.,2019)
RC2	Regular monitoring & checking that waste is disposed as per the requirements.	
RC3	Any spilled must be cleaned as soon as possible using an appropriate procedure/instruction.	
RC4	Commercial regular follow up with suppliers.	
RC5	Proper communication channel	
RC6	implement follow-up system	
RC7	Conduct regular checks, inspect sites with QHSE Patrols and regular audit.	
RC8	Management to be updated as and when required and continuous communication	

RC9	Quality checking of service fluids at laboratory	
RC10	Management & employees are involved in periodic review and risk management planning exercise to monitor, identify and manage risks	
RC11	The management use specific risk management tools to control and manage risk	
RC12	Control Corrosion via Shock and Vibration absorber	
RC13	Limit hydrocarbon leak Dike	
RC14	Toxic Air Control	

Table 2.7 presents overview of risk prevention in petrochemical companies that researcher and academics have been addressed in their studied.

Table 2.7 overview of the risk prevention in petrochemical companies

Symbol	Risk prevention	Authors
RP1	Safe handling techniques shall be employed	(Hosseinnia et al.,2021), (Van et al.,2017), (Chineke et al.,2016), (Groysman, 2017), (Kangavari et al.,2016), (AW & oMAr Mk, 2015), (Balkhyour et al.,2019), (Andreeva et al.,2018)
RP2	Personal Protective Equipment Insurance	
RP3	Frequent review of client needs and strategy	
RP4	Ensure Scaffold or Platform are safe.	
RP5	Use Electrical Rated Gloves.	
RP6	Trained in Work at Height	
RP7	Cartridge Respirator must be use.	
RP8	Standby firefighting equipment.	
RP9	Prevent Temperature Rise High by Temperature Detection and Process Shutdown	
RP10	Prevent Internal Overpressure via Overpressure Detection, Process Shutdown, Clogging Detection	

RP11	Prevent Presence of Oxygen Detection via Oxygen Remover, Process Shutdown	
RP12	Prevent Vibrating Resonance Effect via Shock and Vibration absorber	
RP13	Prevent Ignition Source Isolation, Emergency Shutdown Initiation, Electrical Isolation	

Table 2.8 presents overview of risk prevention in petrochemical companies that researcher and academics have been addressed in their studied.

Table 2.8 overview of the risk transfer in petrochemical companies

Symbol	Risk Transfer	Author
RT1	Suppliers' performance evaluation	(Tong et al.,2020), (Yin et al.,2021), (Chin et al.,2020), (Qin et al.,2020), (Zhang et al.,2015), (Wanasinghe et al.,2020), (Wu et al.,2018), (Filatova et al.,2021), (Wirjo & Pasadilla, 2016).
RT2	Mechanize processes and build improvements	
RT3	Skilled & certify people allow to work only	
RT4	Detect Crack Propagation Inspection and Maintenance	
RT5	Equipment Insurance	
RT6	Machinery Breakdown Insurance	
RT7	periodic maintenance contracts with specialized companies	
RT8	Purchasing Extended warranties from equipment manufacturers	
RT9	Partnerships with specialized maintenance companies	
RT10	Using smart monitoring systems to continuously track equipment performance	
RT11	Using asset management systems to track equipment status	

RT12	hiring leases instead of outright purchase of equipment	
RT13	Develop comprehensive contingency plans to address any major breakdowns	

Chapter Three

Research Methodology

3.1 Introduction

This chapter includes the study approach that addresses qualitative and quantitative method. Quantitative method based on developing survey questionnaire to evaluate the potential risks in petrochemical projects in addition to evaluate risk mitigation strategies suggested to reduce risks in petrochemical projects. Moreover, this chapter explains the method of implementing control process and capability analysis adopted in this study. Also, this chapter describes the qualitative approach using structured interviews that used to ensure quantitative results of the study.

3.2 Quantitative Survey

Based on the literature review that conducted to design questionnaire regarding to risk potential in petrochemical industries and risk mitigation strategies, a quantitative approach will be considered in this research to investigate impact of risk mitigation strategies on financial aspects in petrochemical projects. The design of questionnaire based in three sections, the first section comprises demographic information while the second section of questionnaire includes potential risks categorized into operational risks, human risks, maintenance risks and environmental risks while the third section of questionnaire comprise risk mitigation strategies in terms of retention risks, control risks

Questionnaire survey will be designed on google form and the questionnaire link then will be distributed to sample size online by e-mail, WhatsApp and other social media.

3.2.1 Measurement Development:

The scale had been selected to evaluate the potential risks and risk mitigation strategies based on the level of significance. To do this, ordinal scale has been adopted, with integers for this scale, additionally to utilize Likert scale to estimate the risks and strategies and their level of significance (Babatunde, 2021):

$$\text{Statistical significance levels} = \frac{\text{Max value} - \text{Min.value}}{\text{Max.value}} \quad (3.1)$$

$$\text{Statistical significance levels} = \frac{5-1}{5} = 0.8$$

The table (3.1) display a significance level that researcher used.

Table 3.1: Significance Levels.

Level	Interval of Mean	Description
1	1-1.8	Strongly disagree
2	1.81-2.6	Disagree
3	2.61-3.4	Neutral
4	3.41-4.2	Agree
5	4.21-5	Strongly agree

3.2.2. Questionnaire Design

The survey questionnaire had been set and utilized as a survey technique to gain precise outcomes, and the target respondents was the experts, professionals, personnel in Sankyu company for maintenance and operating petrochemical plants and the findings were assessed utilizing the Five Likert level.

The questionnaire based on various resources sources, comprising literature review of recent researches and studies related to relevant topic, additionally, the questionnaire had been distributed as an open questionnaire to a numerous experts and professionals in risk management of petrochemical projects to determine and define the potential risks and mitigation strategies and to evaluate the questionnaire.

Two major elements of the questionnaire were affirmed:

A. Questionnaire Reliability:

The questionnaire reliability is an instrument used as a criterion that indicates to the stability and consistency of the questionnaire for which the analysis will be executed via data analysis the outcomes of the several samples. the reliability of the questionnaire can be reduced if deviation is noted owing to the respondents. The evaluation operation is executed via empirical methods, after which the reliability of the questionnaire is computed in dependent on alpha coefficient (Babatunde, 2021).

A. Questionnaire Validity:

the questionnaire validity depends on identifying the quantity of mistake in the questionnaire's formulation and composition, where the validity and precise of the questionnaire is affirmed by showing it to an experience committee to execute a precise review of the questionnaire's content and composition to modify, delete or add according to their opinions (babatunde, 2021).

3.2.3 Sampling Techniques

The procedure of choosing the sample size is one of the essential procedures for its function in prevent wasting time. The sample of the study comprise sample size of Sankyu company staff which joins a group of experts, personnel, professionals in petrochemical industries. The number of sample population in this company in the field on operation and maintenance plants and machines is approximately (268).

The following Stephen Thomson formula (2) was utilized to calculate a sample size

$$n = \frac{N \times p \times (1-p)}{(N-1) \times \frac{d^2}{Z^2} + p \times (1-p)} \quad (3.2)$$

Where:

n= sample size

N= population size

d= standard error of the sampling distribution (0.05)

p: population proportion

Z= Standard score corresponding to the significance level (0.95), which is equal to (1.96)

The value of the recommendation (p) is 0.5 if the p-value is unknown depending on a large sample size is obtained as needed. In this study, the researcher used a confidence score of 95%, and a significance of 5%.

The sample size of the population was calculated as follows:

Population (N) are engineers of various disciplines, contractors and workers in the construction sector, N =268

$$n = \frac{268 \times 0.5 \times (1 - 0.5)}{268 \times \frac{0.05^2}{1.96^2} + 0.5 \times (1 - 0.5)} \approx 159$$

3.3 Statistical Analysis

After collecting and extracting data, the data should be analysed using statistical methods and the findings will be gained using SPSS software

3.3.1 Cronbach's Coefficient Alpha

It is used to measure internal consistency, to know the degree of reliability of a test. Each axis is compared with the average of all questionnaire axes, the relationship between the number of test items and the average correlation between these items (Sheetal et al., 2016). The value of Cronbach's alpha coefficient is calculated by equation (3): (Sheetal et al., 2016).

$$\text{Cronbach's alpha } \alpha = \frac{N.C}{V+(N-1).C} \quad (3.3)$$

Where:

N = the number of items

C = the average inter-item variance between items

V = the average variance of all items

3.3.2 Relative Importance Index (RII)

RII analysis determines the most influential criteria or factors depends on respondents' answers. Based on the rated Likert scale, RII contributes to arrange factors or items (Rooshdi, 2018). The relative importance index (RII) technique was used to rank the potential and important risks in

petrochemical companies and most important risk mitigation strategies. The RII values ranges from 0 to 1 (Karim, et al., 2020). An RII value is accepted if the achieved value higher than 0.6 that complies to the significance standard determined in Table 3.2 (Akadiri, 2011). The answers of questions were outlined with a Likert scale varies from 1 to 5.

Table 3.1:RII Value.

RII values	Importance Level	
$0.8 \leq RII \leq 1$	High	H
$0.6 \leq RII < 0.8$	High-Medium	H-M
$0.4 \leq RII < 0.6$	Medium	M
$0.2 \leq RII \leq 0.4$	Medium-Low	M-L
$0 \leq RII \leq 0.2$	Low	L

The relative importance index was calculated as:

$$RII = \frac{\sum W}{A \times N} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5 * N} \quad (3.4)$$

were

W = the weight regarded to each item by the respondents

A = the largest weight

N = the total respondent's number

n_i = frequency

3.3.2 Correlation Coefficient Test

The correlation test adopts on identifying how of the relationship between two variables is strong whose value varies from 1 to -1. It contains two variables (x, y), where the variable (x) is identified by the researcher who will execute the research and is named the independent variable, whereas the variable (y) is named the dependent variable and it is considered as a function of independent variable since the outcomes of this variable is unknown and depends on the values of the independent variable (x). Correlation Types:

- Positive Correlation: It is a relationship between two variables (X, Y) where if one of the variables varies, the other variable will follow it in the same direction.
- Negative Correlation: It is a relationship between two variables (X, Y), where if one of the variables varies, the other variable will follow it in the versus orientation.

3.3.3 Linear Regression Analysis

Regression analysis is used to study the relationship between dependent variable and independent variables. Regression coefficient is calculated in the regression analysis and presents how the dependent variable is as a function of independent variable and regression analysis is expresses by the following formula:(Sarstedt et al.,2019)

$$Y=\beta x.....eq (3.5)$$

X: independent variable

Y: dependent variable

3.3.4 Control chart

The control chart is utilized to guarantee and enhance quality via statistical tools. Control chart I-MR type is apply for continuous data. However, in this study the individuals and moving-range (I-MR) chart is concerned. The I-MR chart is used for time dependent processes of continuous data and plots individual values on the I-chart (Elisson,2017).

3.3.5 Capability analysis

Process capability refers to outline how well a process produces parts in relation to given specifications (LSL and USL), process capability indices (PCI's) are utilized. The process capability, C_p and C_{pk} , outlines capability in relation to the evaluated standard deviation $\sigma\hat{c}$, that is dependent on the average moving range. In order to achieve quality, C_{pk} value should be higher than 1.67(Elisson,2017)

3.4 Qualitative Interviews

the quantitative results obtained the first step will be proves depends on qualitative approach using structured interviews with three experts in petrochemical industries in the field of maintenance and operating plants. The goal is to detect their views on the best strategies to reduce cost and enhance operative efficiency of the petrochemical plants and machines. The interviews will comprise into their practical's, risks encountered, and advices for efficient risk mitigation plan. This qualitative analysis will integrate the quantitative outcomes, offering a thorough knowledge of risk mitigation strategies in petrochemical industries The Interview phase will be conducted with experts as face-to-face interview.

Chapter Four

Results and Discussion

4.1 Introduction

This chapter discuss results of survey questionnaire to evaluate risks impact on petrochemical industries additionally evaluating risk mitigation strategies reviewed in the literature. Also, this chapter provides results of control charts and capability analysis of maintenance cost percentage before and after applying risk mitigation strategies in Sankyu company. Moreover, this chapter discusses results of regression analysis to investigate impact of risk mitigation strategies on financial aspects in petrochemical projects. Finally, qualitative analysis had been executed using structured interviews with experts to investigate questionnaire results.

4.2 Demographic information

In order to ensure that the respondents answered the questionnaire have adequate skills to answer the questionnaire, demographic information have been investigated in the following sub-sections.

4.2.1 Scientific qualification

Respondents were asked of the scientific qualification that contains options: 1.PHD 2.Master degree 3.Diploma 4. Bachelor 5.other.

The results were obtained as a forms of pie chart illustrated in Figure 4.1 shows the percentage value of respondent's answers obtained

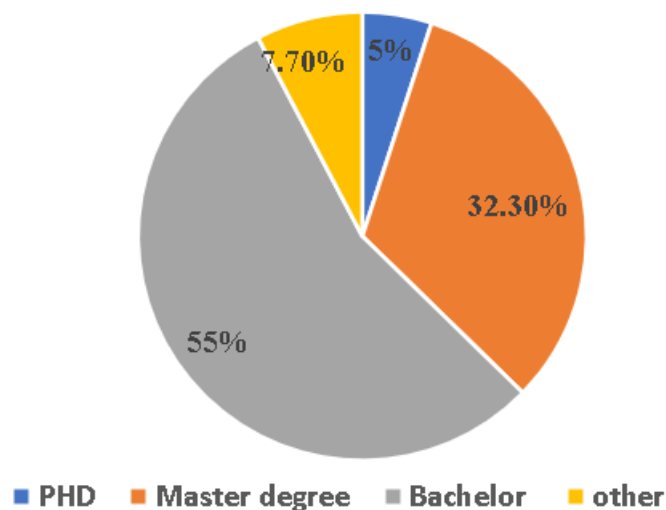


Figure 4.1 Scientific qualification of Respondents

It can be noted the as for the scientific qualification of respondents, respondents are qualified enough to answer the question where the highest percentage with 55% related to Bachelor in addition 33.3% of respondents have a Master degree. In addition, 5% of respondents are of PHD holders.

4.2.2 Years experience

Respondents were asked years of experience in petrochemical industries. This indicates to respondents' skills to answer the questionnaire. Figure 4.2 expresses how extents of respondents in petrochemical industries.

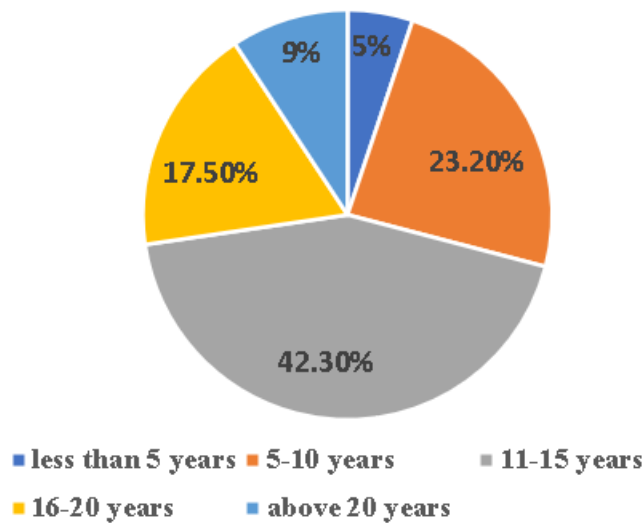


Figure 4.2 Respondent's Experience

Figure 4.2 reveals that majority of respondents who have 11-15 years' experience with percentage 42.3%. Also, 28.3% have experience ranges from five years to 10 years. In addition, 17.5% of respondents have experience 17.5%. It was noted that respondents with low experience got the lowest percentage 5% only.

Demographic information of respondents obtained reveal that respondents are qualified enough for the surveying study in this research.

4.3 Reliability Analysis

The test that utilized to guarantee reliability of statistical analysis is consistency of statistical tests, is Cronbach's alpha coefficient (α) that express the level to which a group of questions or statements is correlated together as a coherent group.

The criteria used to judge whether Cronbach's alpha coefficient is accepted for questions that have selections to answer, or questions based on Likert measurement (McClave et al, 2014)

- i. The scale is excellent $\longrightarrow \alpha > 0.9$.
- ii. The scale is good $\longrightarrow (0.8 < \alpha < 0.9)$
- iii. The scale is accepted $\longrightarrow (0.7 < \alpha < 0.8)$
- iv. The scale is questionable $\longrightarrow (0.6 < \alpha < 0.7)$
- v. The scale is weak $\longrightarrow (0.5 < \alpha < 0.6)$
- vi. If the scale is lower than 0.5 the measurement can't be accepted.

The outcomes in Table 4.5 according to reliability analysis demonstrates that the value of (α) coefficient varies from (0.966 to 0.981), that refers that it is significantly trust and credible to compared to criteria mentioned above that suggest that the accepted α value should be higher than 0.7. Table (4.1) shows (α) coefficient values in accordance to each section of surveying study.

Table 4.1: Reliability analysis findings for the developed sections.

Section Designation	(α)
Risks (probability)	0.97
Risks (severity)	0.966
Strategies	0.967
Effectiveness Risk Management Strategies	0.981

Also, reliability analysis was conducted to achieve consistency for all statements of questionnaire and the value of alpha coefficient is illustrated in Table 4.2.

Table 4.2: Reliability Test.

(α)	N of Items
0.97	102

Table 4.2 shows that reliability coefficient for all items of the survey questionnaire displays high value reach to 0.97 that is considered excellent according to the criteria mentioned.

4.4 Internal Consistency

To extract the implications of the construct validity of the scale, the correlation coefficients were extracted for each item its association with the section to which it belongs. This step was executed adopting calculating the Pearson correlation coefficient computations for each item with relevant section, and this is illustrated in Table 4.3, Table 4.4, Table 4.5, Table 4.6, Table 4.7, Table 4.8, Table 4.9, Table 4.10, Table 4.11.

Table 4.3: Results of Pearson Correlation between operational risk items and average of Total operational risks.

No.	Pearson Coefficient	sig(2-tailed)
O1	.806**	0.001
O2	.852**	0.001
O3	.854**	0.001
O4	.850**	0.001
O5	.814**	0.001
O6	.863**	0.001
O7	.812**	0.001
O8	.843**	0.001
O9	.841**	0.001
O10	.866**	0.001
O11	.846**	0.001
O12	.782**	0.001
O13	.713**	0.001
O14	.780**	0.001
O15	.738**	0.001

Table 4.3 shows that all items of operational risks will be included since correlation coefficients of operational risks items were deemed acceptable and statistically significant.

In addition, Table 4.3 clarifies an obvious internal consistency between the operational risk items, in which values the correlation coefficients refers a robust correlation between each risk and the total average operational risks where the correlation coefficients are higher than 0.5 at a significance level 0.01 achieves value lower than 0.05.

Table 4.4: Results of Pearson Correlation between Human risk items and average of Total Human risks.

No.	Pearson Coefficient	sig(2-tailed)
H1	.882**	0.001
H2	.858**	0.001
H3	.829**	0.001
H4	.855**	0.001
H5	.866**	0.001
H6	.816**	0.001
H7	.860**	0.001
H8	.843**	0.001
H9	.846**	0.001
H10	.870**	0.001

Table 4.4 shows that all items of human risks will be included since correlation coefficients of human risks items were deemed acceptable and statistically significant.

In addition, Table 4.4 clarifies an obvious internal consistency between the human risk items, in which values the correlation coefficients refers a robust correlation between each risk and the total average human risks where the correlation coefficients are higher than 0.5 at a significance level 0.01 achieves value lower than 0.05.

Table 4.5: Results of Pearson Correlation between maintenance risk items and average of Total maintenance risks.

No.	Pearson Coefficient	sig(2-tailed)
M1	.804**	0.001
M2	.793**	0.001
M3	.828**	0.001
M4	.814**	0.001
M5	.839**	0.001
M6	.790**	0.001
M7	.816**	0.001
M8	.774**	0.001
M9	.797**	0.001
M10	.508**	0.001
M11	.501**	0.001
M12	.555**	0.001
M13	.506**	0.001

Table 4.5 shows that all items of maintenance risks will be included since correlation coefficients of maintenance risks items were deemed acceptable and statistically significant.

In addition, Table 4.5 clarifies an obvious internal consistency between the maintenance risk items, in which values the correlation coefficients refers a robust correlation between each risk and the total average maintenance risks where the correlation coefficients are higher than 0.5 at a significance level 0.01 achieves value lower than 0.05.

Table 4.6: Results of Pearson Correlation between environmental risk items and average of total environmental risks

No.	Pearson Coefficient	sig(2-tailed)
E1	.817**	0.001
E2	.892**	0.001
E3	.858**	0.001
E4	.900**	0.001
E5	.896**	0.001
E6	.883**	0.001

Table 4.6 shows that all items of environmental risks will be included since correlation coefficients of environmental risks items were deemed acceptable and statistically significant.

In addition, Table 4.6 clarifies an obvious internal consistency between the environmental risk items, in which values the correlation coefficients refers a robust correlation between each risk and the total average environmental risks where the correlation coefficients are higher than 0.5 at a significance level 0.01 achieves value lower than 0.05.

Table 4.7: Results of Pearson Correlation between Retention risk items and average of total Retention risk.

No.	Pearson Coefficient	sig(2-tailed)
RR1	.830**	0.001
RR2	.831**	0.001
RR3	.859**	0.001
RR4	.850**	0.001
RR5	.825**	0.001
RR6	.765**	0.001
RR7	.853**	0.001
RR8	.799**	0.001
RR9	.875**	0.001
RR10	.880**	0.001
RR11	.808**	0.001

Table 4.7 shows that all items of retention risks will be included since correlation coefficients of retention risk strategies items were deemed acceptable and statistically significant.

In addition, Table 4.7 clarifies an obvious internal consistency between the retention risk strategy items, in which values the correlation coefficients refers a robust correlation between

each strategy and the total average retention risk strategies where the correlation coefficients are higher than 0.5 at a significance level 0.01 achieves value lower than 0.05.

Table 4.8: Results of Pearson Correlation between control risk items and average of total control risk.

No.	Pearson Coefficient	sig(2-tailed)
RC1	.827**	0.001
RC2	.905**	0.001
RC3	.771**	0.001
RC4	.852**	0.001
RC5	.877**	0.001
RC6	.872**	0.001
RC7	.860**	0.001
RC8	.885**	0.001
RC9	.885**	0.001
RC10	.924**	0.001
RC11	.871**	0.001
RC12	.864**	0.001
RC13	.856**	0.001
RC14	.880**	0.001
RC15	.881**	0.001

Table 4.8 shows that all items of control risk strategies will be included since correlation coefficients of control risk strategies items were deemed acceptable and statistically significant.

In addition, Table 4.8 clarifies an obvious internal consistency between the control risk strategy items, in which values the correlation coefficients refers a robust correlation between each strategy and the total average control risk strategies where the correlation coefficients are higher than 0.5 at a significance level 0.01 achieves value lower than 0.05.

Table 4.9: Results of Pearson Correlation between prevention risk items and average of total of prevention risk.

No.	Pearson Coefficient	sig(2-tailed)
RP1	.173*	0.001
RP2	.844**	0.001
RP3	.860**	0.001
RP4	.909**	0.001
RP5	.895**	0.001
RP6	.817**	0.001
RP7	.885**	0.001
RP8	.836**	0.001
RP9	.875**	0.001
RP10	.879**	0.001
RP11	.885**	0.001
RP12	.839**	0.001
RP13	.741**	0.001

Table 4.9 shows that all items of prevention risk strategies will be included since correlation coefficients of prevention risk strategies items were deemed acceptable and statistically significant.

In addition, Table 4.9 clarifies an obvious internal consistency between the prevention risk strategy items, in which values the correlation coefficients refers a robust correlation between each strategy and the total average prevention risk strategies where the correlation coefficients are higher than 0.5 at a significance level 0.01 achieves value lower than 0.05.

Table 4.10: Results of Pearson Correlation between transfer risk strategy items and average of total transfer risk strategy.

No.	Pearson Coefficient	sig(2-tailed)
RT1	.768**	0.001
RT2	.860**	0.001
RT3	.810**	0.001
RT4	.872**	0.001
RT5	.867**	0.001
RT6	.807**	0.001
RT7	.846**	0.001
RT8	.862**	0.001
RT9	.826**	0.001
RT10	.885**	0.001
RT11	.846**	0.001
RP12	.859**	0.001
RP13	.885**	0.001

Table 4.10 shows that all items of transfer risk strategies will be included since correlation coefficients of transfer risk strategies items were deemed acceptable and statistically significant.

In addition, Table 4.10 clarifies an obvious internal consistency between the transfer risk strategy items, in which values the correlation coefficients refers a robust correlation between each strategy and the total average transfer risk strategies where the correlation coefficients are higher than 0.5 at a significance level 0.01 achieves value lower than 0.05.

4.5 Evaluation risk Maintenance

This section shows results of survey questionnaire to assess all risks in the case study “Sankyu company that effects on financial aspects of the project and leads to cost overrun and reduce quality of maintenance and operating plants and equipment and result in extra costs.

The risks that assessed in this chapter categorized into four categories based on integration of risks collected using risks data occurred in Sankyu company and comprehensive literature review conducted in chapter 2. Risk categories comprise: operational risks, human risks, maintenance risks and environmental risks.

In order to assess the risks identified, descriptive statistical analysis comprise means, standard deviations, relative importance index. Also, risk index (R.I) had been identified based on 5*5 risk matrix illustrated in Figure 4.1 based on risk probability to happen and risk severity and the total assessment expressed by:

$$\mathbf{R.I = risk\ likelihood * risk\ severity.....eq.4.1}$$

		Impact →				
		Negligible	Minor	Moderate	Significant	Severe
Likelihood ↑	Very Likely	Low Med	Medium	Med Hi	High	High
	Likely	Low	Low Med	Medium	Med Hi	High
	Possible	Low	Low Med	Medium	Med Hi	Med Hi
	Unlikely	Low	Low Med	Low Med	Medium	Med Hi
	Very Unlikely	Low	Low	Low Med	Medium	Medium

Figure 4.1 Risk Matrix Tool

Table 4.11 presents mean values, standard deviation, relative importance index and risk index of operational risks that effect on financial performance in petrochemical companies' projects. Table 4.11 shows that the most likelihood of operational risks to occur and evaluation the severity of each risk in accordance to the respondents' views. Each operational risk had been ranked according to R.I.I value which represent the most risks impact among the identified risks. Also, each operational risk had been assessed based on risk index given in equation 4.1 that requires probability mean values and severity means values of each risk. Next, Risk index value had been evaluated using Risk matrix tool illustrated in Figure 4.1

Table 4.11 means, standard deviations, R.I.I and R.I of operational risks

Symbol	Operational Risk	Mean		STDEV		R.I.I	Rank	Risk index	Assessment
		Probability	Severity	Probability	Severity				
O1	Chemical concentration inside vessel due to cleaning result in O2 deficiency	4.52	4.64	0.83	0.72	0.92	2	21.0	High
O2	Crane Lifting faults that cause deterioration	4.63	4.66	0.76	0.71	0.93	1	21.6	High

	in Production lines and pipes.								
O3	Crane Lifting faults that cause Falling lifted object.	4.50	4.58	0.78	0.75	0.91	3	20.6	High
O4	Oil escape from equipment during service.	4.50	4.60	0.78	0.72	0.91	3	20.7	High
O5	Production, storage and disposal of general waste result in pollution and fire	4.41	4.53	0.86	0.76	0.89	5	20.0	High
O6	Corrosion in natural gas systems	4.50	4.57	0.81	0.76	0.91	3	20.6	High
O7	Gasket damage/wor n out result in Leakage of service fluid	4.58	4.67	0.76	0.68	0.93	1	21.4	High
O8	failure of valve lead to fluid leakage, Increased gland packing wear and tear, Service fluid loss and fire hazard, Inconsistent process output	4.55	4.62	0.76	0.67	0.92	2	21.0	High

O9	tube failure led to Intermixing of service fluid, Low flow, Loss of heat transfer	4.50	4.57	0.77	0.73	0.91	3	20.6	High
O10	Lack of equipment	4.52	4.62	0.77	0.68	0.91	3	20.9	High
O11	Equipment operating errors	4.52	4.62	0.79	0.74	0.91	3	20.9	High
O12	energy waste	4.43	4.55	0.85	0.78	0.90	4	20.2	High
O13	Delays of material supply	4.37	4.49	0.94	0.86	0.89	5	19.6	High
O14	Lack of proper suppliers	4.52	4.63	0.79	0.73	0.92	2	20.9	High
O15	Lack of supply chain management	4.44	4.57	0.88	0.79	0.90	4	20.3	High

Table 4.11 reveals that all R.I.I values are higher than 0.7 and this indicates that all operational risks suggested are important and ranked the operational risks that impact financial aspect of project as follows:

The most operational risks lead to cost overrun and have negatively impact on financial aspects of petrochemical projects are : Crane Lifting faults that cause deterioration in Production lines and pipes, Gasket damage/worn out result in Leakage of service fluid .The operational risks that occupy the second level in terms of significance are : Chemical concentration inside vessel due to cleaning result in O2 deficiency, failure of valve lead to fluid leakage ,Increased gland packing wear and tear ,Service fluid loss and fire hazard, Inconsistent process output, Lack of proper suppliers. The third level of operational risks influence on financial aspects are: Oil escape from equipment during service, Corrosion in natural gas systems, Equipment operating errors, Lack of equipment, tube failure led to Intermixing of service fluid, Low flow, Loss of heat transfer. The risks factors occupy ranked as fourth level are: Lack of supply chain management and energy waste. The risks that form the fifth rank are: Delays of material supply and Production, storage and disposal of general waste result in pollution and fire. Risk index (R.I) revealed that all operational risks assessed constitute high impact on financial Aspects in petrochemical companies.

Table 4.12 presents mean values, standard deviation, relative importance index and risk index of human risks that effect on financial performance in petrochemical companies' projects. Table 4.12 shows that the most likelihood of human risks to occur and evaluation the severity of each risk in accordance to the respondents' views. Each human risk had been ranked according to R.I.I value which represent the most risks impact among the identified risks. Also, each human risk had been assessed based on risk index given in equation 4.1 that requires probability mean values and severity means values of each risk. Next, Risk index value had been evaluated using Risk matrix tool illustrated in Figure 4.1

Table 4.12 means, standard deviations, R.I.I and R.I of Human risks

Symbol	Human Risk	Mean		STDEV		R.I.I	Rank	Risk index	Assessment
		Probability	Severity	Probability	Severity				
H1	Lack of skilled maintenance staff	4.47	4.62	0.78	0.69	0.91	4	20.65	High
H2	Lack of skilled labor to operate plant, equipment and machines	4.49	4.58	0.81	0.76	0.91	4	20.56	High
H3	Lack of supplying information	4.57	4.69	0.75	0.65	0.93	2	21.43	High
H4	Lack of regular checks for machines and plants	4.53	4.60	0.79	0.73	0.91	4	20.84	High
H5	Lack of communication result in shortage in inaccurate maintenance	4.63	4.70	0.72	0.65	0.93	2	21.76	High
H6	Delay to make decision for maintenance processes	4.48	4.64	0.84	0.71	0.91	4	20.79	High
H7	Poor knowledge of the original design of the equipment by the maintenance team	4.53	4.63	0.84	0.72	0.92	3	20.97	High

H8	Lack of managerial processes	4.67	4.75	0.67	0.59	0.94	1	22.18	High
H9	Lack of knowledge of operating machines and plants	4.56	4.71	0.78	0.63	0.93	2	21.48	High
H10	Insufficient training	4.53	4.65	0.87	0.72	0.92	3	21.06	High

Table 4.12 indicates that all R.I.I values are higher than 0.7 and this indicates that all human risks suggested are important and ranked the human risks that impact financial aspect of project as follows:

The most human risk led to cost overrun and have negatively impact on financial aspects of petrochemical projects is Lack of managerial processes. The human risks that occupy the second level in terms of significance are: Lack of supplying information, Lack of communication result in shortage in inaccurate maintenance, Lack of knowledge of operating machines and plants. The third level of human risks influence on financial aspects are: Insufficient training, Poor knowledge of the original design of the equipment by the maintenance team, Lack of communication result in shortage in inaccurate maintenance, Lack of supplying information. The risks factors occupy ranked as fourth level are: Poor knowledge of the original design of the equipment by the maintenance team, Lack of skilled maintenance staff, Lack of skilled labor to operate plant, equipment and machines, Lack of regular checks for machines and plants, Lack of regular checks for machines and plants, Delay to make decision for maintenance processes. Risk index (R.I) revealed that all human risks assessed constitute high impact on financial Aspects in petrochemical companies.

Table 4.13 presents mean values, standard deviation, relative importance index and risk index of maintenance risks that effect on financial performance in petrochemical companies' projects. Table 4.13 shows that the most likelihood of maintenance risks to occur and evaluation the severity of each risk in accordance to the respondents' views. Each maintenance risk had been ranked according to R.I.I value which represent the most risks impact among the identified risks. Also, each maintenance risk had been assessed based on risk index given in equation 4.1 that requires probability mean values and severity means values of each risk. Next, Risk index value had been evaluated using Risk matrix tool illustrated in Figure 4.1

Table 4.13 means, standard deviations, R.I.I and R.I of maintenance risks

Symbol	maintenance Risk	Mean		STDEV		R.I.I	Rank	Risk index	Assessment
		Probability	Severity	Probability	Severity				
M1	Release Chemicals hazardous material into atmosphere as a result of Pipe lines Modification	4.58	4.70	0.75	0.64	0.93	3	21.53	High
M2	Filter Cleaning & Replacement result in Product spillage	4.60	4.71	0.71	0.62	0.93	3	21.67	High
M3	Filter Cleaning & Replacement lead to Chemical powder inhalation.	4.64	4.72	0.72	0.65	0.94	2	21.90	High
M4	Pump Strainer Cleaning result in Product splash	4.61	4.71	0.70	0.59	0.93	3	21.71	High
M5	Reactor Cleaning & Inspection can lead to Fire & Explosion	4.59	4.70	0.78	0.62	0.93	3	21.57	High
M6	Reactor Cleaning & Inspection can lead to Emission of Fumes and Smoke.	4.60	4.68	0.70	0.62	0.93	3	21.53	High

M7	Scaffolding collapse	4.62	4.71	0.67	0.59	0.93	3	21.76	High
M8	Reactor Cleaning & Inspection can lead to release hazardous material into atmosphere	4.63	4.74	0.69	0.59	0.94	2	21.95	High
M9	Flying of welding Flash.	4.69	4.79	0.64	0.54	0.95	1	22.47	High
M10	Valve Replacement led to Release Chemicals into atmosphere.	4.52	4.54	0.83	0.82	0.91	5	20.52	High
M11	Electrocution	4.62	4.62	0.77	0.77	0.92	4	21.34	High
M12	Fire & Explosion.	4.47	4.51	0.80	0.80	0.90	6	20.16	High
M13	Exposing Ultraviolet or IR.	4.48	4.51	0.79	0.79	0.90	6	20.20	High

Table 4.13 indicates that all R.I.I values are higher than 0.7 and this indicates that all maintenance risks suggested are important and ranked the maintenance risks that impact financial aspect of project as follows:

The most maintenance risk led to cost overrun and have negatively impact on financial aspects of petrochemical projects is Flying of welding Flash. The maintenance risks that occupy the second level in terms of significance are: Filter Cleaning & Replacement lead to Chemical powder inhalation and Reactor Cleaning & Inspection can lead to lead to release hazardous material into atmosphere. The third level of human risks influence on financial aspects are: Release Chemicals hazardous material into atmosphere as a result of Pipe lines Modification, Scaffolding collapse, Filter Cleaning & Replacement result in Product spillage, Pump Strainer Cleaning result in Product splash, Reactor Cleaning & Inspection can lead to lead to Emission of Fumes and Smoke. The risk factor ranked as fourth level is Electrocution. The risk factor ranked as fifth level are: Valve Replacement led to Release Chemicals into atmosphere. The final factors ranked as six in terms of significance impact are: Fire & Explosion and Exposing Ultraviolet or IR. Risk index (R.I) revealed that all, maintenance risks assessed constitute high impact on financial Aspects in petrochemical companies.

Table 4.14 presents mean values, standard deviation, relative importance index and risk index of environmental risks that effect on financial performance results in petrochemical companies' projects. Table 4.13 shows that the most likelihood of maintenance risks to occur and evaluation the severity of each risk in accordance to the respondents' views. Each environmental risk had been ranked according to R.I.I value which represent the most risks impact among the identified risks. Also, each environmental risk had been assessed based on risk index given in equation 4.1 that requires probability mean values and severity means values of each risk. Next, Risk index value had been evaluated using Risk matrix tool illustrated in Figure 4.1

Table 4.14 means, standard deviations, R.I.I and R.I of environmental risks

Symbol	Compliance Risk	Mean		STDEV		R.I.I	Rank	Risk index	Assessment
		Probability	Severity	Probability	Severity				
E1	Rain	3.5	3.3	0.86	0.87	0.68	2	11.55	Med high
E2	High temperature	3.7	3.6	0.82	0.81	0.73	1	13.32	Med high
E3	storm	1.4	2.1	0.78	0.78	0.35	-	2.94	low
E4	Wind speed	3.5	3.8	0.77	0.76	0.73	1	13.30	Med high
E5	Earthquakes	1.05	1.2	0.79	0.79	0.23	-	1.26	low
E6	Fire	3.2	3.1	0.78	0.74	0.63	3	9.92	Low med

Table 4.14 indicates that all R.I.I values are higher than 0.7 and this indicates that all environmental risks suggested are important and ranked the environmental risks that impact financial aspect of project as follows:

The most environmental risk led to cost overrun and have negatively impact on financial aspects of petrochemical projects are high temperature and wind speed. The environmental risks that occupy the second level in terms of significance are is probability of Rain. The third level of environmental risks influence on financial aspects is fire. Risk index (R.I) revealed that all, environmental risks range in terms of impact from low to med high.

4.6 Evaluation Risk management strategies in Petrochemical companies

Risk assessment processes conducted in petrochemical companies showed there is a need to establish risk management strategies. Moreover, after evaluating the effectiveness of risk management strategies in control cost and quality of petrochemical projects.

Comprehensive risk mitigation strategies that have been mentioned in chapter four according to several categories: risk retention, risk control, risk prevention and risk transfer had been measured using questionnaire survey targeted Sankyu company employees. descriptive statistical analysis comprise means, standard deviations, relative importance index have been

adopted in data analyze to evaluate the effectiveness of these strategies to mitigate risks that lead to reduce quality and increase costs.

Table 4.15 presents mean values, standard deviation, relative importance index of risk retention strategies that affect positively on financial performance in petrochemical projects. Table 4.15 shows that Each risk retention strategy had been ranked according to R.I.I values.

Table 4.15 means, standard deviations, R.I.I of Risk Retention

Symbol	Risk Retention	Mean	STDEV	R.I.I	Rank
RR1	Waste shall be stored securely	0.77	4.54	0.91	1
RR2	Minimize the consumption of natural resources.	0.79	4.48	0.90	2
RR3	Operation and maintenance as per manufacturer's instructions.	0.78	4.50	0.90	2
RR4	Introducing new technology	0.79	4.51	0.90	2
RR5	Training and awareness Programs.	0.86	4.43	0.89	3
RR6	Ensure following company rules	0.95	4.35	0.87	4
RR7	Regular intervals workshop and program shall be organized	0.79	4.52	0.90	2
RR8	Proper grounding.	0.88	4.44	0.89	3
RR9	Management consider and calculate risk management during the initial project planning	0.76	4.48	0.90	2
RR10	Equipment High Temperature Detection and using Cooling System	0.84	4.45	0.89	3
RR11	Control Fatigue Gas Detection, Oil Detection, Overpressure Detection	0.76	4.55	0.91	1

Table 4.15 shows that all R.I.I values are higher than 0.7 and this indicates that all risk retention strategies suggested are important and ranked the risk retention strategies that impact financial aspect of project as follows:

The most risk retention strategies positively impact on financial aspects of petrochemical projects and reduce costs are: Waste shall be stored securely, Control Fatigue Gas Detection, Oil Detection, Overpressure Detection. The risk retention strategies that occupy the second level in terms of significance are: Management consider and calculate risk management during the initial project planning, Regular intervals workshop and program shall be organized, Regular intervals workshop and program shall be organized, introducing new technology, Operation and maintenance as per manufacturer's instructions and minimize the consumption of natural resources. The third level of risk retention strategy influence on financial aspects are: Equipment High Temperature Detection and using Cooling System, Equipment High

Temperature Detection and using Cooling System, Proper grounding, Training and awareness Programs. The risk retention strategies factor ranked as fourth level is ensure following company rules.

Table 4.16 presents mean values, standard deviation, relative importance index of risk control strategies that affect positively on financial performance in petrochemical projects. Table 4.16 shows that Each risk control strategy had been ranked according to R.I.I values.

Table 4.16 means, standard deviations, R.I.I of Risk Control

Symbol	Risk Control	Mean	STDEV	R.I.I	Rank
RC1	Regular monitoring & checking for the leakage.	4.52	0.79	0.90	4
RC2	Regular monitoring & checking that waste is disposed as per the requirements.	4.60	0.75	0.92	2
RC3	Any spilled must be cleaned as soon as possible using an appropriate procedure/instruction.	4.48	0.84	0.90	4
RC4	Commercial regular follow up with suppliers.	4.53	0.80	0.91	3
RC5	Proper communication channel	4.65	0.70	0.93	1
RC6	implement follow-up system	4.53	0.86	0.91	3
RC7	Conduct regular checks, inspect sites with QHSE Patrols and regular audit.	4.57	0.76	0.91	3
RC8	Management to be updated as and when required and continuous communication	4.58	0.72	0.92	2
RC9	Quality checking of service fluids at laboratory	4.62	0.75	0.92	2
RC10	Management & employees are involved in periodic review and risk management planning exercise to monitor, identify and manage risks	4.60	0.71	0.92	2

RC11	The management use specific risk management tools to control and manage risk	4.57	0.79	0.91	3
RC12	Control Corrosion via Shock and Vibration absorber	4.57	0.72	0.91	3
RC13	Limit hydrocarbon leak Dike	4.62	0.68	0.92	2
RC14	Toxic Air Control	4.62	0.70	0.92	2

Table 4.16 shows that all R.I.I values are higher than 0.7 and this indicates that all risk control strategies suggested are important and ranked the risk control strategies that impact financial aspect of project as follows:

The most risk control strategies positively impact on financial aspects of petrochemical projects and reduce costs is: Proper communication channel. The risk control strategies that occupy the second level in terms of significance are: Toxic Air Control, Limit hydrocarbon leak Dike, Management & employees are involved in periodic review and risk management planning exercise to monitor, identify and manage risks, Quality checking of service fluids at laboratory, Regular monitoring & checking that waste is disposed as per the requirements. The third level of risk control influence on financial aspects are: Control Corrosion via Shock and Vibration absorber, The management use specific risk management tools to control and manage risk, conduct regular checks, inspect sites with QHSE Patrols and regular audit, implement follow-up system, Commercial regular follow up with suppliers. The risk control strategies factor ranked as fourth level are: Any spilled must be cleaned as soon as possible using an appropriate procedure/instruction and Regular monitoring & checking for the leakage.

Table 4.17 presents mean values, standard deviation, relative importance index of prevention strategies that affect positively on financial performance in petrochemical projects. Table 4.17 shows that Each risk prevention strategy had been ranked according to R.I.I values.

Table 4.17 means, standard deviations, R.I.I of Risk Prevention

Symbol	Risk prevention	Mean	STDEV	R.I.I	Rank
RP1	Safe handling techniques shall be employed	4.69	0.65	0.94	1
RP2	Personal Protective Equipment Insurance	4.53	0.83	0.91	4
RP3	Frequent review of client needs and strategy	4.64	0.77	0.93	2
RP4	Ensure Scaffold or Platform are safe.	4.50	0.80	0.90	5
RP5	Use Electrical Rated Gloves.	4.51	0.79	0.90	5

RP6	Trained in Work at Height	4.42	0.87	0.88	7
RP7	Cartridge Respirator must be use.	4.52	0.82	0.90	5
RP8	Standby firefighting equipment.	4.58	0.78	0.92	3
RP9	Prevent Temperature Rise High by Temperature Detection and Process Shutdown	4.57	0.77	0.91	4
RP10	Prevent Internal Overpressure via Overpressure Detection, Process Shutdown, Clogging Detection	4.50	0.79	0.90	5
RP11	Prevent Presence of Oxygen Detection via Oxygen Remover, Process Shutdown	4.53	0.78	0.91	4
RP12	Prevent Vibrating Resonance Effect via Shock and Vibration absorber	4.54	0.79	0.91	4
RP13	Prevent Ignition Source Isolation, Emergency Shutdown Initiation, Electrical Isolation	4.45	0.87	0.89	6

Table 4.17 shows that all R.I.I values are higher than 0.7 and this indicates that all risk prevention strategies suggested are important and ranked the risk control strategies that impact financial aspect of project as follows:

The most risk prevention strategies positively impact on financial aspects of petrochemical projects and reduce costs are: Safe handling techniques shall be employed. The risk prevention strategies that occupy the second level in terms of significance are: Frequent review of client needs and strategy. The third level of risk prevention strategies influence on financial aspects are Standby firefighting equipment. The risk prevention strategies factor ranked as fourth level are: Prevent Vibrating Resonance Effect via Shock and Vibration absorber, Prevent Presence of Oxygen Detection via Oxygen Remover, Process Shutdown, Prevent Temperature Rise High by Temperature Detection and Process Shutdown and Personal Protective Equipment Insurance. The risk prevention strategies factor ranked as fifth level are: Prevent Internal Overpressure via Overpressure Detection, Process Shutdown, Clogging Detection, Cartridge Respirator must be use, Use Electrical Rated Gloves, Ensure Scaffold or Platform are safe.

Table 4.18 presents mean values, standard deviation, relative importance index of risk transfer strategies that affect positively on financial performance in petrochemical projects. Table 4.17 shows that Each risk transfer strategies had been ranked according to R.I.I values.

Table 4.18 means, standard deviations, R.I.I of Risk Transfer

Symbol	Risk Transfer	Mean	STDEV	R.I.I	Rank
RT1	Suppliers' performance evaluation	4.38	0.95	0.88	6
RT2	Mechanize processes and build improvements	4.56	0.79	0.91	3
RT3	Skilled & certify people allow to work only	4.45	0.89	0.89	5
RT4	Detect Crack Propagation Inspection and Maintenance	4.52	0.76	0.90	4
RT5	Equipment Insurance	4.48	0.84	0.90	4
RT6	Machinery Breakdown Insurance	4.59	0.76	0.92	2
RT7	periodic maintenance contracts with specialized companies	4.56	0.78	0.91	3
RT8	Purchasing Extended warranties from equipment manufacturers	4.62	0.74	0.92	2
RT9	Partnerships with specialized maintenance companies	4.52	0.84	0.90	4
RT10	Using smart monitoring systems to continuously track equipment performance	4.56	0.80	0.91	3
RT11	Using asset management systems to track equipment status	4.68	0.70	0.94	1
RT12	hiring leases instead of outright purchase of equipment	4.61	0.77	0.92	2
RT13	Develop comprehensive contingency plans to address any major breakdowns	4.55	0.86	0.91	3

Table 4.18 shows that all R.I.I values are higher than 0.7 and this indicates that all risk transfer strategies suggested are important and ranked the risk transfer strategies that impact financial aspect of project as follows:

The most risk transfer strategies positively impact on financial aspects of petrochemical projects and reduce costs using asset management systems to track equipment status. The risk transfer strategies that occupy the second level in terms of significance are: hiring leases instead of outright purchase of equipment, Purchasing Extended warranties from equipment manufacturers, Machinery Breakdown Insurance. The third level of risk transfer strategies influence on financial aspects are: Develop comprehensive contingency plans to address any major breakdowns, using smart monitoring systems to continuously track equipment performance, periodic maintenance contracts with specialized companies and Mechanize processes and build improvements. The risk transfer strategies factor ranked as fourth level are: Partnerships with specialized maintenance companies, Equipment Insurance, Detect Crack Propagation Inspection and Maintenance. The risk transfer strategies factor ranked as fifth level is Skilled & certify people allow to work only.

4.7 Enhancing financial aspects of petrochemical projects

In this section, respondents were asked to evaluate effectiveness of Risk management strategies in enhancing effectiveness of financial aspects in petrochemical companies and the statistical analysis found that respondents are strongly agree that all risk management tools including : Risk prevention, risk control, risk retention and risk transfer are efficient techniques to enhance financial aspects of petrochemical industries comprising reducing cost and controlling cost , cost overrun prevention and addition to enhance quality of petrochemical products.

Table 4.19 Effectiveness of Risk Management in Industrial Companies

NO.	Enhancing Financial Aspects	Mean	STDEV	Description
1	Risk management strategies can reduce cost overrun	4.48	0.84	Strongly agree
2	Risk transfer lead enhance project productivity and consequently enhance budget	4.50	0.80	Strongly agree
3	Risk transfer can significantly affect on company profit.	4.62	0.70	Strongly agree
4	Risk Retention can significantly reduce risks effect on financial aspects	4.2	0.81	Strongly agree
5	Risk control significantly control cost in industrial companies and prevent cost overrun	4.86	0.76	Strongly agree
6	Risk prevention has a great impact to mitigate risks effect on budget	4.73	0.78	Strongly agree
7	Adopting Risk management tools during planning stage enable control cost	4.56	0.84	Strongly agree

4.8 Impact of Risk management strategies on financial aspects in petrochemical projects

Linear Regression analysis using SPSS has been applied using SPSS software in order to study impact of risk management strategies on financial aspects in petrochemical projects.

4.8.1 Impact of Risk prevention on Financial Aspects

In order to study impact of risk management, Linear regression model have been developed considering financial aspects as dependent variable while risk prevention tool had been considered as independent variables.

Table 4.20 shows that in the regression model that investigates correlation between financial aspects and risk prevention strategy, it was noted that there is a strong correlation between financial aspects and risk prevention strategy with Adjusted R Square =0.928 that indicated a robust correlation.

Table 4.20 Regression Model of risk prevention strategy

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.964 ^a	.928	.928	.20593

a. Predictors: (Constant), Risk prevention has a great impact to mitigate risks effect on budget

Table 4.21 displays that the risk prevention strategy significantly impact on financial aspect of the petrochemical project in which, the significant value is 0.00 that is lower than 0.05.

Table 4.21 ANOVA of risk prevention strategy

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	86.436	1	86.436	2038.213	.000 ^b
	Residual	6.658	157	.042		
	Total	93.094	158			

a. Dependent Variable: Financial aspect

b. Predictors: (Constant), Risk prevention s

Table 4.22 illustrates standard regression coefficient in addition to t and sig -value for the studies regression. The regression coefficients expressed the variation in the financial aspect in units of its standard deviation. It can be noted that risk prevention strategy has a positive impact on financial aspects of petrochemical projects where the regression coefficient value is Beta= 0.964 at significance level 0.00.

Table 4.22 Regression Coefficients of risk prevention

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.220	.098		2.253	.026
	Risk retention	.941	.021	.964	45.147	.000

a. Dependent Variable: Financial aspect

4.8.2 Impact of Risk control on Financial Aspect

In order to study impact of risk management, Linear regression model have been developed considering financial aspects as dependent variable while risk control tool had been considered as independent variables.

Table 4.23 shows that in the regression model that investigates correlation between financial aspects and risk control strategy, it was noted that there is a strong correlation between financial aspects and risk control strategy with Adjusted R Square =0.871 that indicated a robust correlation.

Table 4.23 Regression Model of risk control strategy

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.934 ^a	.872	.871	.27536

a. Predictors: (Constant), Risk control can significantly reduce risks effect on financial aspects

Table 4.24 displays that the risk control strategy significantly impact on financial aspect of the petrochemical project in which, the significant value is 0.00 that is lower than 0.05.

Table 4.24 ANOVA of risk control strategy

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	81.190	1	81.190	1070.776	.000 ^b
	Residual	11.904	157	.076		
	Total	93.094	158			

a. Dependent Variable: Financial aspect

b. Predictors: (Constant), Risk control can significantly reduce risks effect on financial aspects

Table 4.25 illustrates standard regression coefficient in addition to t and sig -value for the studies regression. The regression coefficients expressed the variation in the financial aspect in units of its standard deviation. It can be noted that risk control strategy has a positive impact on financial aspects of petrochemical projects where the regression coefficient value is Beta= 0.934 at significance level 0.00.

Table 4.25 Regression coefficients of Risk Control strategy

Model	Coefficients ^a		Standardized Coefficients Beta	t	Sig.
	Unstandardized Coefficients B	Std. Error			
1	(Constant)	.594	.123	4.819	.000
	Risk control	.877	.027	.934	.000

a. Dependent Variable: Financial aspect

4.8.3 Impact of risk retention on financial aspect

In order to study impact of risk management, Linear regression model have been developed considering financial aspects as dependent variable while risk retention tool had been considered as independent variables.

Table 4.26 shows that in the regression model that investigates correlation between financial aspects and risk retention strategy, it was noted that there is a strong correlation between financial aspects and risk retention strategy with Adjusted R Square =0.897 that indicated a robust correlation.

Table 4.26 Regression Model of risk retention strategy

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.947 ^a	.898	.897	.24626

a. Predictors: (Constant), Risk retention

Table 4.27 displays that the risk retention strategy significantly impact on financial aspect of the petrochemical project in which, the significant value is 0.00 that is lower than 0.05.

Table 4.27 ANOVA of risk retention strategy

ANOVA ^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	83.572	1	83.572	1378.030	.000 ^b
	Residual	9.521	157	.061		
	Total	93.094	158			

a. Dependent Variable: Financial aspect

b. Predictors: (Constant), Risk retention

Table 4.28 illustrates standard regression coefficient in addition to t and sig -value for the studies regression. The regression coefficients expressed the variation in the financial aspect in units of its standard deviation. It can be noted that risk retention strategy has a positive impact

on financial aspects of petrochemical projects where the regression coefficient value is Beta= 0.947 at significance level 0.00.

Table 4.28 Regression Coefficient of risk retention model

Coefficients ^a					
Model		Unstandardized Coefficients		Standardized Coefficients	Sig.
		B	Std. Error	Beta	
1	(Constant)	.436	.113		.000
	Risk retention	.908	.024	.947	.000

a. Dependent Variable: Financial aspect

4.8.4 Impact of risk transfer on financial aspect

In order to study impact of risk management, Linear regression model have been developed considering financial aspects as dependent variable while risk transfer tool had been considered as independent variables.

Table 4.29 shows that in the regression model that investigates correlation between financial aspects and risk transfer strategy, it was noted that there is a strong correlation between financial aspects and risk transfer strategy with Adjusted R Square =0.861 that indicated a robust correlation.

Table 4.29 Regression Model of risk transfer strategy

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.932	.868	.861	.24528

a. Predictors: (Constant), risk transfer

Table 4.30 displays that the risk transfer strategy significantly impact on financial aspect of the petrochemical project in which, the significant value is 0.00 that is lower than 0.05.

Table 4.30 ANOVA of risk transfer strategy.

ANOVA ^a					
Model		Sum of Squares	df	Mean Square	Sig.
1	Regression	81.190	1	81.190	.000 ^b
	Residual	11.904	157	.076	
	Total	93.094	158		

a. Dependent Variable: Financial aspect

b. Predictors: (Constant), risk transfer

Table 4.31 illustrates standard regression coefficient in addition to t and sig -value for the studied regression. The regression coefficients expressed the variation in the financial aspect

in units of its standard deviation. It can be noted that risk transfer strategy has a positive impact on financial aspects of petrochemical projects where the regression coefficient value is Beta= 0.951 at significance level 0.00.

Table 4.31s Regression Coefficient of risk transfer model

Coefficients ^a					
Model		Unstandardized Coefficients		Standardized Coefficients	
		B	Std. Error	Beta	t
1	(Constant)	.432	.111		3.945
	Risk transfer	.901	.024	0.951	35.132
					Sig.
					.000
					.000

a. Dependent Variable: Financial aspect

4.9 Control charts and Capability process of cost control in Sankyu Company

In order to assess whether Sankyu KPIs enables the budget to be controlled within limits, control charts and capability analysis have been used by obtaining data during 12 months before the company applies risk mitigation techniques. Also, data obtained by Sankyu comprise actual cost percentage of maintenance and operating plants. The company budget for maintenance and operating plants ranges from 5% to 20% and the data obtained is the actual cost per month for cost and maintenance machines and plants. To monitor cost and capability process, Minitab software v.19 had been adopted.

Table 4.32 displays actual cost data result in maintenance and operating plants and machines before applying risk mitigation strategies. The company budget for maintenance and operating process of plants and machines ranges from 5% to 20%. Table 4.33 illustrates that actual maintenance cost exceed the predicted cost of the company during. For example, in march, the actual maintenance cost up to 30% several months in which exceeded the cost range expected (5%-20%)

Table 4.32 Actual Cost data before applying Risk management plan

Month	Actual cost maintenance monthly	Predicted
January	0.10	0.05%-20%
February	0.11	0.05%-20%
March	0.30	0.05%-20%
April	0.12	0.05%-20%
May	0.23	0.05%-20%
June	0.22	0.05%-20%
July	0.14	0.05%-20%
August	0.55	0.05%-20%
September	0.13	0.05%-20%
November	0.11	0.05%-20%
October	1.30	0.05%-20%
December	0.15	0.05%-20%

Figure 4.4 shows control chart of actual cost maintenance before applying risk management tools to investigate whether the company controls the actual cost for the maintenance plan. It can be noted by Figure 4.4 that an out-of-control point exists on the I-MR chart. Consequently, an alarm has been taken affirming the process is out-of-control since the red point is above upper line and it can be revealed that the company has limitation in controlling cost since, there is no emergency response plan to respond potential risks occurs in company in the field of maintenance and operating plants and machines of petrochemical products.

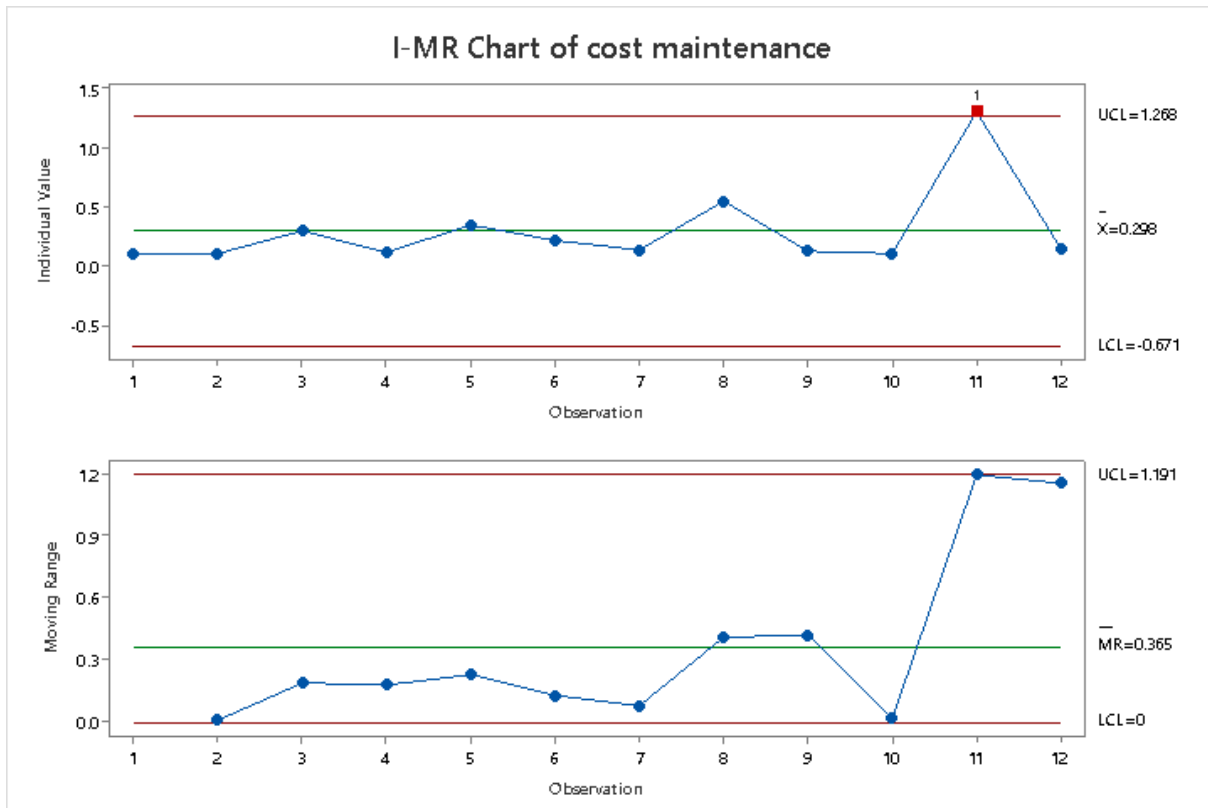


Figure 4.4 control chart of actual cost maintenance before risk management application.

Figure 4.5 depicts capability process outcomes of actual cost during 12 months. It can be noted in Figure 4.4 that the process mean is initially off-target (sample mean = 0.288) with PCI value of -0.08 that is lower than 1.67. Also, most actual costs are out of upper and lower limits.

The indicators of control chart and capability process shows lack of maintenance plan to control actual cost within limits.

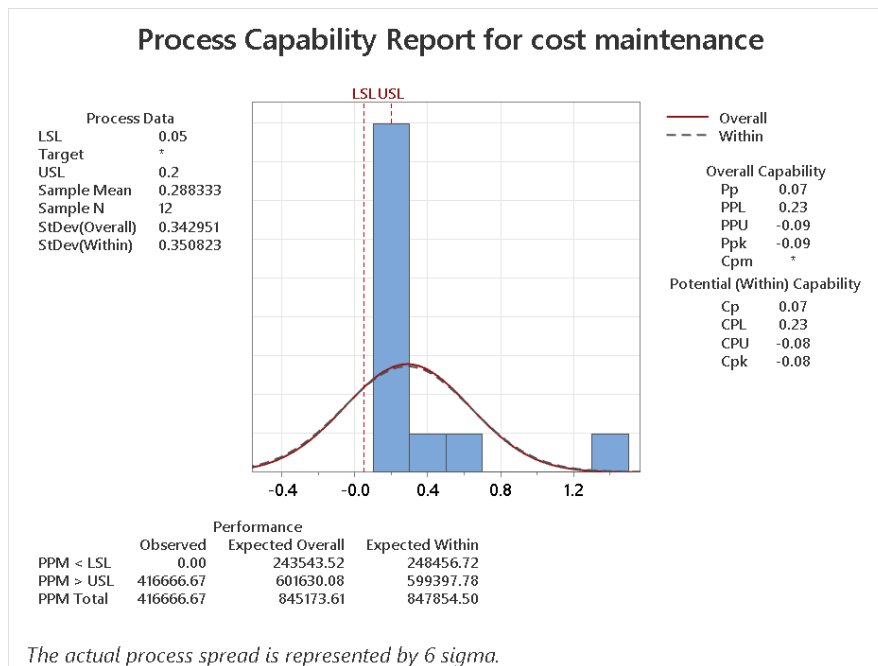


Figure 4.5 control chart of actual cost maintenance before risk management application.

Table 4.33 displays actual cost data related to maintenance and operating plants and machines after applying risk transfer tool. The company budget for maintenance and operating process of plants and machines ranges from 5% to 20%. Table 4.33 illustrates that actual maintenance cost within the predicted cost of the company during where the actual is within the range of expected cost (5%-20%)

Table 4.33 Actual Cost data After applying Risk transfer tool

Month	Actual cost maintenance monthly	Predicted
January	0.12	0.05%-20%
February	0.13	0.05%-20%
March	0.11	0.05%-20%
April	0.13	0.05%-20%
May	0.13	0.05%-20%
June	0.14	0.05%-20%
July	0.11	0.05%-20%
August	0.11	0.05%-20%
September	0.12	0.05%-20%
November	0.12	0.05%-20%
October	0.15	0.05%-20%
December	0.11	0.05%-20%

Figure 4.6 shows control chart of actual cost maintenance after applying risk transfer tool to investigate whether the company controls the actual cost for the maintenance plan. It can be noted by Figure 4.6 that no out-of-control point exists on the I-MR chart and that indicates that the process is on control since there is no red points is above upper line or lower line and it can be revealed that the company could using risk control tool to control cost maintenance.

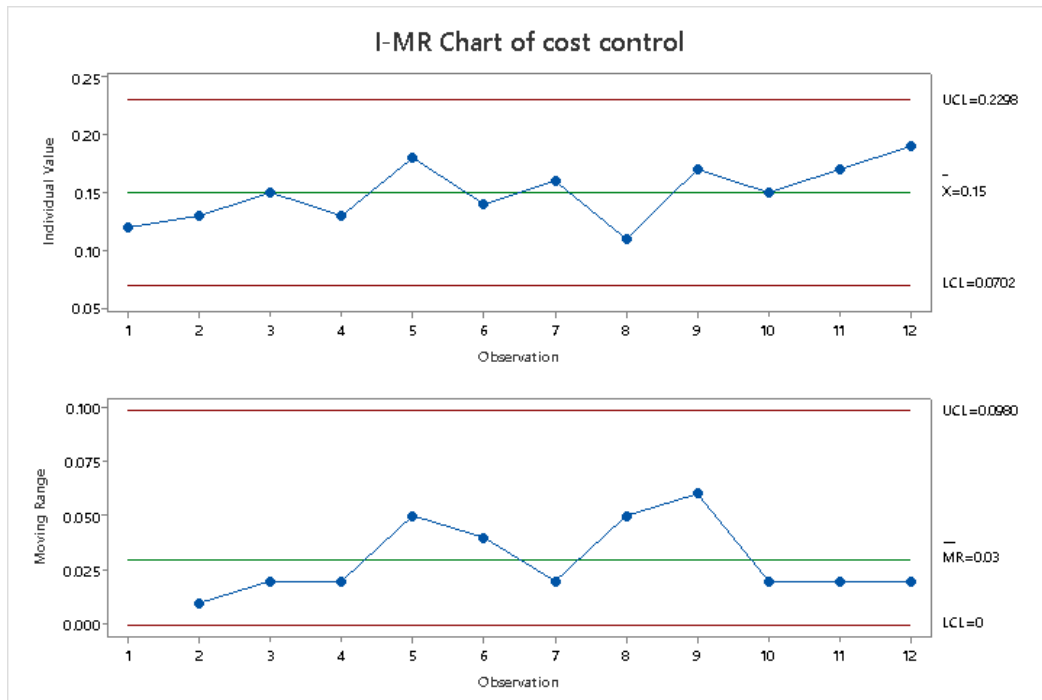


Figure 4.6 control chart of actual cost maintenance after risk transfer application.

Figure 4.7 depicts capability process outcomes of actual cost during 12 months. It can be noted in Figure 4.7 that the process mean is initially on-target (sample mean = 0.123) with PCI value of 1.83 that is higher than 1.67. Also, all actual costs are within upper and lower limits.

The indicators of control chart and capability process shows the efficiency of risk transfer strategy to control actual cost within limits.

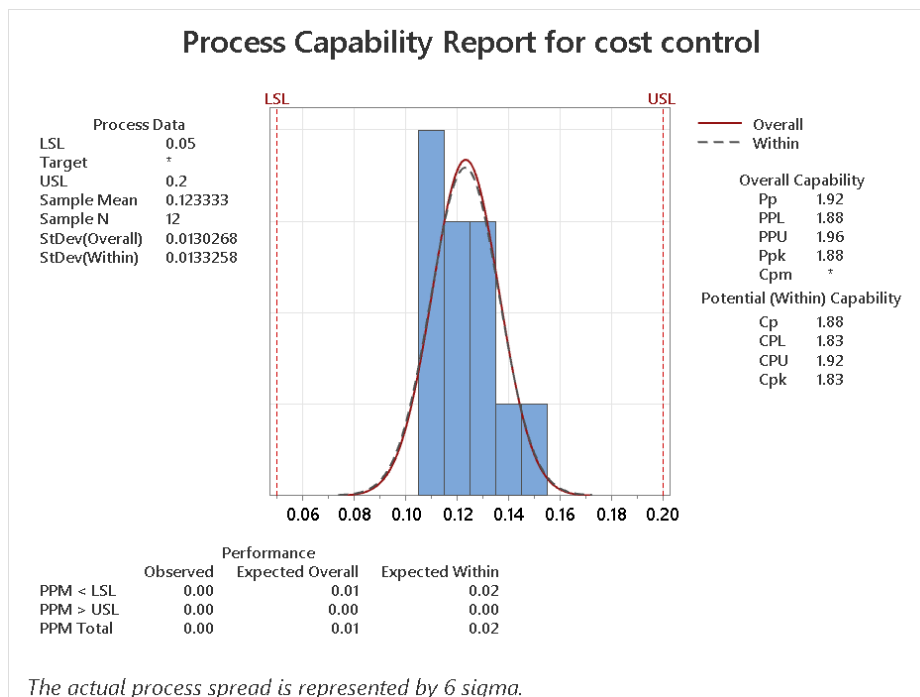


Figure 4.7 capability process of actual cost maintenance after risk transfer application.

Table 4.34 displays actual cost data related to maintenance and operating plants and machines after applying risk control tool. The company budget for maintenance and operating process of plants and machines ranges from 5% to 20%. Table 4.35 illustrates that actual maintenance cost within the predicted cost of the company during where the actual is within the range of expected cost (5%-20%)

Table 4.34 Actual Cost data After applying risk control tool

Month	Actual cost maintenance monthly	Predicted
January	0.12	0.05%-20%
February	0.11	0.05%-20%
March	0.10	0.05%-20%
April	0.12	0.05%-20%
May	0.13	0.05%-20%
June	0.11	0.05%-20%
July	0.13	0.05%-20%
August	0.13	0.05%-20%
September	0.11	0.05%-20%
November	0.12	0.05%-20%
October	0.13	0.05%-20%
December	0.10	0.05%-20%

Figure 4.8 shows control chart of actual cost maintenance after applying risk control tool to investigate whether the company controls the actual cost for the maintenance plan. It can be noted by Figure 4.8 that no out-of-control point exists on the I-MR chart and that indicates that the process is on control since there is no red points is above upper line or lower line and it can be revealed that the company could using risk control tool to control cost maintenance

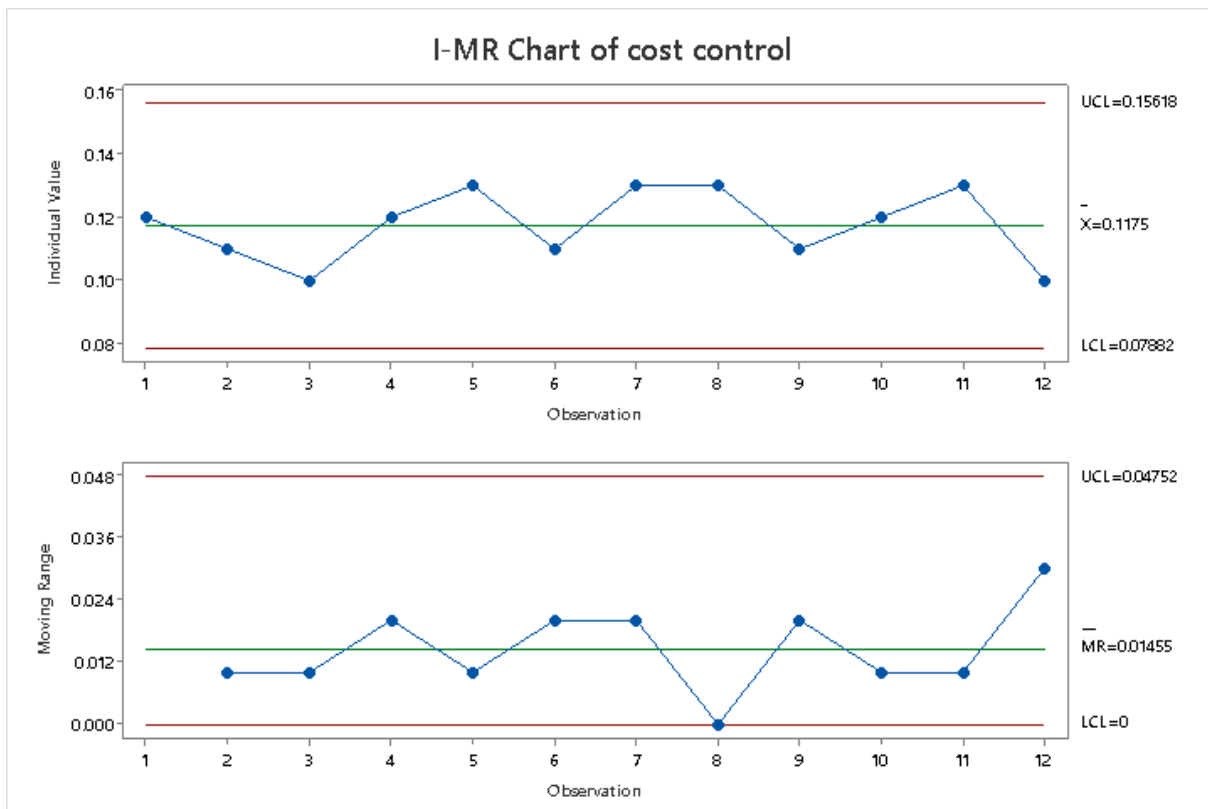


Figure 4.8 control chart of actual cost maintenance after risk control application.

Figure 4.9 depicts capability process outcomes of actual cost during 12 months. It can be noted in Figure 4.9 that the process mean is initially on-target (sample mean = 0.117) with PCI value of 1.93 that is higher than 1.67. Also, all actual costs are within upper and lower limits.

The indicators of control chart and capability process shows the efficiency of risk control strategy to control actual cost within limits.

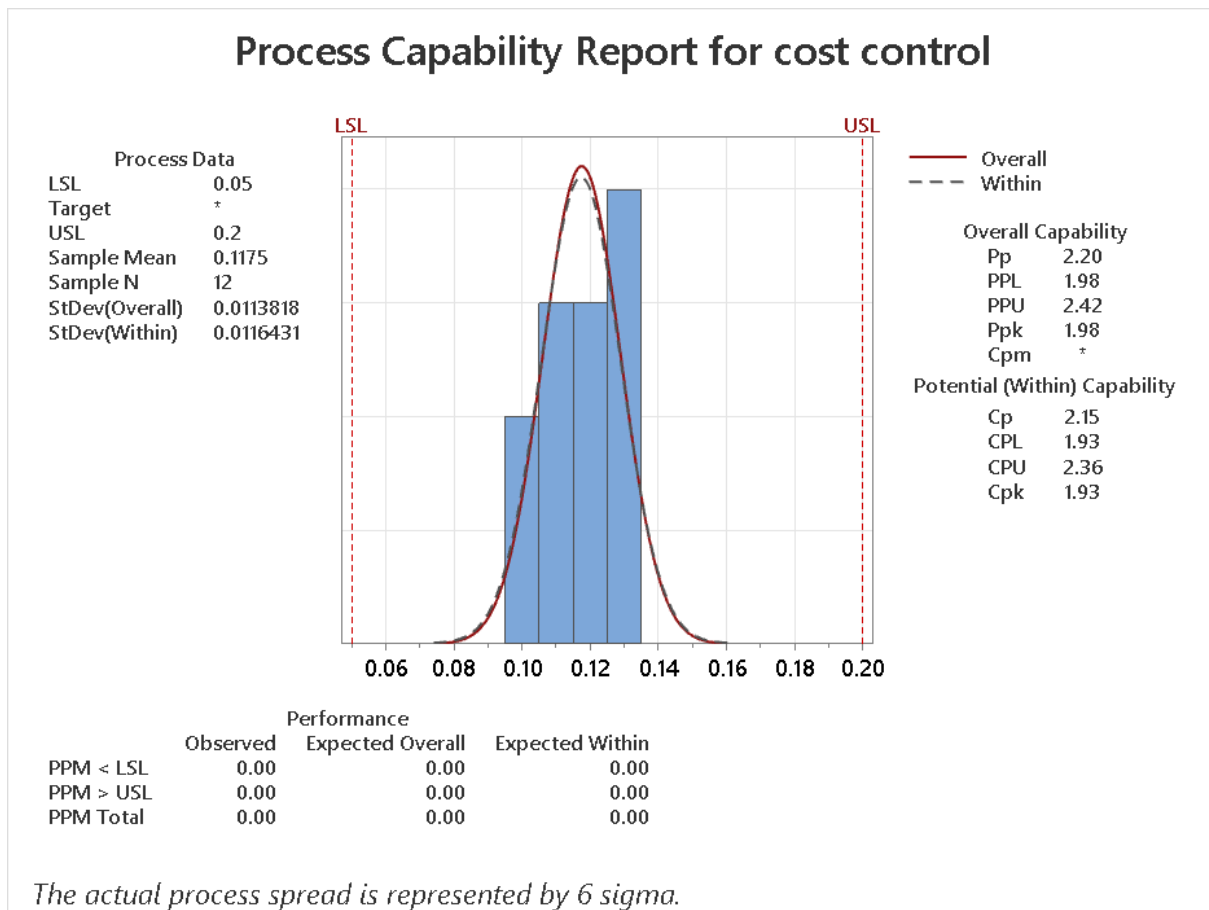


Figure 4.9 capability process of actual cost maintenance after risk control application

Table 4.35 displays actual cost data related to maintenance and operating plants and machines after applying risk retention tool. The company budget for maintenance and operating process of plants and machines ranges from 5% to 20%. Table 4.36 illustrates that actual maintenance cost within the predicted cost of the company during where the actual is within the range of expected cost (5%-20%).

Table 4.35 Actual Cost data After applying risk retention tool

Month	Actual cost maintenance monthly	Predicted
January	0.13	0.05%-20%
February	0.15	0.05%-20%
March	0.14	0.05%-20%
April	0.15	0.05%-20%
May	0.12	0.05%-20%
June	0.15	0.05%-20%
July	0.14	0.05%-20%
August	0.15	0.05%-20%
September	0.12	0.05%-20%
November	0.12	0.05%-20%
October	0.13	0.05%-20%
December	0.13	0.05%-20%

Figure 4.9 shows control chart of actual cost maintenance after applying risk retention tool to investigate whether the company controls the actual cost for the maintenance plan. It can be

noted by Figure 4.10 that no out-of-control point exists on the I-MR chart and that indicates that the process is on control since there is no red points is above upper line or lower line and it can be revealed that the company could using risk retention tool to control cost maintenance

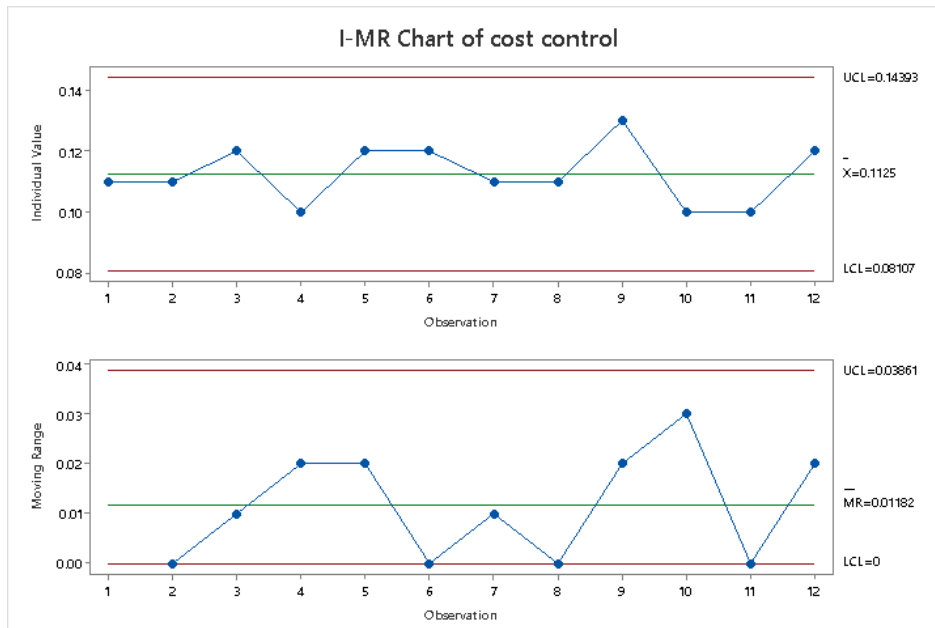


Figure 4.10 control chart of actual cost maintenance after risk retention application.

Figure 4.11 depicts capability process outcomes of actual cost during 12 months. It can be noted in Figure 4.11 that the process mean is initially on-target (sample mean = 0.112) with PCI value of 2.11 that is higher than 1.67. Also, all actual costs are within upper and lower limits.

The indicators of control chart and capability process shows the efficiency of risk retention strategy to control actual cost within limits.

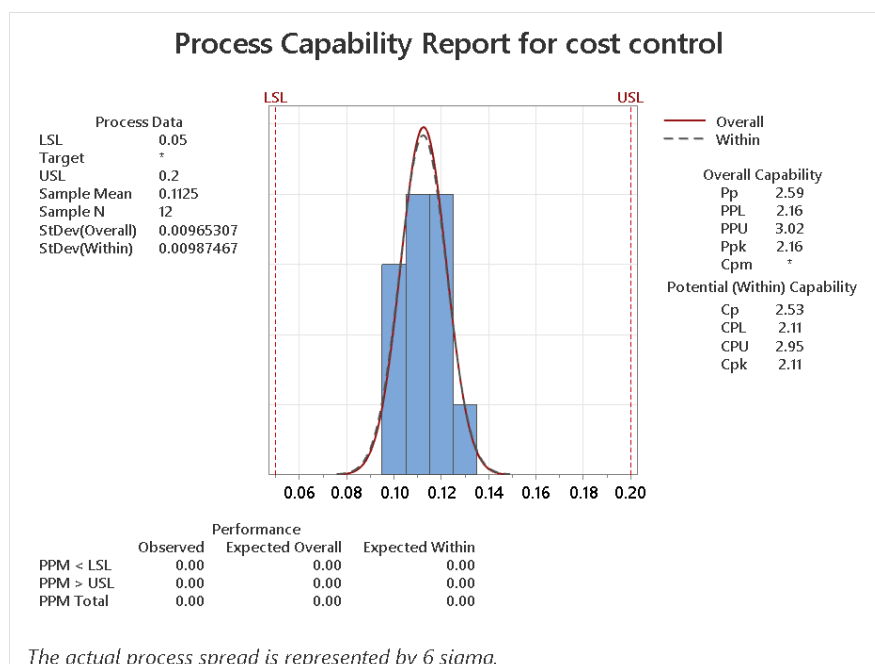


Figure 4.11 capability process of actual cost maintenance after risk retention application

It can be noted that Sankyu company could control costs related to maintenance and operated processes of petrochemical projects using risk management tools and that proves the ability of these tools to manage risks efficiency.

4.10 Structured interviews

In order to investigate quantitative outcomes, structures interviews have been designed based on five questions targeting three experts have adequate experience in petrochemical industries. The following will include the structured interviews with experts and the outcomes of the interviews:

1- hat methods and plans do you use to increase profitability in petrochemical projects when making a plan for the maintenance and operation of petrochemical machinery?

Expert 1: We use methods and techniques related to data analysis and the use of smart systems to determine the status of equipment, operating condition, and the extent of their need for maintenance and to track faults periodically and regularly. This procedure reveals the locations of faults in equipment that can be quickly avoided before they turn into major uncontrollable risks, which contributes to reducing maintenance costs and improving financial returns.

Expert 2: We work on using artificial intelligence systems and automatic control of machinery and equipment in the field of maintenance and operation to monitor the production process.

Expert 3: Proactive preventive maintenance plans can be adopted and modern technology can be used to enhance operational efficiency and increase the service life of equipment.

2- How can risk management strategies (risk avoidance, risk prevention, risk control, and risk transfer) be used optimally to improve the financial aspects of petrochemical projects? Do they reduce maintenance costs? Increase profitability? Improve operating efficiency?

Expert 1 and 2: Risk avoidance assessment can be used by conducting periodic updates to the mechanisms, equipment, and technology necessary to increase operational efficiency, which can avoid any risks represented by increased or worsening malfunctions. As for risk prevention technology, strategic maintenance plans can be prepared that include preventive inspection and conducting training workshops for workers on maintenance and operation processes. Risk can also be controlled by adopting advanced remote-control systems to track performance and manage the risks that occur. Risk can also be transferred by contracting with maintenance teams from outside the company, consisting of experts and specialists.

Expert 3: Risk can be avoided according to good knowledge of equipment and machinery design to understand malfunctions when they occur and the possibility of dealing with them, while risk can be prevented by adopting regular audits and market-driven updates. Risk control can be done through continuous monitoring of mechanisms and equipment. Risk can also be transferred by contracting with insurance companies.

3- What are the most important potential risks that you face when completing projects that require maintenance and operation of machinery manufactured for petrochemical products, and what are the possible ways to identify, determine and reduce them?

First expert: The most important risks facing petrochemical manufacturing companies are unskilled labor, weak maintenance team, lack of sufficient knowledge of how to operate equipment, health problems resulting from toxins and chemical vapors released, in addition to

lifting heavy loads, electrical shocks and fires. These risks vary from one company to another, and these risks can be identified based on the experience and previous experiments of the company itself or other companies. It is necessary to identify these potential risks and then evaluate them using one of the common evaluation methods and means such as the risk matrix, and then start developing solutions and strategies to mitigate these risks according to each potential risk.

The second expert: I believe that the most influential risks in the petrochemical industries are the lack of machinery, the lack of workers, unskilled workers, the lack of raw materials or their late arrival, the inefficiency of suppliers and the lack of energy security. These risks can be assessed by finding appropriate risk indicators that suit each company and then proposing strategic plans based on experts and specialists in the field of risk management. The third expert: In my opinion, the delay in information or the lack of access to the information necessary to operate and maintain equipment represents a major risk that affects the cost and productivity. In addition, not working within a team and the lack of communication between engineering teams, maintenance teams and financial performance teams pose major risks in the field of equipment operation and maintenance. The impact of these risks can be assessed according to several factors that are studied by the company and setting standards and foundations for measuring them and then proposing strategies to solve them such as avoiding risk, controlling risk, transferring risk and preventing risk.

4- To what extent can risk management tools reduce the cost of petrochemical projects and enhance the financial profitability of petrochemical companies?

Expert 1, 2 and 3: The effectiveness of risk management tools in improving operational efficiency and reducing the cost resulting from maintenance and operation of petrochemical industry operations cannot be determined except by defining a plan and evaluating it through experts in the fields of risk management tools. It is possible to choose strategies for cost management and operational efficiency without obtaining any improvements. Therefore, improvement processes require experience and full knowledge of project planning.

5- Can you mention any practical applications from your previous experience in which risk mitigation strategies were applied to enhance the financial aspects of petrochemical projects?

Expert 1: In the recent projects I have undertaken, I was able to reduce 35% of the costs of maintenance through automated and intelligent systems for tracking faults in machinery

Expert 2: I have developed a plan based on conducting training workshops for workers to qualify them on the optimal use of equipment in addition to knowing the process of designing equipment to be able to carry out immediate maintenance operations and reduce this procedure costs by 30%

Expert 3: Adopting raw materials from reliable suppliers that do not contain any dirt or grime reduced maintenance costs by

10%

Chapter Five

Conclusion and Recommendation

5.1 Summary

This study has been executed to investigate impact of risk management strategies on financial aspects in petrochemical companies. To achieve this goal, the study comprised three steps, the first step based on executing surveying study adopting survey questionnaire targeting experts, specialists and labor in the field of petrochemical industries. The questionnaire survey comprised risk evaluation that have been identified according to several categories: operational risks, human risks, maintenance risks and environmental risks adopting extensive literature review. Also, questionnaire investigated evaluation of risk mitigation strategies in petrochemical industries that comprise risk retention, risk control, risk prevention and risk transfer. After data collection, statistical analysis using mean, I.R.R and risk index have been conducted to analyze data. Also, linear regression analysis has been used to study impact of risk mitigation strategies on financial aspects of petrochemical projects. Next, data obtained from Sankyu company have been analyzed using Minitab software. Data obtained comprise percentage of cost maintenance during 12 months where cost control charts and capability analysis have been used to analyze Sankyu company data before and after risk mitigation strategies to ensure that the maintenance costs are in within limits. The final step addressed qualitative analysis using structured interviews with three experts to ensure and investigate the results obtained. Finally, results concluded and recommended

5.2 Conclusion

This study has detected important results to answer the questions of the study than comprise investigating impact of risk management strategies on financial aspects in petrochemical projects.

5.2.1 Risk Evaluation affect on maintenance and operation in petrochemical projects

The evaluation process of the potential risks in petrochemical industries comprised the following outcomes:

- The most operational risks lead to cost overrun and have negatively impact on financial aspects of petrochemical projects are : Crane Lifting faults that cause deterioration in Production lines and pipes, Gasket damage/worn out result in Leakage of service fluid .The operational risks that occupy the second level in terms of significance are : Chemical concentration inside vessel due to cleaning result in O₂ deficiency, failure of valve lead to fluid leakage ,Increased gland packing wear and tear ,Service fluid loss and fire hazard, Inconsistent process output, Lack of proper suppliers. The third level of operational risks influence on financial aspects are: Oil escape from equipment during service, Corrosion in natural gas systems, Equipment operating errors, Lack of equipment, tube failure led to Intermixing of service fluid, Low flow, Loss of heat transfer. The risks factors occupy ranked as fourth level are: Lack of supply chain management and energy waste. The risks that form the fifth rank are: Delays of material supply and Production, storage and disposal of general waste result in pollution and fire. Risk index

(R.I) revealed that all operational risks assessed constitute high impact on financial Aspects in petrochemical companies.

- The most maintenance risk led to cost overrun and have negatively impact on financial aspects of petrochemical projects is Flying of welding Flash. The maintenance risks that occupy the second level in terms of significance are: Filter Cleaning & Replacement lead to Chemical powder inhalation and Reactor Cleaning & Inspection can lead to lead to release hazardous material into atmosphere. The third level of maintenance risks influence on financial aspects are: Release Chemicals hazardous material into atmosphere as a result of Pipe lines Modification, Scaffolding collapse, Filter Cleaning & Replacement result in Product spillage, Pump Strainer Cleaning result in Product splash, Reactor Cleaning & Inspection can lead to lead to Emission of Fumes and Smoke. The risk factor ranked as fourth level is Electrocution. The risk factor ranked as fifth level are: Valve Replacement led to Release Chemicals into atmosphere. The final factors ranked as six in terms of significance impact are: Fire & Explosion and Exposing Ultraviolet or IR. Risk index (R.I) revealed that all, maintenance risks assessed constitute high impact on financial Aspects in petrochemical companies.

- The most environmental risk led to cost overrun and have negatively impact on financial aspects of petrochemical projects are high temperature and wind speed. The environmental risks that occupy the second level in terms of significance are is probability of Rain. The third level of environmental risks influence on financial aspects is. Risk index (R.I) revealed that all, environmental risks range in terms of impact from low to med high.

- The most human risk led to cost overrun and have negatively impact on financial aspects of petrochemical projects is Lack of managerial processes. The human risks that occupy the second level in terms of significance are: Lack of supplying information, Lack of communication result in shortage in inaccurate maintenance, Lack of knowledge of operating machines and plants. The third level of human risks influence on financial aspects are: Insufficient training, Poor knowledge of the original design of the equipment by the maintenance team, Lack of communication result in shortage in inaccurate maintenance, Lack of supplying information. The risks factors occupy ranked as fourth level are: Poor knowledge of the original design of the equipment by the maintenance team, Lack of skilled maintenance staff, Lack of skilled labor to operate plant, equipment and machines, Lack of regular checks for machines and plants, Lack of regular checks for machines and plants, Delay to make decision for maintenance processes. Risk index (R.I) revealed that all human risks assessed constitute high impact on financial Aspects in petrochemical companies.

-Control charts and capability process of maintenance cost data obtained from Sankyu company and analyzed using Minitab v.19 showed lack of company of controlling maintenance cost and consequently cost overrun occurs.

-The structured interviews conducted proved the potential risks identified in the surveying study.

5.2.2 Impact of risk retention tool on the project's financial performance

- The most risk retention strategies positively impact on financial aspects of petrochemical projects and reduce costs are: Waste shall be stored securely, Control Fatigue Gas Detection, Oil Detection, Overpressure Detection. The risk retention strategies that occupy the second level in terms of significance are: Management consider and calculate risk management during the initial project planning, Regular intervals workshop and program shall be organized,

Regular intervals workshop and program shall be organized, introducing new technology, Operation and maintenance as per manufacturer's instructions and minimize the consumption of natural resources. The third level of risk retention strategies influence on financial aspects are: Equipment High Temperature Detection and using Cooling System, Equipment High Temperature Detection and using Cooling System, Proper grounding, Training and awareness Programs. The risk retention strategies factor ranked as fourth level is ensure following company rules.

5.2.3 Impact of risk control tool on the project's financial performance

-The most risk control strategies positively impact on financial aspects of petrochemical projects and reduce costs is: Proper communication channel. The risk control strategies that occupy the second level in terms of significance are: Toxic Air Control, Limit hydrocarbon leak Dike, Management & employees are involved in periodic review and risk management planning exercise to monitor, identify and manage risks, Quality checking of service fluids at laboratory, Regular monitoring & checking that waste is disposed as per the requirements. The third level of risk control influence on financial aspects are: Control Corrosion via Shock and Vibration absorber, The management use specific risk management tools to control and manage risk, conduct regular checks, inspect sites with QHSE Patrols and regular audit, implement follow-up system, Commercial regular follow up with suppliers. The risk control strategies factor ranked as fourth level are: Any spilled must be cleaned as soon as possible using an appropriate procedure/instruction and Regular monitoring & checking for the leakage.

-The results showed that risk control strategy has a positive impact on financial aspects of petrochemical projects where the regression coefficient value is $\text{Beta} = 0.934$ at significance level 0.00.

-The structured interviews conducted proved that the risk control strategy is efficient tool in to control financial aspects in petrochemical industries

-Control charts and capability process of maintenance cost data obtained from Sankyu company and analyzed using Minitab v.19 showed that risk control strategy that the company adopted to control maintenance cost could control maintenance costs within limits.

5.2.4 Impact of risk prevention tool on the project's financial performance

-The most risk prevention strategies positively impact on financial aspects of petrochemical projects and reduce costs are: Safe handling techniques shall be employed. The risk prevention strategies that occupy the second level in terms of significance are: Frequent review of client needs and strategy. The third level of risk prevention strategies influence on financial aspects are Standby firefighting equipment. The risk prevention strategies factor ranked as fourth level are: Prevent Vibrating Resonance Effect via Shock and Vibration absorber, Prevent Presence of Oxygen Detection via Oxygen Remover, Process Shutdown, Prevent Temperature Rise High by Temperature Detection and Process Shutdown and Personal Protective Equipment Insurance. The risk prevention strategies factor ranked as fifth level are: Prevent Internal Overpressure via Overpressure Detection, Process Shutdown, Clogging Detection, Cartridge Respirator must be use, Use Electrical Rated Gloves, Ensure Scaffold or Platform are safe.

- The results showed that risk prevention strategy has a positive impact on financial aspects of petrochemical projects where the regression coefficient value is $\text{Beta} = 0.964$ at significance level 0.00.
- The structured interviews conducted proved that the risk prevention strategy is efficient tool in to control financial aspects in petrochemical industries
- Control charts and capability process of maintenance cost data obtained from Sankyu company and analyzed using Minitab v.19 showed that risk prevention strategy that the company adopted to control maintenance cost could control maintenance costs within limits.

5.2.5 Impact of risk transfer tool on the project's financial performance

- The most risk transfer strategies positively impact on financial aspects of petrochemical projects and reduce costs using asset management systems to track equipment status. The risk transfer strategies that occupy the second level in terms of significance are: hiring leases instead of outright purchase of equipment, Purchasing Extended warranties from equipment manufacturers, Machinery Breakdown Insurance. The third level of risk transfer strategies influence on financial aspects are: Develop comprehensive contingency plans to address any major breakdowns, using smart monitoring systems to continuously track equipment performance, periodic maintenance contracts with specialized companies and Mechanize processes and build improvements. The risk transfer strategies factor ranked as fourth level are: Partnerships with specialized maintenance companies, Equipment Insurance, Detect Crack Propagation Inspection and Maintenance. The risk transfer strategies factor ranked as fifth level is Skilled & certify people allow to work only.
- The results showed that risk transfer strategy has a positive impact on financial aspects of petrochemical projects where the regression coefficient value is $\text{Beta} = 0.951$ at significance level 0.00.
- The structured interviews conducted proved that the risk transfer strategy is efficient tool in to control financial aspects in petrochemical industries
- Control charts and capability process of maintenance cost data obtained from Sankyu company and analyzed using Minitab v.19 showed that risk transfer strategy that the company adopted to control maintenance cost could control maintenance costs within limits.

5.3 Recommendations

Based on the findings gained in this study, the following recommendations have been developed:

- It is recommended academics and researchers to conduct more studies in the field of risk management in petrochemical companies.
- It is recommended the industrial companies in KSA to consider the potential risks and risk management tools during planning stage of petrochemical companies to reduce costs.

References

- Ahmad, W. N. K. W., Rezaei, J., Tavasszy, L. A., & de Brito, M. P. (2016). Commitment to and preparedness for sustainable supply chain management in the oil and gas industry. *Journal of environmental management*, 180, 202-213.
- Al-Shatti, A., Al-Rakdan, A., & Al-Khaldy, A. (2015, October). Major Incidents Prevention and Sharing Lessons Learnt in Oil Field. In *SPE Asia Pacific Oil and Gas Conference and Exhibition* (pp. SPE-176064). SPE.
- Ancione, G., Paltrinieri, N., & Milazzo, M. F. (2020). Integrating real-time monitoring data in risk assessment for crane related offshore operations. *Journal of Marine Science and Engineering*, 8(7), 532.
- ABESI, M. (2017). Technical inspection in petrochemical plants.
- Ahmadi, M., Behzadian, K., Ardeshir, A., & Kapelan, Z. (2017). Comprehensive risk management using fuzzy FMEA and MCDA techniques in highway construction projects. *Journal of Civil Engineering and Management*, 23(2), 300-310
- Akhtar, M. H., & Asif, M. (2017). Evaluating managerial efficiency of petrochemical firms in Saudi Arabia. *Benchmarking: An International Journal*, 24(1), 244-256.
- Alhassan, Mohammad Mabruk. 2016. Exploring Project Risk Management Practices of Ghanaian Building Contractors. Kumasi: Kwame Nkrumah University of Science and Technology
- Aljohani, M, (2021), PROCESS SAFETY MANAGEMENT IN THE PETROCHEMICAL INDUSTRY: A COMPARATIVE STUDY BETWEEN THE KINGDOM OF SAUDI ARABIA AND THE UNITED KINGDOM, Saudi Vision Document (2030). [Online]. Available at: file:///C:/Users/pc/Downloads/Saudi_Vision2030_EN%20(1).pdf
- Alsaadi, N., & Norhayatizakuan, N. (2021). The impact of risk management practices on the performance of construction projects. *Studies of Applied Economics*, 39(4).
- Aven, T. (2016). Risk assessment and risk management: Review of recent advances on their foundation. *European Journal of Operational Research*, 253(1): 1-13
- Akadiri, O. P. (2011). Development of a multi-criteria approach for the selection of sustainable materials for building projects.
- Akbarpour, N., Hajiaghahi-Keshteli, M., & Tavakkoli-Moghaddam, R. (2020). New approaches in meta-heuristics to schedule purposeful inspections of workshops in manufacturing supply chains. *International Journal of Engineering*, 33(5), 833-840.
- Al Attar, L., Doubal, W., Al Abdullah, J., Khalily, H., Abdul Ghani, B., & Safia, B. (2015). Characterization of NORM solid waste produced from the petroleum industry. *Environmental technology*, 36(9), 1104-1113.
- AW, M. J., & oMAr Mk, M. (2015). Safety matters concerning timber scaffold board application in national oil and gas industry. *International Journal of Current Research and Academic Review. Special*, (2), 129-139.

- Andreeva, T., Zhulina, E., Popova, L., & Yashin, N. (2018). Integration of strategic and quality management in oil and gas companies of Russia. *Calitatea*, 19(163), 81-84.
- Bhandari P., "Normal Distribution | Examples, Formulas, & Uses," Scribbr, 2022.
- Bahadori, A., Nwaoha, C., & Clark, M. W. (2014). *Dictionary of oil, gas, and petrochemical processing*. Boca Raton: CRC Press.
- Bahadori, A. (2020). *Waste management in the chemical and petroleum industries*. John Wiley & Sons.
- Boulamanti, A., & Moya, J. A. (2017). Energy efficiency and GHG emissions: Prospective scenarios for the Chemical and Petrochemical Industry. *Report 9789279657344, EU Science Hub*.
- Bouafia, A., Bougofa, M., Rouainia, M., & Medjram, M. S. (2020). Safety risk analysis and accidents modeling of a major gasoline release in petrochemical plant. *Journal of Failure Analysis and Prevention*, 20(2), 358-369.
- Bijańska, J., & Wodarski, K. (2014). Risk management in the planning of development projects in the industrial enterprises. *Metallurgija*, 53(2), 276-278.
- Butt, M. H., Iqbal, S., Saddique, M. A., & Shahid, H. (2021). The effect of risk management at project planning phase on performance of construction projects in Pakistan. *Journal of Business and Social Review in Emerging Economies*, 7(1), 107-117.
- Bazin, N. (2017). Project and risk management – 4. Initiation of Risks Management Plan. 13-16 February 2017: VIA University College, Denmark.
- Banaitiene, N., & Banaitis, A. (2012). Risk management in construction projects. *Risk management-current issues and challenges*, 429-448.
- Balkhyour, M. A., Ahmad, I., & Rehan, M. (2019). Assessment of personal protective equipment use and occupational exposures in small industries in Jeddah: Health implications for workers. *Saudi journal of biological sciences*, 26(4), 653-659.
- Clancy, S. A., Worrall, F., Davies, R. J., & Gluyas, J. G. (2018). The potential for spills and leaks of contaminated liquids from shale gas developments. *Science of the Total Environment*, 626, 1463-1473.
- Chen, M., Wang, K., Guo, H., & Yuan, Y. (2019). Human factors of fire and explosion accidents in petrochemical enterprises. *Process safety progress*, 38(4), e12043.
- Cormican, K. (2014). Integrated enterprise risk management: From process to best practice. *International Journal of Modern Economy*, 5(4), 401–413. Available at: <https://doi.org/10.4236/me.2014.54039>.
- Ciucci, M., Vezzari, V., & Marino, A. (2023). Smart approach to integrated seismic risk management in major hazard industrial plants. *Procedia Structural Integrity*, 44, 347-354.
- Chineke, H. N., Adogu, P. O. U., Egenti, N. B., Ezemenahi, B. E., & Egwuatu, C. C. (2016). Occupational hazards among workers in petroleum-allied industries in Nigeria: A case study. *Journal of Environmental Science, Toxicology and Food Technology*, 10(7), 72-76.
- Chin, H. H., Varbanov, P. S., Klemeš, J. J., Benjamin, M. F. D., & Tan, R. R. (2020). Asset maintenance optimisation approaches in the chemical and process industries—A review. *Chemical Engineering Research and Design*, 164, 162-194.

- Dong, G., & Chen, P. (2016). A review of the evaluation, control, and application technologies for drill string vibrations and shocks in oil and gas well. *Shock and Vibration*, 2016(1), 7418635.
- DeRosa, S. E., & Allen, D. T. (2015). Impact of natural gas and natural gas liquids supplies on the United States chemical manufacturing industry: production cost effects and identification of bottleneck intermediates. *ACS Sustainable Chemistry & Engineering*, 3(3), 451-459.
- Duma, S. D., Makhanya, B. B., & Nel, H. (2021, December). A Systematic Literature Review on Industrial Fire and Explosion Accidents in the Petrochemical Industry. In *2021 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)* (pp. 1526-1530). IEEE.
- Elisson, A. (2017). Implementing SPC for non-normal processes with the I-MR chart: A case study.
- El-Borhamy, K., Elgarahy, A. M., Maged, A., & Kharbush, S. (2022). Evaluating the safe disposal of hydrocarbons present in the oil and gas plants prior to the periodic maintenance operation on the occupational safety and health. *Frontiers in Scientific Research and Technology*, 4(1).
- Ekefre, A., Ekanem, I. I., & Ikpe, A. E. (2024). Physical survey on the health hazards of welding activities on welding operators in Uyo, Nigeria. *Ibom Medical Journal*, 17(2), 302-312.
- El-Sherif, N., Mendler, R., Trotte, J., & Pathak, A. (2016). Ground-fault protection of personnel: The field applications of a Class C GFCI in a crude oil refinery. *IEEE Industry Applications Magazine*, 22(2), 54-59.
- Ebrahimia, M., Asadia, M., Akbarib, H., & Shakeric, A. (2012). Petrochemical industries and the opportunities provided by effective risk management: A case study. In *26th IPMA World Congress*.
- Filatova, Irina, Liubov Nikolaichuk, Dokka Zakaev, and Igor Ilin. "Public-private partnership as a tool of sustainable development in the oil-refining sector: Russian case." *Sustainability* 13, no. 9 (2021): 5153
- Gholami, P. S., Nassiri, P., Yarahmadi, R., Hamidi, A., & Mirkazemi, R. (2015). Assessment of Health Safety and Environment Management System function in contracting companies of one of the petro-chemistry industries in Iran, a case study. *Safety Science*, 77, 42-47.
- Groysman, A. (2017). Corrosion problems and solutions in oil, gas, refining and petrochemical industry. *KOM—Corrosion and Material Protection Journal*, 61(3), 100-117.
- George, R. A., Siti-Nabiha, A. K., Jalaludin, D., & Abdalla, Y. A. (2016). Barriers to and enablers of sustainability integration in the performance management systems of an oil and gas company. *Journal of cleaner production*, 136, 197-212.
- Hosseinnia Davatgar, B., Paltrinieri, N., & Bubbico, R. (2021). Safety barrier management: risk-based approach for the oil and gas sector. *Journal of Marine Science and Engineering*, 9(7), 722.
- Hopkinson, M. (2017). *The Project Risk Maturity Model: Measuring and improving risk management capability*. Routledge

Hussain ,A.,(2024), Navigating the Hazards: Understanding Risks in Petrochemical Plant Operations, [Navigating the Hazards: Understanding Risks in Petrochemical Plant Operations \(linkedin.com\)](#)

Hallowell, M. R., Molenaar, K. R., & Fortunato, B. R. (2013). Enterprise Risk Management Strategies for State Departments of Transportation. *Journal of Management in Engineering*, 114–122. [https://doi.org/10.1061/\(ASCE\)ME.1943-5479.0000136](https://doi.org/10.1061/(ASCE)ME.1943-5479.0000136).

Hassani, H., Silva, E. S., & Al Kaabi, A. M. (2017). The role of innovation and technology in sustaining the petroleum and petrochemical industry. *Technological Forecasting and Social Change*, 119, 1-17.

Huang, J., Chen, G., Shu, L., Wang, S., & Zhang, Y. (2016). An experimental study of clogging fault diagnosis in heat exchangers based on vibration signals. *IEEE access*, 4, 1800-1809.

Jung, S., Woo, J., & Kang, C. (2020). Analysis of severe industrial accidents caused by hazardous chemicals in South Korea from January 2008 to June 2018. *Safety science*, 124, 104580.

Jafarinejad, S., & Jiang, S. C. (2019). Current technologies and future directions for treating petroleum refineries and petrochemical plants (PRPP) wastewaters. *Journal of Environmental Chemical Engineering*, 7(5), 103326.

Jarvis, R., & Goddard, A. (2017). An analysis of common causes of major losses in the onshore oil, gas & petrochemical industries. *Loss prevention bulletin*, (255).

Jaderi, F., Ibrahim, Z. Z., & Zahiri, M. R. (2019). Criticality analysis of petrochemical assets using risk-based maintenance and the fuzzy inference system. *Process Safety and Environmental Protection*, 121, 312-325.

Khahro, S. H., Khahro, Q. H., Ali, T. H., & Memon, Z. A. (2023, January). Industrial Accidents and Key Causes: A Case Study of the Steel Industry. In *Proceedings of the 2023 10th International Conference on Industrial Engineering and Applications* (pp. 66-70).

Kim, Y. S., & Kang, H. W. (2017). Development of a model for risk and cost analysis in overseas plant construction projects focusing on petrochemical plant construction projects. *KSCE Journal of Civil Engineering*, 21, 1549-1562.

Kangavari, M., Salimi, S., Nourian, R., Omidi, L., & Askarian, A. (2015). An application of failure mode and effect analysis (FMEA) to assess risks in petrochemical industry in Iran.

Klemetti, Anna. 2006. Risk Management in Construction Project Networks (Report 2006/2). Helsinki: Laboratory of Industrial Management, Helsinki University of Technology.

Kozhemyatov, K. Y., & Bulauka, Y. A. (2019). The improving of the safety level of the equipment working under excessive pressure. In *Topical Issues of Rational Use of Natural Resources, Volume 2* (pp. 822-831). CRC Press.

Kangavari, M., Salimi, S., Nourian, R., Omidi, L., & Askarian, A. (2015). An application of failure mode and effect analysis (FMEA) to assess risks in petrochemical industry in Iran.

Kangavari, M., Salimi, S., Nourian, R., Omidi, L., & Askarian, A. (2015). An application of failure mode and effect analysis (FMEA) to assess risks in petrochemical industry in Iran.

Liu, J., Jin, F., Xie, Q., & Skitmore, M. (2017). Improving risk assessment in financial feasibility of international engineering projects: A risk driver perspective. *International Journal of project management*, 35(2), 204-211.

- Lachapelle, E., & Hundozi, B. (2018). ISO 31000:2018, Risk management–guidelines, www.pecb.com
- Eskander, R. F. A. (2018). Risk assessment influencing factors for Arabian construction projects using analytic hierarchy process. *Alexandria Engineering Journal*, 57(4), 4207-42
- Li, D. (2016). Perspective for smart factory in petrochemical industry. *Computers & Chemical Engineering*, 91, 136-148.
- Loganathan, M. K., Neog, S. S., & Rai, S. (2018, December). Process safety and performance improvement in oil refineries through active redundancy and risk assessment method-A case study. In *2018 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM)* (pp. 98-102). IEEE.
- Li, Z., Shao, S., Shi, X., Sun, Y., & Zhang, X. (2019). Structural transformation of manufacturing, natural resource dependence, and carbon emissions reduction: Evidence of a threshold effect from China. *Journal of cleaner production*, 206, 920-927.
- Matthews, L. R. (2020). Factors associated with unsafe work behaviours in an Iranian petrochemical company: perspectives of workers, supervisors, and safety managers. *BMC Public Health*, 20, 1-13.
- Morag, I., Chemweno, P., Pintelon, L., & Sheikhalishahi, M. (2018). Identifying the causes of human error in maintenance work in developing countries. *International Journal of Industrial Ergonomics*, 68, 222-230.
- Μοσχολιάννη, Ε. Ν. (2023). *Failure mechanisms in heat exchangers* (Bachelor's thesis).
- Moktadir, M. A., Ali, S. M., Rajesh, R., & Paul, S. K. (2018). Modeling the interrelationships among barriers to sustainable supply chain management in leather industry. *Journal of cleaner production*, 181, 631-651.
- Mhetre, Krantikumar, Konnur Amarsinh, and Landage Amarsinh. 2016. Risk Management in Construction Industry. *International Journal of Engineering Research* 5: 153–5.
- Murtaja, O., & Al Wattar, A. A. (2016). Enterprise Risk Management Analysis-Case Study of a Petrochemical Company in Qatar.
- Mollaalizadeh Zavardehi, S., Shiarbahadori, M., & Mahmoodirad, A. (2021). A Comprehensive Structural Equation Modeling for Financial Performance Evaluation of Petrochemical Companies. *Petroleum Business Review*, 5(2), 37-58.
- Motahari, A., Malmasi, S., & Haghighi Fard, N. J. (2015). Application of a multi-criteria decision-making approach for ranking environmental risks caused by petrochemical industries: a case study of a sodium carbonate production unit. *Human and Ecological Risk Assessment: An International Journal*, 21(2), 358-374.
- Narayanan, D. K., Ravooof, A. A., Jayapriya, J., Revathi, G., & Murugan, M. (2023). Hazards in oil, gas, and petrochemical industries. In *Crises in Oil, Gas and Petrochemical Industries* (pp. 71-99). Elsevier.
- Negara, I. M. Y., Fahmi, D., Asfani, D. A., Hernanda, I. S., Pratama, R. B., & Ksatria, A. B. (2021). Investigation and improvement of standard external lightning protection system: Industrial case study. *Energies*, 14(14), 4118.
- Nocco, B. W., & Stulz, R. M. (2006). Enterprise risk management: Theory and practice. *Journal of applied corporate finance*, 18(4), 8-20.

- O. K. Babatunde, "A reprise of TQM practices among construction enterprises in Nigeria," *The TQM Journal*, Aug. 2021, doi: 10.1108/TQM-01-2021-0018.
- Petrovic, Dario. 2017. Risk Management in Construction Projects: A Knowledge Management Perspective from Swedish Contractors. Available online: <https://www.semanticscholar.org/paper/Risk-Management-in-Construction-Projects-%3A-A-from-Petrovi%20C4%87/9ab4b371fc9a41a0b3bb6568bcfeeb0008cbdd20> (accessed on 12 April 2023).
- Potts, Keith, and Nii Ankrah. 2008. *Construction Cost Management: Learning from Case Studies*. London and New York: Taylor & Francis Group. ISBN 978-0-203-75294-4(EBK)
- PMI. 2017. *A Guide to Project Management Book of Knowledge (PMBOK Guide)*, 6th ed. Agile Guide. Newtown Square: PMI.
- Qureshi, M. I., Khan, N., Qayyum, S., Malik, S., Sanil, H. S., & Ramayah, T. (2020). Classifications of sustainable manufacturing practices in ASEAN region: A systematic review and bibliometric analysis of the past decade of research. In *Sustainability (Switzerland)* (Vol. 12, Issue 21, pp. 1–19). MDPI AG. <https://doi.org/10.3390/su12218950>.
- Qi, H., Zhou, Z., Irizarry, J., Deng, X., Yang, Y., Li, N., & Zhou, J. (2024). Modification of HFACS model for path identification of causal factors of collapse accidents in the construction industry. *Engineering, construction and architectural management*.
- Qin, X., Shao, L., & Jiang, Z. Z. (2020). Contract design for equipment after-sales service with business interruption insurance. *European Journal of Operational Research*, 284(1), 176-187.
- Rooshdi Raja Muhammad., 2018. Relative Important Index of Sustainable Design and Construction Activities Criteria for Green Highway
- Karim I., Kalya P. and Person A., 2020. Methods of Demographic Analysis, [online] Available at: <https://www.researchgate.net/publication/318438466_Methods_of_Demographic_Analysis
- Raut, R. D., Narkhede, B., & Gardas, B. B. (2017). To identify the critical success factors of sustainable supply chain management practices in the context of oil and gas industries: ISM approach. *Renewable and Sustainable Energy Reviews*, 68, 33-47.
- Ruqaishi, M., & Bashir, H. A. (2015). Causes of delay in construction projects in the oil and gas industry in the gulf cooperation council countries: a case study. *Journal of management in engineering*, 31(3), 05014017.
- Rovins, Jane E., Tom M. Wilson, Josh Hayes, and Steven J. Jensen. 2015. *Risk Assessment Handbook*. (GNS Science Miscellaneous Series; No. 84). GNS Science. Available online: <https://www.research.ed.ac.uk/en/publications/risk-assessment-handbook> (accessed on 12 April 2023)
- Rostami, P., & Rahimpour, M. R. (2023). Effect of hurricane and storm on oil, gas, and petrochemical industries. In *Crises in Oil, Gas and Petrochemical Industries* (pp. 135-152). Elsevier.
- Rahmatmand, B., Makarem, M. A., & Rahimpour, M. R. (2023). Hazardous materials and dust release in disasters of oil, gas, and petrochemical units. In *Crises in Oil, Gas and Petrochemical Industries* (pp. 217-237). Elsevier.
- Ragothaman, A., & Anderson, W. A. (2017). Air quality impacts of petroleum refining and petrochemical industries. *Environments*, 4(3), 66.

Sarstedt, M., Mooi, E., Sarstedt, M., & Mooi, E. (2019). Regression analysis. *A concise guide to market research: The process, data, and methods using IBM SPSS Statistics*, 209-256.

Saeidi, Parvaneh, Sayyede Parisa Saeidi, Saudah Sofian, Sayede Parastoo Saeidi, Mehrbakhsh Nilashi, and Abbas Mardani. 2019. The impact of enterprise risk management on competitive advantage by moderating role of information technology. *Computer standards & interfaces* 63: 67–82

Steyn, Jurie. 2018. Introduction to Project Risk Management: Part 1-Planning for project risk management. Available online: https://www.researchgate.net/publication/327981091_Introduction_to_Project_Risk_Management_Part_1-Planning_for_project_risk_management (accessed on 12 April 2023).

Serpell, Alfredo, Ximena Ferrada, Larissa Rubio, and Sergio Arauzo. 2015. Evaluating Risk Management Practices in Construction Organizations. *Procedia—Social and Behavioral Sciences* 194: 201–10.

Savchina, O., Bratanov, A., Konovalova, N., & Saksonova, S. (2021). Evaluation of financial condition and performance optimization of the petrochemical industry organization in the context of increased financial risks. *Universal Journal of Accounting and Finance*, 9(5), 1169-1183.

Serraino, Andrea. 2014. Introduction to Risk Assessment Terminology. *Italian Journal of Food Safety* 3. [CrossRef]

Sheetal, M. A. C. P. M., Marawar, D., & Bhalerao, M. N. V. (2016). A Methodology for Ranking of Causes of Delay for Residential Projects.

Shu, L., Mukherjee, M., Pecht, M., Crespi, N., & Han, S. N. (2017). Challenges and research issues of data management in IoT for large-scale petrochemical plants. *IEEE Systems Journal*, 12(3), 2509-2523.

Saloua, B., Mounira, R., & Salah, M. M. (2019). Fire and explosion risks in petrochemical plant: assessment, modeling and consequences analysis. *Journal of failure analysis and prevention*, 19, 903-916.

Sweis, R., Moarefi, A., Amiri, M. H., Moarefi, S., & Saleh, R. (2019). Causes of delay in Iranian oil and gas projects: a root cause analysis. *International Journal of Energy Sector Management*, 13(3), 630-650.

Tong, L., Pu, Z., Chen, K., & Yi, J. (2020). Sustainable maintenance supplier performance evaluation based on an extend fuzzy PROMETHEE II approach in petrochemical industry. *Journal of Cleaner Production*, 273, 122771.

Van Thuyet, N., Ogunlana, S. O., & Dey, P. K. (2019). Risk management in oil and gas construction projects in Vietnam. In *Risk Management in Engineering and Construction* (pp. 225-247). Routledge.

Vinnem, J. E., & Røed, W. (2015). Root causes of hydrocarbon leaks on offshore petroleum installations. *Journal of Loss Prevention in the Process Industries*, 36, 54-62.

Winarto, A. J., & Chariri, A. (2022). The effect of enterprise risk management and firm financial performance: empirical study on manufacturing companies listed on the Indonesia stock exchange. *Diponegoro journal of accounting*, 11(4).

- Wanasinghe, T. R., Gosine, R. G., James, L. A., Mann, G. K., De Silva, O., & Warrian, P. J. (2020). The internet of things in the oil and gas industry: a systematic review. *IEEE Internet of Things Journal*, 7(9), 8654-8673.
- Wirjo, A., & Pasadilla, G. O. (2016). Manufacturing of oil and gas industry equipment in Singapore. *Services in Global Value Chains: Manufacturing Related Services*, 239-79.
- Wu, W., Zheng, Y., Chen, K., Wang, X., & Cao, N. (2018, April). A visual analytics approach for equipment condition monitoring in smart factories of process industry. In *2018 IEEE Pacific Visualization Symposium (PacificVis)* (pp. 140-149). IEEE.
- Yin, Z., Caldas, C., de Oliveira, D., Hwang, B. G., & Shan, M. (2021). Mechanization level assessment and technology identification for productivity improvement in petrochemical facility maintenance. *Journal of Quality in Maintenance Engineering*, 27(1), 1-20.
- Yolchuyeva, U., Japharova, R., Vakhshouri, A. R., Khamiyev, M., Salmanova, C., & Khamiyeva, G. (2020). Photochemical investigation of aromatic hydrocarbons of Balakhani crude oil as petroleum luminophores. *Applied Petrochemical Research*, 10, 139-148.
- Zhang, Q., Qin, A., Shu, L., Sun, G., & Shao, L. (2015). Vibration sensor based intelligent fault diagnosis system for large machine unit in petrochemical industries. *International Journal of Distributed Sensor Networks*, 11(8), 239405.
- Zahiri Harsini, A., Ghofranipour, F., Sanaeinasab, H., Amin Shokravi, F., Bohle, P., &

Appendix A
Letter of Introduction

Ziyad Salem Awad Al-harbi

KSA

Dear Sir /Madam

Re: Request for Participation in Research Study

I am a postgraduate student at Midocean University

Faculty of Management – Department of Project Management undertaking a study entitled:
“Impact of Risk Management Techniques on the Financial aspects during Petrochemical
Project Planning” as a requirement for the Degree of Master’s in Department of Project
Management.

Since you are better placed to provide information required for this study, I have selected you
as my study respondent. You are kindly supposed to rate yourself as per the question items
given.

Please take a few minutes to respond to the questionnaire items. I assure you that your
answers will be kept completely confidential and will be used for academic purposes only.
Your participation in facilitating this study will be highly appreciated. Any assistance will be
highly appreciated. Thank you.

Yours faithfully

Sign.....Date.....

Ziyad Salem Awad Al-harbi

Midocean University

Faculty of management – Department of project Management

This questionnaire is to gather information to investigate impact of risk mitigation strategies on financial aspects of petrochemical projects.

Section A: Demographic Information

1. what is your scientific qualification?
 - a. Bachelor
 - b. Diploma
 - c. Master Degree
 - d. PHD
 - e. Other
2. How long have you worked in industrial companies?
 - a. Less than 5 years
 - b. 5-10 years
 - c. 11-16 years
 - d. 16-20 years
 - e. More than 20 years

Section B: In this section, it is required to evaluate the significant level of risks identified in petrochemical industries according to several categories: operational risks, maintenance risks, environmental risks, human risks.

Operational Risks

Symb ol	Operational Risk	Significance level				
		1	2	3	4	5
O1	Chemical concentration inside vessel due to cleaning result in O2 deficiency					
O2	Crane Lifting faults that cause deterioration in Production lines and pipes.					
O3	Crane Lifting faults that cause Falling lifted object.					
O4	Oil escape from equipment during service.					
O5	Production, storage and disposal of general waste result in pollution and fire					
O6	Corrosion in natural gas systems					
O7	Gasket damage/worn out result in Leakage of service fluid					
O8	failure of valve lead to fluid leakage, Increased gland packing wear and tear, Service fluid loss and fire hazard, Inconsistent process output					
O9	tube failure led to Intermixing of service fluid, Low flow, Loss of heat transfer					

O10	Lack of equipment					
O11	Equipment operating errors					
O12	energy waste					
O13	Delays of material supply					
O14	Lack of proper suppliers					
O15	Lack of supply chain management					

Human Risks

Symbol	Human Risk	Significance Level				
		1	2	3	4	5
H1	Lack of skilled maintenance staff					
H2	Lack of skilled labor to operate plant, equipment and machines					
H3	Lack of supplying information					
H4	Lack of regular checks for machines and plants					
H5	Lack of communication result in shortage in inaccurate maintenance					
H6	Delay to make decision for maintenance processes					
H7	Poor knowledge of the original design of the equipment by the maintenance team					
H8	Lack of managerial processes					
H9	Lack of knowledge of operating machines and plants					
H10	Insufficient training					

Maintenance Risks

Symbol	maintenance Risk	Significance Level				
		1	2	3	4	5
M1	Release Chemicals hazardous material into atmosphere as a result of Pipe lines Modification					
M2	Filter Cleaning & Replacement result in Product spillage					
M3	Filter Cleaning & Replacement lead to Chemical powder inhalation.					
M4	Pump Strainer Cleaning result in Product splash					
M5	Reactor Cleaning & Inspection can lead to Fire & Explosion					
M6	Reactor Cleaning & Inspection can lead to lead to Emission of Fumes and Smoke.					
M7	Scaffolding collapse					
M8	Reactor Cleaning & Inspection can lead to lead to release hazardous material into atmosphere					
M9	Flying of welding Flash.					
M10	Valve Replacement led to Release Chemicals into atmosphere.					
M11	Electrocution					
M12	Fire & Explosion.					
M13	Exposing Ultraviolet or IR.					

Environmental Risks

Symbol	Compliance Risk	Significance level				
		1	2	3	4	5
E1	Rain					
E2	High temperature					
E3	storm					
E4	Wind speed					
E5	Earthquakes					
E6	Fire					

Section B: In this section, it is required to evaluate the significant level of risk mitigation strategies identified in petrochemical industries according to several tools: risk retention, risk control, risk prevention, risk transfer

. Risk Retention

Symbol	Risk Retention	Significance Level				
		1	2	3	4	5
RR1	Waste shall be stored securely					
RR2	Minimize the consumption of natural resources.					
RR3	Operation and maintenance as per manufacturer's instructions.					
RR4	Introducing new technology					
RR5	Training and awareness Programs.					
RR6	Ensure following company rules					

RR7	Regular intervals workshop and program shall be organized					
RR8	Proper grounding.					
RR9	Management consider and calculate risk management during the initial project planning					
RR10	Equipment High Temperature Detection and using Cooling System					
RR11	Control Fatigue Gas Detection, Oil Detection, Overpressure Detection					

Risk control

Significance Level	Significance Level	Significance Level				
		1	2	3	4	5
RC1	Regular monitoring & checking for the leakage.					
RC2	Regular monitoring & checking that waste is disposed as per the requirements.					
RC3	Any spilled must be cleaned as soon as possible using an appropriate procedure/instruction.					
RC4	Commercial regular follow up with suppliers.					
RC5	Proper communication channel					
RC6	implement follow-up system					

RC7	Conduct regular checks, inspect sites with QHSE Patrols and regular audit.					
RC8	Management to be updated as and when required and continuous communication					
RC9	Quality checking of service fluids at laboratory					
RC10	Management & employees are involved in periodic review and risk management planning exercise to monitor, identify and manage risks					
RC11	The management use specific risk management tools to control and manage risk					
RC12	Control Corrosion via Shock and Vibration absorber					
RC13	Limit hydrocarbon leak Dike					
RC14	Toxic Air Control					

Risk prevention

Symbol	Risk prevention	Significance Level				
		1	2	3	4	5
RP1	Safe handling techniques shall be employed					
RP2	Personal Protective Equipment Insurance					
RP3	Frequent review of client needs and strategy					
RP4	Ensure Scaffold or Platform are safe.					
RP5	Use Electrical Rated Gloves.					

RP6	Trained in Work at Height					
RP7	Cartridge Respirator must be use.					
RP8	Standby firefighting equipment.					
RP9	Prevent Temperature Rise High by Temperature Detection and Process Shutdown					
RP10	Prevent Internal Overpressure via Overpressure Detection, Process Shutdown, Clogging Detection					
RP11	Prevent Presence of Oxygen Detection via Oxygen Remover, Process Shutdown					
RP12	Prevent Vibrating Resonance Effect via Shock and Vibration absorber					
RP13	Prevent Ignition Source Isolation, Emergency Shutdown Initiation, Electrical Isolation					

Risk transfer

Symbol	Risk Transfer	Significance Level				
		1	2	3	4	5
RT1	Suppliers' performance evaluation					
RT2	Mechanize processes and build improvements					
RT3	Skilled & certify people allow to work only					
RT4	Detect Crack Propagation Inspection and Maintenance					
RT5	Equipment Insurance					
RT6	Machinery Breakdown Insurance					
RT7	periodic maintenance contracts with specialized companies					

RT8	Purchasing Extended warranties from equipment manufacturers					
RT9	Partnerships with specialized maintenance companies					
RT10	Using smart monitoring systems to continuously track equipment performance					
RT11	Using asset management systems to track equipment status					
RT12	hiring leases instead of outright purchase of equipment					
RT13	Develop comprehensive contingency plans to address any major breakdowns					

