INVESTIGATING THE NATURALISTIC DECISION MAKING ROLE OF BUSINESS INTELLIGENCE IN THE OIL AND GAS INDUSTRY

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ABSTRACT

This study aims to investigate the naturalistic decision-making role of business intelligence (BI) in the oil and gas (O&G) industry. O&G organisations spend a lot of time, effort and resources in maximising their operations to gain a competitive advantage. With the introduction of technological solutions, BI provides organisations with the ability to collect, sort, analyse and transform data into timely intelligence. However, the industry is characteristically competitive, difficult to predict and continuously changing with decision-makers sometimes faced with naturalistic decisions necessitating quick decisions under pressure, strict timeframes and with incomplete data.

Literature on the role BI in the O&G industry has been minimal, with the focus being on how BI is used to assist rational decision-making. This study relies on data collected from two O&G organisations operating in different streams of the industry. Using a dynamic model of situated cognition, this study employs an interpretive, qualitative approach to data analysis in an attempt to fill the gap in the literature and determine whether BI plays any role in facilitating the decision-making process in response to naturalistic decisions. A dynamic model of situated cognition has been employed because of its strong correlation with naturalistic decision-making (NDM).

The findings of this study indicate that different naturalistic decisions exist in the two streams of the industry and these decisions vary in their levels of complexity and domains. Furthermore, the findings show that while BI plays a major role NDM, this role is mitigated by the cognitive capabilities of individual decision-makers and their areas of expertise.

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GLOSSARY

Actual Situational Awareness (ASA): is the true level of situation awareness of an individual decision maker, measured by comparing what the factors the decision maker considered when making a decision and how he/she perceived any changes that occurred to them, compared to the ground truth and cross referenced with other decision maker's PSA levels.

Bounded rationality: is the idea that when individuals make decisions, their rationality is limited by the tractability of the decision problem, the cognitive limitations of their minds, and the time available to make the decision.

Business Intelligence (BI): is a way and method of improving business performance by providing powerful assets for executive decision-makers to provide them with actionable information

Cognitive Capabilities: are brain based skills; individual participants use to carry out tasks. They are concerns with the ability for individuals to learning remembering through mental cues when problem solving.

Crude Oil: is a naturally occurring, unrefined petroleum

Cues: A stimulus, either consciously or unconsciously perceived, that elicits or signals a type of behaviour.

Deadweight: is a measure of how much weight a ship is carrying or can safely carry

Knowledge Management: efficient handling of information and resources within a commercial organization.

Laycan: Period during which the ship-owner must tender notice of readiness to the charterer that the ship has arrived at the pod of loading and is ready to load

Naturalistic Decision Making (NDM): is the study of how experienced individuals in dynamic, uncertain, and often fast-paced environments, identify and asses their situation, make decisions and take actions whose consequences are meaningful to them and the larger organization in which they operate.

Storage Tank: a container or reservoir that temporarily holds oil in the various stages of processing into other oil products, or before it is used or consumed.

Perceived Situational Awareness (PSA): is the level of perceived awareness of an individual decision maker with the decision faced, the factors likely to influence the decision and how the dynamic of these factors are changing or likely to change.

Pipelines: a long pipe, typically underground, for conveying oil, gas, over long distances.

Rational Decision-Making Approach: is a multi-step process for making choices between alternatives. The process of rational decision-making favours; logic, objectivity, and analysis over subjectivity and insight.

Situational Awareness (SA): represents an individual' perception of the elements in an environment within a volume of space and time, the comprehension of what these elements represent, and the projection of their status.

The Ground Truth: it is represented by an outcome of a naturalistic decision, the factors that influenced the decision and how they evolved overtime

CHAPTER 1

INTRODUCTION

1.1 Overview

This chapter introduces the research problem at hand. Section 1.2 outlines background information to the research problem that informed the development of the research question. Section 1.3 lists the aim, research questions and objectives of the study. Section 1.4 describes the data collection methods, research design and methods of analysis employed in this study. Section 1.5 describes the structure of the thesis. Finally, Section 1.6 provides a summary of the key points discussed throughout this chapter.

1.2 Background

The O&G industry is often characterised as being unstable and continuously changing, with decision-makers within the industry relying more than ever before on timely data in order to make better decisions. Since the turn of the last century, advances in technology have seen more and more companies in the industry beginning to adopt sophisticated BI systems for the gathering, sorting and analysing data. The adaption of BI has allowed companies to excel at identifying where their profit advantage lies and how best to capitalise on this advantage. Some executives within the industry continue to stress the essential role of BI in the industry. For example, according to Gary Linsing, Vice President and Chief Information Officer (CIO) for Hess Corporation, data drives everything within the industry. According to Nash (2008), multinational oil corporations spend a lot of resources to gathering internal and external data, whilst factoring in influences such as war, weather and global politics. According to Ranjar (2009) BI aides companies in different ways such as; establishing their market position in relation to their competitors, any behaviour or financial changes in the company's customer base, the strengths and weaknesses of the company, the current and future state of the market and its trends, and the social and political environment in which the organisation operates. According to Kyper et al. (2012), BI

supports three distinct types of users: (a) executives, who need BI for strategic information to gauge the health of an organisation; (b) analytical users, who use it for managing and planning the organisation's goals; and (c) operational users, who use BI for frequently occurring short-term decisions.

However, despite the above, BI is a considered to be a defused technology as no sufficient research been conducted in identifying how the tools of the systems are being used in real world settings. Furthermore, the unstable and dynamic nature of the O&G industry means that decision-makers occasionally have to make decisions whilst not in possession of all the necessary data or facts to inform their decision-making. Such decisions affect not only the organisation financially, but also the individual decision-maker at the time of having to make the decision. Decisions of this nature are what are commonly referred to as naturalistic decision-making (NDM). NDM has been widely discussed in the literature, including Klein's (1987) Recognition Primed Decision (RPD), which describes the different stages decision-makers go through during the process of making a decision using the NDM approach. This model involves the decision-maker spending more time analysing the situation they face rather than the different actions that might be undertaken. Furthermore, NDM allows decision-makers to develop what is describes as situational awareness (SA), which represents the decision-maker's level of perception of all the elements affecting the environment, their comprehension of what these elements mean and how these elements are likely to interact in the future. Randel et al. (1996), in their study comparing the level of situation awareness between novice decision makers and experts found that a high level of SA when faced with naturalistic decisions is correlated with better decision-making outcomes. However, the role of BI when organisations are faced with such decisions is unclear, and there is a significant gap in the literature concerning the application of NDM in the industry.

Furthermore, the only model that takes into account the influences, contributions and architecture of technological systems in the decision-making process is the Dynamic Model of Situation Cognition (DMSC) (Shattuck and Miller, 2006). However, the application of

DMSC and RPD models have been limited to fields of aviation, traffic control and the military.

Finally, there are different decision making approaches individuals could use, when facing naturalistic decisions, where NDM is not appropriate due to individual's lack of prior or expert knowledge on the subject. These approaches had been discussed extensively in the literature and include: *The Incremental Model* where decision makers should choose a less controversial decision which is aligned with their organisation's current policies (DeVault, 2011), *The Programme Approach* where decision makers deal with uncertainty by reverting to the traditional cultural guidelines set by the company during the decision making process (Huber, 1981), and finally, *The Individual Difference Perspective*, which is explained as the idea that the background, personality and managerial style of individual decision-makers lead them towards the adoption of specific decision-making methods and courses of action that differ from other individuals with different personality characteristic (Turpin and Marais, 2004).

1.3 Aims and Objectives

The study aims to investigate the role of BI in O&G industry-related naturalistic decisions.

In order to achieve the study's aim, a number of objectives have been established, including:

- Conduct a literature review related to:
    i. BI, in order to gain a better understanding of what it is, where it has been applied, its components, the domains in which it has been applied and the role it plays in the O&G industry;
    ii. NDM, in order to gain a better understanding of what it is, how it differs from conventional decision-making frameworks, where it has been applied and the different theoretical models developed to explain the process,
- Evaluate the different research methods that can be used to conduct the study and their underlying philosophical foundations, with justification for the methods chosen for data collection and analysis,

- Collect data using the methods chosen from two multinational O&G organisations,
- Conduct initial data analysis using cognitive mapping in order to aid in the coding and visible representation of the data collected,
- Modify the dynamic model of situated cognition in order to analyse the flow of the decision-making process, and
- Present the findings on the study and its implication/contributions on theory and practice.

1.4 Research Methodology

Research methods employed in this study are largely determined by the study's aim and objectives. This study aims to understand the NDM role of BI in the O&G industry. Therefore, in order to gain an understanding of how decision-makers within the industry make such decision, and if and to what extent they rely on BI in the making of such decisions, an interpretive approach using qualitative research methods and a multiple case study design has been employed, the reason for selecting an interpretive approach was due to the fact that the present study, is focused on complex human sense-making, as situations emerge and decisions are made in naturalistic settings. Therefore, the only way to gain access to knowledge in this setting is through the social constructions of individual participants.

The multiple case design (Eisenhardt, 1989) was adopted simply because there was a need to collect more detailed data concerning what naturalistic decisions exist in both sectors of the industry (upstream and downstream), how individuals operating in these various sectors go about making naturalistic decisions and the level of reliance and differences in reliance in these sectors. In addition, multiple data collection methods were employed, namely participant observations, interviews and focus groups.

Furthermore, to ensure information richness the researcher ensured carefully selecting the appropriate participants who could best inform the study, and the adequate sampling of organisations and, scenarios in order to fully address the research question and to arrive at a full description of the phenomenon being studied (Fossey et al., 2002). Therefore, Purposeful snowball sampling was used in order to recruit the organisations and individual

participants from within them as it was deemed necessary to ensure the richness of the data collected

Multiple data analysis methods were used to analyse the data, including standard qualitative data analysis procedures discussed by Lacy and Luff (2007), cognitive mapping for the coding and the visible representation of data at an early stage of the analysis, and the modification of the DMSC for the tracing and analysis of the flow of the decision-making process. Finally, a measuring technique was developed to analyse individual participants' levels of SA throughout the decision-making process.

1.5 Structure of this Thesis

The first chapter of this thesis provides an introduction into the subject matter of the study, the nature of the O&G industry, the use of BI in the industry for decision-making and NDM. It further introduces the research aims by introducing the research question and objectives, the methods used to conduct the study and the structure of the thesis

The second chapter of the thesis presents a review of the BI literature, the definition of BI, its components, advantages and technological tools and capabilities. Furthermore, this chapter presents literature on decision-making, with a strong focus on NDM, its application and frameworks, and cognitive activities associated with NDM.

The third chapter explores existing traditions related to sense-making and information systems, with specific focus on the research philosophies and theoretical assumptions made in these fields. This chapter also describes the research design and provides an overview of data collection and analysis methods, with justification given for the choice of methods ultimately embraced for the purposes of the present study. Finally, a brief overview on the O&G industry, the subject of the inquiry and the companies taking part in the study is presented.

Chapters 4 and 5 present the data collected from both companies. Both chapters start with an introduction to the site where the study took place, provide an overview of the company's BI system and its capabilities as described by the BI manager of the company and give an introduction to each of the selected scenarios or problems observed that meet

the characteristics of naturalistic decisions. Furthermore, this chapter includes data from observations and focus groups, an analysis of the level of reliance on the BI tools used by each of the participants, the decision-making outcomes and a retrospective analysis of each participant based on their decision recommendations and outcomes.

Chapter 6 takes the form of a discussion around the findings of the study and their implication on literature, theory and practice. This chapter describes the nature of the naturalistic decisions faced in the industry, the level of reliance on BI when faced with these decisions, and the implications and findings from the use of the DMSC in tracing the flow of the decision-making process. This sixth chapter will also explore the role played by cognitive mapping in the structuring and analysis of the data collected at the beginning of the analysis. Similarly, this chapter describes the role of the real-time SA measuring technique developed to measure individual participants' Perceived Situation Awareness (PSA) and Actual Situation Awareness (ASA) levels at different stages of the process in comparison to the measurements discussed in the literature. Finally, a summary of the results is presented and their implications on the field are highlighted.

Chapter 7 presents a reflective summary of the study in relation to the research question, the contributions of this study to research in the fields of NDM and BI applications in the O&G industry and the practical implications of this study to the O&G industry. Furthermore, the chapter describes the limitations to the study and identifies areas of future research.

Figure 1 illustrates the structure of the research

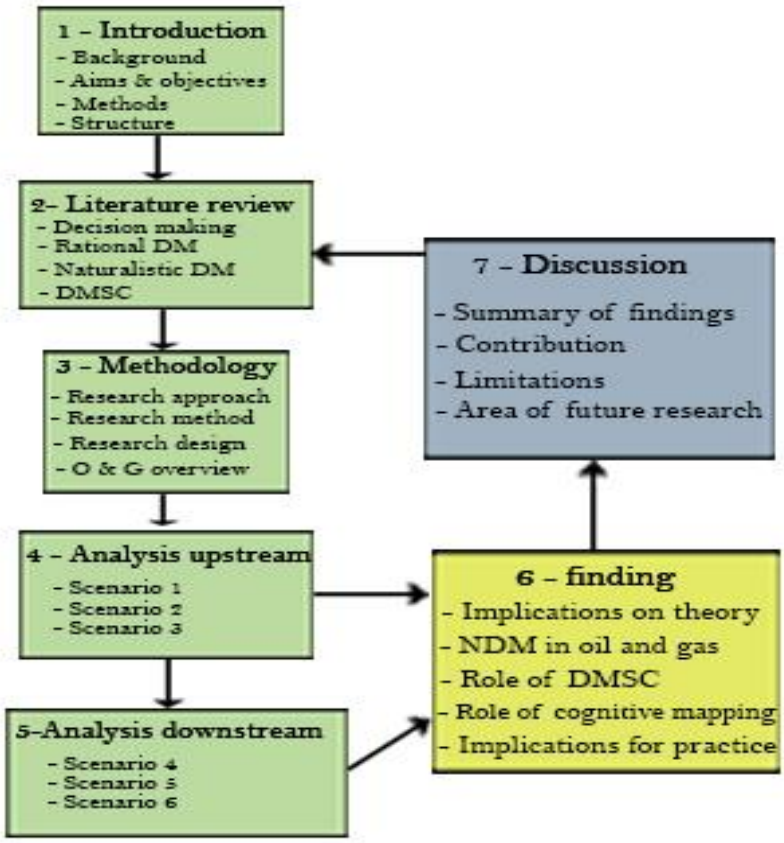


Figure 1 Research Structure

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter presents a review of the BI and decision-making literature, with a strong emphasis on NDM and SA. Section 2.2 of this chapter explores and defines BI, its definition, components, advantages and technological tools and capabilities. The literature then focuses on the role of BI in the O&G industry, making comparisons with other industries. Section 2.3 focuses on decision-making and the various approaches to decision-making as discussed in the academic literature, along with the fields in which these approaches have been developed. Section 2.4 provides an overview of the literature with respect to NDM, its application and frameworks, with a focus on the cognitive activities associated with NDM; in particular, SA and how it is measured and fields of application. Section 2.5 concludes this chapter by providing a summary of the topics discussed thus far.

2.2 Business Intelligence (BI)

Since the BI term was coined by Howard Dresdner about twenty years ago to describe an emerging discipline concerned with the discovery of information that a corporation was oblivious of (McKay, 2008), there has been a multitude of BI definitions offered by various academics, including Stackowiak et al. (2007) and Zeng et al. (2007). However, Cui et al. (2007) best summarised BI, describing it as a method of improving business performance by providing powerful assets for executive decision-makers to provide them with actionable information. BI tools are seen as technology that enables the efficiency of business operations by increasing the value of enterprise information and the way this information is utilised (Ranjan, 2009).

According to Kenney (2007), the need for BI arose as organisations found that they have much more data than they can analyse in a reasonable time frame. Kenney indicated that

one study of a major industry found that businesses within this industry accessed only 20% of their data, delivering that data to just 10% of the people who needed it to do their jobs.

2.2.1 Components of BI

Throughout the years, advances in technology have greatly affected the infrastructure, tools, applications and methodologies that make up a BI system. According to Agrotta and Sosa (2009), a traditional BI system comprises of:

- Data warehouses (Gill, 1996);
- Online Analytical Processing (OLAP) and related methods (e.g. MOLAP, ROLAP, etc.) (Brackett, 1996);
- Knowledge Discovery in Databases (KDD) and data mining (Piatetsky-Shapiro, 1991);
- Artificial intelligence areas and algorithms, such as machine learning and intelligent multi-agent systems;
- Artificial neural networks, fuzzy logic, case-based reasoning and pattern recognition; and
- Genetic algorithms, statistical analysis, or any algorithm, tool or method that serves to transform data into knowledge (Turban et al., 2005).

Ranjar (2009) similarly explained that BI includes software for use for extraction, transformation and loading (ETL), data warehousing, database query and reporting (Berson et al., 2002; Hall, 1999), multidimensional/online analytical processing (OLAP) data analysis, data mining and visualisation.

According to Kyper et al. (2012), BI supports three distinct types of users: (a) executives, who need BI for strategic information to gauge the health of an organisation; (b) analytical users, who use it for managing and planning the organisation's goals; and (c) operational users, who use BI for frequently occurring short-term decisions.

2.2.2 Advantages of BI

According to Ranjar (2009), companies who adopt BI are able to make well-informed business decisions, which is in itself a source of competitive advantage. Ranjar (2009, p64) noted that this is especially the case when firms are able to 'extrapolate information from indicators in the external environment and make accurate forecasts about future trends or economic conditions'. Ranjar found that BI can elucidate a company's market position in relation to their competitors, any behaviour or financial changes in the company's customer base, the strengths and weaknesses of the company, the current and future state of the market and its trends, and the social and political environment in which the organisation operates.

The ultimate objective of BI is to improve the timeliness and quality of information. According to Leon (2008, p81), 'timely and good quality information is like having a crystal ball that can give an indication of what's the best course to take'. Kyper et al. (2012) demonstrated that the use of a BI system for call centres gave such organisations a clear competitive advantage.

According to Tvrdíková (2007), incorporating BI solutions into integrated IT technologies within an organisation resulted in:

- A simpler and higher quality of work from all departments involved in decision-making at all organisational levels;
- Enhanced belief by users in the reliability of data; and
- The development of new solutions due to the increase in the effectiveness of the support units.

2.2.3 Tools of BI

BI manufacturers continue to develop tools for the gathering and end-user analysis of data. Ranjar (2009) explained that these tools include: business performance management and performance measurement tools to assess the health of an organisation, business planning tools to plan the appropriate direction of an organisation which should be aligned with its overall strategy, competitive analysis and decision support systems (DSS) and forecasting

tools to continue to analyse and gain a competitive advantage, customer relationship management (CRM), trend analysis and marketing tools in order to analyse and manage an organisation's customer base and improve its profitability, human resources, supply chain management tools to plan, organise and utilise the company's resources at a high level and finally, other reporting mapping, information visualisation and dash boarding for ease of end user access and analysis of data. Each manufacturer has their own set of tools that organisations can integrate or further develop to suit their needs, with most manufacturers also offering integration and implementation services.

2.2.4 BI in the O&G Industry

Researchers have given a lot of attention throughout the years to trying to understand the critical success factors in BI (Harrison, 2012; Ko and Abudulaev, 2007), data modelling (Tettamanzi et al., 2007), data optimisation (Vercllis, 2009) and the alignment of BI with business strategies (Kypra, 2012; Ranjar, 2005). Academics across various fields have highlighted the role of BI in their respective fields of interest, such as Mettler and Vimarlund (2009) in healthcare and Dell'Aguila et al. (2008) in the education domain. However, research on the true value of BI in any industry is scarce, with little empirical research on how end user BI tools are deployed within the O&G industry. Nash (2008), being one of the few examples of how BI is being used in the industry, indicated that BI allowed companies to excel at identifying where their profit advantage lies and how best to capitalise on this advantage. Nash (2008, p1) further indicated that senior executives from within the industry, including Gary Lensing VP and CIO for Hess Corporation, feel that companies have 'always lived and died on BI'. Nash (2008) also explained that multinational oil corporations spend a lot of resources gathering this internal and external data, whilst factoring in dynamic influences, such as war, weather and global politics. Notwithstanding, the use of BI in the industry is not as simplistic as buying a set of analysis tools and feeding them data. Oil companies ensure that information is passed through multiple layers of software, with nearly every employee focused on collecting and storing some kind of data. ExxonMobile, for example, ensures that their geologists learn and know various computer coding languages in order for them to analyse their own data quickly on the spot.

Baaziz and Quoniam (2013) investigated the role BI plays in the industry, examining ways to optimise operations in the upstream sector of the industry by modelling and optimising the data collected by organisations in the industry. Nonetheless, this does not give a clear understanding of what are the tools used in the industry, how they are being deployed, and to what extent. Therefore, there is evidently a clear gap within academic literature on the role of BI in the industry; this could be due to organisations keeping their technological advancements and capabilities confidential to gain and maintain their competitive edge. Alternatively, researchers might simply assume that everyone already understands how the system is used in the industry, negating the need for further research. However, the literature has so far focused on how BI can provide value and timely data for rational decision-making, such as upstream exploration decisions, which require months of analysis before production-level decisions are taken. The issue with this, however, is that no thought has been given to whether BI aids organisations in the industry at all when they are faced with naturalistic decisions, where the data is incomplete, and to factors such as market price, competitors, demand, supply, shipping war and political changes which are dynamically changing. This lack of research means that the role of BI in such situations is wholly unknown, and the level of reliance on it could be minimal, meaning that decision-makers in the industry might rely on their own cognitive capabilities rather than on the data provided by such BI systems.

2.3 Decision-Making

As this research is focused on understanding the decision-making aspect of BI, it is paramount to first reflect on the subject of decision making and its various approaches. Decision-making has been a subject of considerable interest amongst researchers for over a century. Academics from fields as diverse as cognitive informatics, cognitive science, computer science, psychology, management science, decision science, economics, sociology, political science and statistics have discussed the importance of decision-making in great detail and gradually developed new theories to aid executives in making effective decisions (Wang et al., 2004; Edwards and Fasolo, 2001; Hastie, 2001; Wilson et al., 2001; Matlin, 1998; Payne & Wenger, 1998; Pinel, 1997; Berger, 1990; Wald, 1950). Jenkis et al.

(2010) state that decision-making is fundamental to all human activities and plays a significant role in the safe and efficient running of sociotechnical systems.

Edwards (1954) discussed the psychological experiments that were undertaken by psychologists and economists to evaluate theoretical decision-making theories, such as riskless choice theory. However, most executives at that point in time were relying on what was called the *intuition approach*, whereby an executive relies on their personal experience when judging a particular situation, using past experiences to make decisions (Huber, 1981). The author indicated that this technique was very suitable when executives were faced with day-to-day tasks; however, when faced with more complex and strategic problems, in most cases, the experiences of these executives would not be sufficient enough to solve them.

These executives soon realised that in order to understand and solve these problems they would need to gather as much relevant data as possible (Huber, 1981). At that time, various operational data analysis and processing techniques were introduced to provide the much needed data to solve these complex issues. However, these tools outputted mathematical data, which was unfamiliar to the executive and led to problems in communication, which in turn led to the executives reverting back to their intuition approach.

2.3.1 Decision-Making Approaches

Throughout the years, different decision-making theories have been discussed by researchers, and psychological experiments performed in order to determine what drives a decision-maker's decisions when intuition is insufficient. Some of the approaches highlighted by researchers include the:

- 'Garbage Can Approach' (Fick and Sprague, 1980, p.48). Useful for when 'organizational decisions are consequences of intersections of problems looking for solutions, solutions looking for problems, and opportunities to making decisions', this approach relies on the role of chance and timing when making decisions. The garbage can approach originated from the idea that all decisions are made when particular opportunities arise, thus suggesting that solutions can be developed to

different scenarios in advance and when a problem occurs the most relevant pre-developed solution should be used to solve it (Turpin and Marais 2004; Rainey, 2003; Whithead, 1979).

- Incremental Model (DeVault, 2011; Rainey, 2003; Field & Andrews, 1998; Hirst et al., 1993; Whitehead, 1979). This is the idea that complex problems sometimes negate the possibility of using the rational approach to solve problems. Moreover, such complex problems might lack any clear objective for the decision-maker(s) to achieve; therefore, incrementalists suggest that instead of relying on a rational choice amongst alternatives, decision-makers should chose a less controversial decision which is aligned with their organisation's current policies. However, as this approach suggests, the decision-maker(s) will often have no clear strategy and no clear objectives to achieve, thus suggesting that the organisation would only have a passive role, which would most likely be a negative role to adopt in the long run.

- Programme Approach (Huber, 1981). Here, the actions of the decision-makers are affected by what are described as programmes, which consist of the everyday observations or experiences of the individuals involved in the decision-making process. The organisational culture affects the behaviour of the individuals responsible for making the decisions. For example, company training is a form of programming that affects the actions of decision-makers as they are likely to draw upon the information learnt during training when making decisions. Turpin and Marais (2004, p.145) referred to this approach as the 'organizational procedures view'. Das and Teng (1999, p.765) referred to it as the 'avoidance mode', which is used as a systematic process to avoid uncertainty by resisting any cultural changes which usually works at the cost of innovation.

- Political/Competitive Approach (Turpin and Marais, 2004; Huper, 1981). This involves organisational decisions being influenced by the strategies and tactics employed by individuals seeking results favourable for their personal gain.

- Individual Difference Perspective, which Turpin and Marais (2004) defined as the process of trying to explain how the background, personality and managerial style

of individual decision-makers lead them towards the adoption of specific decision-making methods and courses of action which may be different from other individuals with different personality characteristic. This approach has received little attention in the research literature, most likely due to the fact that organisations rely on group decision-making.

However, none of these approaches offers an explanation for how an individual can make a decision or which decision they can make, only suggesting what might or might not drive an individual or an organisation to making a decision.

Rasmussen (1997) reported that most of the decision-making research revolved around two major approaches used by individuals when making decisions:

- Normative or rational decision-making strategies; and
- Actual behavioural knowledge (NDM).

2.3.1.1 *Rational Decision-Making Approach*

Whitehead (1979), in his experiment for developing a decision-making technique for planning, discussed the rational decision-making approach. This approach is based on the decision-maker's awareness that a problem exists, followed by an analysis stage for the reasons behind solving the problem, the development of possible alternative courses of action that might solve the problem and the selection and implementation of the best possible strategy. Several investigators have discussed this rational or logical approach in decision-making, arguing that decision-makers should approach whatever complex situation that they are faced with rationally (e.g. Kingdon, 2003; Rainey, 2003; Baker, et al. 2002; Vroom, 1974; Audley, 1964;). The process is seen a stepwise one, with decision-makers defining all the possible actions available to them, selecting ways to measure the results that would likely be produced by each action, forecasting the results from undertaking each action and constructing a decision rule by which an action can be chosen based on the fact that it achieves the best possible outcome for the situation. Similarly, Minkes (1987) and Dawson and Mcloughlin, (1986) described the decision-making process associated with this approach as a sequential series of activities starting with the initial recognition of a problem, through to the identification and evaluation of alternative courses

of action, and the selection of the preferred alternative, ending with the implementation of the action selected.

Figure 2 illustrates the decision-making process associated with this approach.

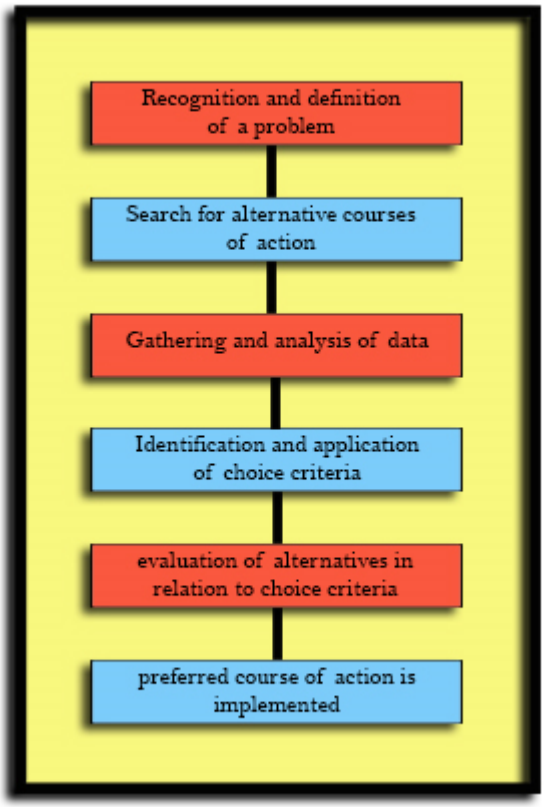


Figure 2 Rational decision-making (adapted from Hopwood, 1974).

2.3.1.2 *Bounded Rationality Approach*

In real-world settings, decision-makers often do not have the time to evaluate all the alternatives or all of the available data to identify the alternatives. With this realisation, Simon (1979) developed the bounded rationality approach, which is characterised by the idea that the decision-makers do not always search for all the alternative choices of action; rather, instead of finding the optimal solution, they *satisfice*. This means that alternatives are searched for, sequentially evaluated, and the first alternative that satisfies a criteria set is chosen or *satisficed*, and the search is terminated. However, many researchers consider the

bounded rationality model to be essentially a rational model, albeit a constraint one; therefore, they do not distinguish between the rational approach and the bounded rationality approach when classifying decision-making models (Turpin and Marais; 2004; Das and Tang, 1999; Huber, 1981).

2.3.1.3 *Issues and Limitations of the Rational and Bounded Rationality Approaches*

The role of decision-making continued to grow, and with continued advancements in the field of technology, the use of DSS and analytical tools grew simultaneously. Consequently, executives started having a lot more help in gathering and analysing the data needed to make decisions that would help them apply their approaches to finding the right decision. However, most of these approaches/models described situations where the decision-maker would evaluate a situation and develop an action/alternative and weigh the possible outcomes of each alternative before choosing the most suitable or satisfactory outcome. These approaches were only adequate when the problems were not urgent, as they took a significant amount of time to be conducted. Therefore, these approaches were not suitable for times where the executives were faced with situations under time pressure, high stakes or a continually changing environment, which is typical of the environment faced by executives in the O&G industry.

2.4 Naturalistic Decision-Making (NDM)

*'The study of NDM asks how experienced people, working as individuals or groups in dynamic, uncertain, and often fast-paced environments, identify and assess their situation, make decisions and take actions whose consequences are meaningful to them and the larger organization in which they operate' (*Zsambok, 1997, p.5*).* NDM is a framework for understanding how people actually make decisions in complex situations (Klein, 2008). The framework applies when decision-makers are confronted with a high stakes, complex situation in a demanding and competitive environment, and where the tasks and goals at hand are ill structured, poorly defined, dynamic and continually changing (Klein, 1998). In such situations, the data needed to make an informed decision is often incomplete, and any wrong decisions can have a significant impact on both the individual and the organisation;

therefore, individuals faced with these decisions rely on the use of mental cues or shortcuts based on prior similarly related experiences to analyse these decisions (Klein, 1998).

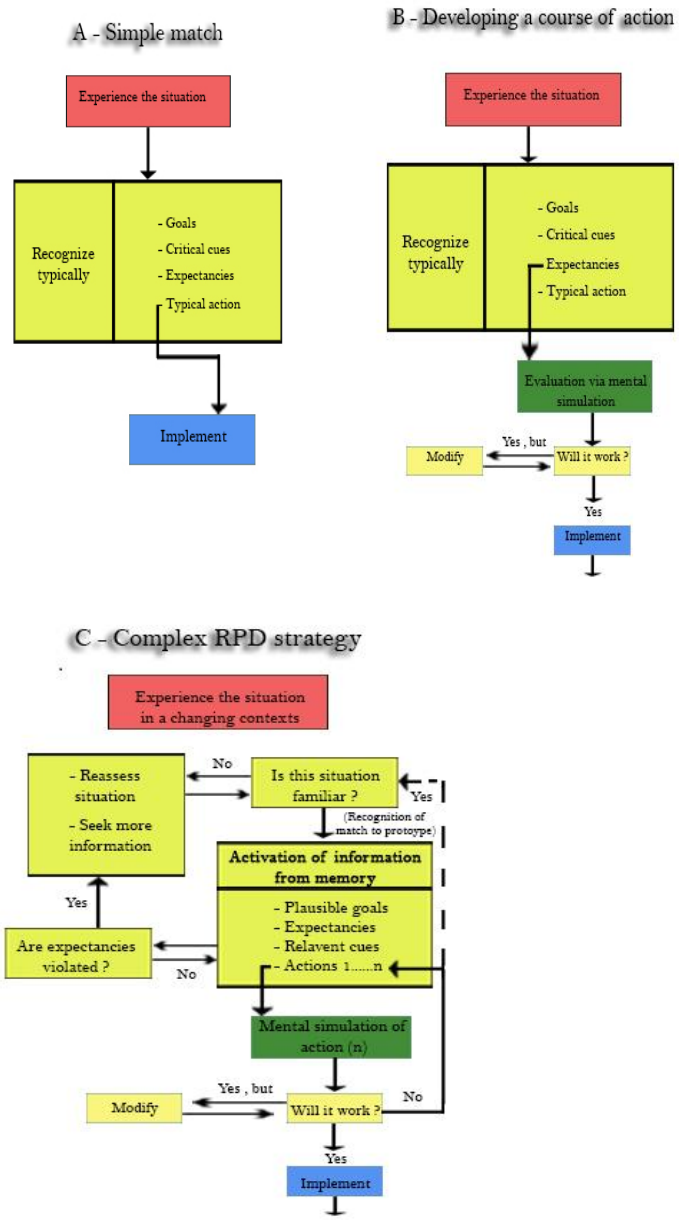
According to Carrol et al. (2006), NDM researchers take a fresh look at how decision-makers approach real-world decisions that guide actions with real consequences. Falzer (2004) argued that NDM approaches offer a greater variety of explanation than rational decision making approaches and Shattuck and Miller (2006) indicated that many fields of practice have adopted NDM as a doctrinal framework.

NDM is also very helpful in team decision-making, as the role of experience in these team settings plays a huge role, as highlighted by Carroll et al. (2006) in their experimental study examining the link between NDM and organisational learning, which represents the improvements in knowledge, performance and routines based on experience. The researchers found that when teams have to make decisions in naturalistic settings, decision-makers need management experience and assistance in order to improve their own decision-making skills, which increases organisational learning.

RPD Model

NDM provides a description of decision-making as it actually happens; furthermore, since the environment in which the framework is characterised is dynamic and continually changing, new information continually presents itself, which in turn leads to the goals and sub-goals of the decision needing to be redefined. Klein (1987) developed the RPD model to describe the different stages the decision-maker goes through during the process of making a decision using the NDM approach. With this model, the decision-maker spends more time analysing the situation faced rather than the different actions that might be undertaken and deciding on which action to take. Randel et al. (1996) further described the RPD model as the process in which a situation is assessed and recognised as typical, and the best course of action is determined based on the decision-maker's experience and familiarity with the situation. Baber et al. (2010) explained that the RPD model assumes that people develop certain patterns based on their experiences in related situations, which enables one to develop the ability to recognise certain environmental cues and to use these to match what is happening and what needs to be done.

Klein (1987) presented the model in three different forms (Figure 3). In its most simplified form, the situation the decision-maker is faced with is recognised and the obvious course of action is identified and implemented. Another form is when the situation is a little more complex and the decision-maker mentally stimulates a course of action and its probable outcome using imagery to uncover any potential problems before carrying out a certain decision. The final form is where the situation is the most complex and the decision-maker recognises a situation but evaluates certain flaws with it that would then require the decision taken to be modified. At times, the judgement would prove to be inadequate and rejected in favour of a different one.



.Figure 3 The three forms of Klein's RPD model

The development of NDM has been rapid and applied successfully across many disciplines. Scmitt and Klein (1999) have adapted the RPD model for military planning guidance and it has since become the standard for tactical decision-making in the Swedish Armed Forces. Researchers have continued to experiment with NDM in other fields, such as aviation

science (Oesanau, 2005), psychology (Chapman, 2006), medical science (Falzer, 2004; Currey and Botti, 2003) and of course, business and management (Carrol et al., 2006).

As previously mentioned, when relying on the RPD model, decision-makers generally rely on mental shortcuts in order to quickly recognise if they have been through the situation previously or have faced a similar situation, a process called *heuristics*. Simon (1990, p.11) argued that heuristics are 'methods for arriving at satisfactory solutions with modest amounts of computation', suggesting that people seek to reduce the effort associated with their decisional processes. Todd (2007) noted that there are different types of heuristic decision-making approaches where individuals do not rely on rationality when making a decision. Such approaches include:

- Recognition Heuristic-Ignorance Based Decision-Making, in which decisions are made based on having dismissed an action due to the decision-maker's unfamiliarity with it;
- One Reason Heuristic Approach, which is described as making a decision by defining one cue to separate two decisions, and deciding based on which decision offers the most satisfaction with this cue;
- Multiple Cue Decision Approach, which is when the decision-maker is faced with more than one option; more than one cue is also identified and a process of elimination is used until the more satisfactory decision is chosen;
- Sequential Search Heuristic Approach, in which the decision-maker seeks out the possible alternatives and solutions to a given problem until finding and choosing the best possible solution, a method that relies heavily on the search capabilities of the decision-maker.

Other NDM Models

2.4.1.1 *Image Theory Model*

Falzer (2004) concluded that one of the most researched theories inspired by NDM is that of image theory. This theory was developed by researchers in the field of psychology and

emphasises descriptive modelling in order to describe real-world events and the relationship between the factors responsible for their occurrence. Falzer explains that image theory 'represents an intersection between empirical theories of decision-making, cognitive psychology and organizational behaviour' (2004, p. 90). Image theory exists in two forms: the first focuses on the processes employed by individual decision-makers, and the second is concerned with organisational processes in making decisions. Image theory has three cognitive images that describe an individual/organisational decision-making process:

- the trajectory image, which reflects the goal or future vision of making a decision;
- the strategic image, which reflects the ways to meet the goals set for the decision; and
- the value image, which reflects on whether there are any principles and ethical considerations that need to be accounted for when making a decision.

2.4.1.2 *Extended Decision Ladder Model*

Jenkis et al. (2010) compared the decision ladder approach, which is part of the cognitive work analysis model, to the RPD model of NDM. Cognitive work analysis is a formative approach developed to model the work domain's activity process and attempts to support the development of knowledge or understanding from this activity. Jenkis et al. argued that whereas RPD focuses on human decision-making, the decision ladder model focuses on the activity that is taking place regardless of whether it is conducted by a human or automation. Furthermore, Jenkis et al. indicated that whereas RPD focuses on rule-based behaviour, the decision ladder model is used to accommodate skill-rule and knowledge-based behaviour.

The original decision ladder approach was developed by Rasmussen (1974) when it was observed that experts were relying on rule-based behaviours to conduct familiar tasks. As shown in Figure 3, the ladder consists of two sides; the left side represents the observations of the current system state and the right side represents the planning and execution of the tasks and procedures that are necessary to achieve the target system state. A sequence of information processing steps is represented by the ladder, starting from the bottom left to the bottom right side of the ladder. Novice users are expected to follow the decision ladder in a linear way, whereas experts are likely to link both sides of the ladder and take shortcuts and move directly onto the execution process.

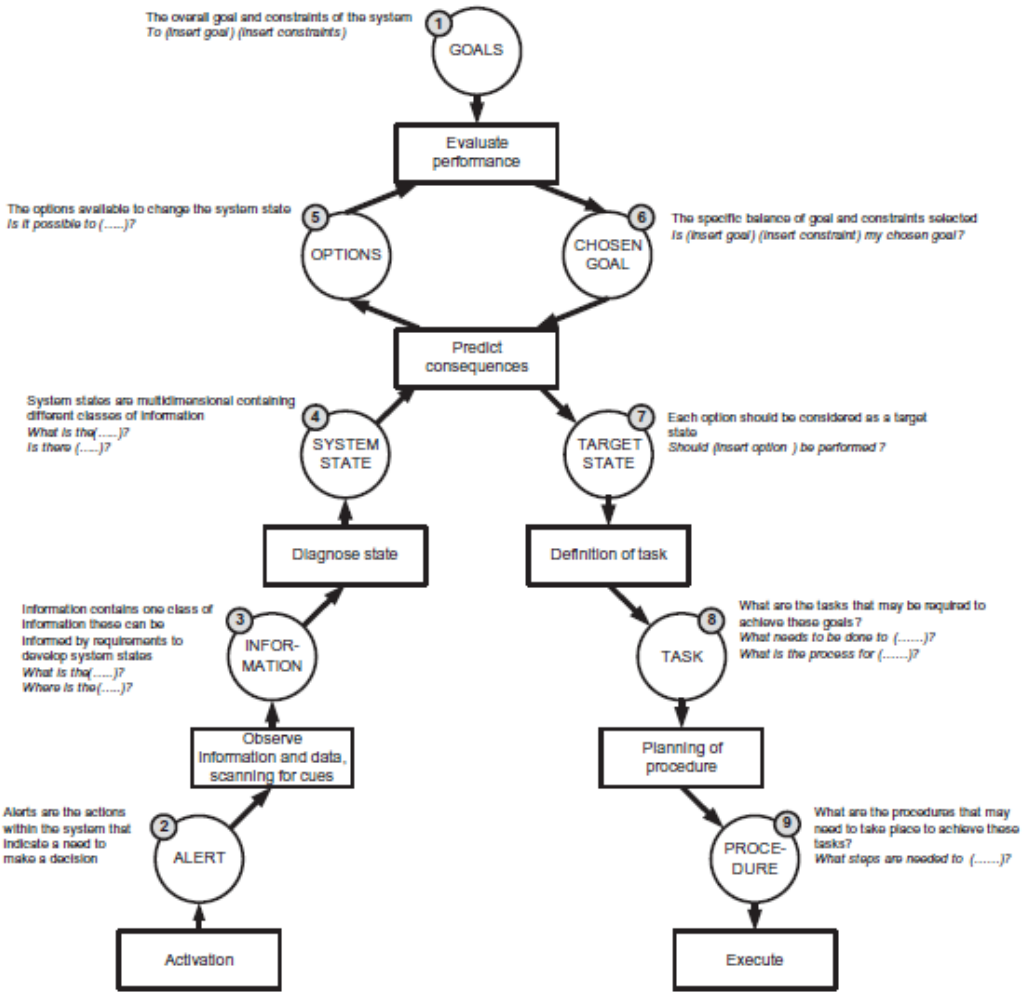


Figure 4 The extended decision ladder approach (adopted from Jenkis et al., 2010)

Jenkins et al. (2010) developed a model using the decision ladder approach by adding new elements that would capture the relationships between information elements, system states and the options available to the decision-maker. Jenkins et al. believe that their model can be used as a compatible approach to support NDM.

Cognitive Activities of NDM

2.4.1.3 *Situational Awareness (SA)*

Overtime, NDM enables the decision-maker to develop SA, which was defined by Endsley (1995) as the 'perception of the elements in the environment within a volume of space and

time, the comprehension of their meaning and the projection of their status in the near future' (p. 36). This ability enables decision-makers to look at a problem and decide on the course of action in a timely fashion, a necessary skill in such dynamic environments. Endsley indicated that SA is comprised of three levels: (a) perception, (b) comprehension and (c) projection. Perception involves an individual's sensory detection of significant environmental cues when faced with a problem. The next level, comprehension, entails understanding the meaning or significance of the information perceived in relation to the goal at hand. The final and highest level of SA is projection, which consists of extrapolating information forward in time to determine how it will affect future states of the operating environment. This merges what the individual knows about the current situation with their mental models to predict what is likely to happen next. Endsley indicates that higher levels of SA allow individuals to function in a timely and effective manner, even when faced with very complex and challenging tasks.

Studies, such as Randel et al. (1996), have compared the different levels of SA and NDM between a novice and expert electronic warfare engineers. They suggest that the difference between novice and expert decision-making lies in the different abilities to perceive meaningful information patterns and to associate certain actions with these patterns, and this ability can only be built through experience. Randel et al. indicated that NDM involves not only assessing situations, but also selecting a course of action. However, one of the main problems faced when selecting a course of action is knowing how an individual can apply the knowledge they have gained from their experiences accurately and quickly when faced with a particular situation. In their study, Randel et al. assessed 28 electronic warfare engineers with different levels of experience, ranging between 6 months to 7 years, and measured their performances using the RPD model of NDM; the results typically indicated that experts had much higher levels of SA when faced with a situation.

Studies on the role of SA have focused on the aviation industry (Kaber et al., 2006; Endsley, 1993), anaesthesiology (Gaba et al., 1995), driving (Ma and Kaber, 2007), military command and control (Artman, 2000), energy distribution (Salmon et al., 2008), sports (James and Patrick, 2004), emergency services (Blandford and Wong, 2004) and process control (Patrick et al., 2006; Hogg et al. 1995).

2.4.1.4 *Measurement of SA*

Endsley (1995) developed the Situation Awareness Global Assessment Technique (SAGAT) to measure an individual's SA levels. SAGAT was designed for real-time, human-in-the-loop simulations where the simulation is frozen at randomly selected times and subjects are queried as to their perceptions of the situation at that instant. SAGAT queries concern specific data or data criteria corresponding to the three levels of SA (i.e. perception, comprehension and projection). Endsley argued that the technique provides an objective measure of SA based on queries during freezes in a simulation. The queries are determined based on an in-depth cognitive task analysis that must be conducted for each domain where SAGAT is in use, and therefore requires a high level of expertise in their design. Participants' answers will be compared with 'ground truth' information or expert answers to the same queries.

The technique provides a number of advantages:

- the ability to broadly test SA directly;
- recognition of the need for a complete understanding of the skills required when designing the queries;
- provides quantitatively measurable data as results;
- the possibility to compare with similar data in a similar context (Jeannot et al., 2003); and
- avoids problems collecting data post-trial (Stanton et al., 2005).

The disadvantages of the technique include:

- the disruptive nature of the simulation interrupts the natural flow of the task;
- all queried items are considered equal for different users;
- does not account for outside human influences;
- subject to memory decay and inaccurate beliefs;
- requires expensive simulators (Salmon et al., 2006);
- requires the capability to pause the simulation;

- cannot be applied ‘in the field’ or in real-time;
- analysis requires extensive preparation (Stanton et al., 2005);
- low sensitivity; and
- intrusive to primary task.

The technique has primarily been applied to the fields of aerospace (Endsley, (1988), air traffic control (Endsley and Kiris, 1995) and automation (Endsley et al., 2000)—fields in which simulations are considered affordable and have become a routine part of these industries. Nonetheless, it is argued that the disadvantages of this approach far outweigh the advantages. The results might be representative of the simulated problem, but in studies where data needs to be collected in real-time and in the field, the application of the technique is impossible.

Other SA measuring techniques include SART (Selcon and Taylor, 1989), which is a self-rating technique for measuring the respondents’ subjective opinions on how aware a person was while performing a task. This technique involves the administration of a post-task questionnaire with bipolar responses. The technique has been used exclusively in the aviation industry and has a number of disadvantages, which include most importantly the reliance on the participant to judge their own level of SA, which compromises the validity of the results.

Finally, Kleine et al. (2003) discussed other cognitive activities apart from SA that experienced people use in contexts with which they are familiar, with this level of analysis being referred to as *macrocognition*. Macrocognition decision-making includes uncertainty management, mental simulation, sense-making, attention management, problem detection, planning and option generation.

2.4.1.5 *The Dynamic Model of Situated Cognition*

Shattuck and Miller (2006) argued that whilst NDM represents a major leap forward in understanding decision-making activities in real-world settings, it mostly focuses on the individual making a decision within complex systems and has not ‘emphasized the influence, contributes and modelling of technological aspects of these systems’ (p.989).

Shattuck and Miller asserted that whilst it is important to understand how decisions are made in naturalistic settings, it is equally important to investigate complex systems from a technological perspective and to identify how this technology influences the decision-makers. Due to these issues, Shattuck and Miller extended the standard RPD model of NDM to address these limitations by developing a conceptual model which they called the *dynamic model of situated cognition*, which would incorporate both human and technological aspects of complex systems. They based their model on situation cognition, which represents the interplay between multiple individuals and their environment, arguing that it is another macrocognition activity that values the role of experience and situational familiarity.

The model attempts to highlight the relationship between technological systems and human perceptual and cognitive processes. As illustrated in Figure 5, the model has six ovals divided to represent (on the right) the human side of the model and (on the left) the technological side of the model. The first oval on the technological systems side represents the data that exists in the environment, which is continually changing and dynamic. The second oval represents the data detected by the technological systems; the data in this oval would ideally be a subset of the data in the first oval, however, achieving data accuracy in many cases is not possible for a number of reasons. This problem might occur due to the fact that the number of sensors used to detect the data in the environment is not sufficient or they may malfunction. The third oval presents the data that would appear at the decision-maker's workstation.

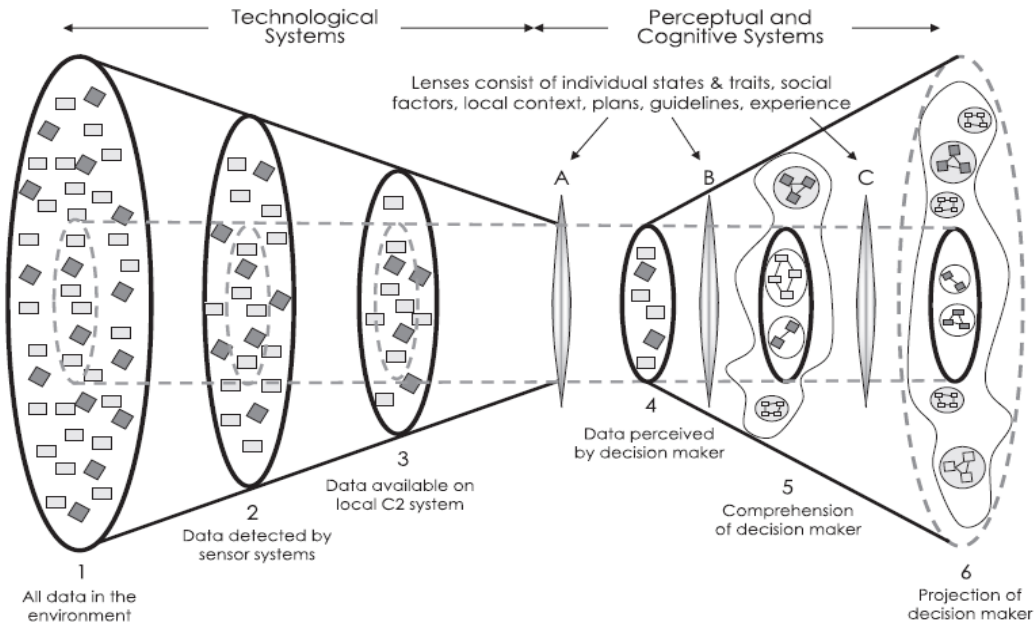


Figure 5 The DMSC (Adopted from Shattuck and Miller, 2006)

The model also includes three dynamic lenses, adopted from Brunswick's (1947) model, which indicates that a decision-maker should make inferences about events by using available cues. In this model, each lens has two sides, the left side includes a description of events that are occurring in the environment and the cues that represent these events, the right side of the lens describes how the decision-maker uses the cues to makes an inference about what is happening on the other descriptive side of the lens. In this model, the lenses are placed between different ovals, which is significant, as although the data within the lenses is the same, the location of the lenses suggest different functions are performed by each lens.

Lens A, located between ovals 3 and 4, directs attention to selected incoming stimuli. The fourth oval represents all the data that is perceived by the decision-maker. Between ovals 4 and 5 is lens B, which influences the process of organising the data into information. The fifth oval deals with the process of understanding the information that is organised through the lens. Lens C, located between ovals 5 and 6, guides the process of investigating the

information and turning it into predictions for the future. The sixth oval represents the projections or predictions of the decision-maker.

The model's application has been limited to tracing the relationship between technological systems, human perception and the cognitive processes of users when facing naturalistic decisions, especially in relation to warfare (Shattuck and Miller, 2006). Therefore, the technological side of the model consists of all the data in the environment relevant to the army or military unit involved (Oval 1), and the data detected by the technological sensors of the unit (Oval 2). The model, however, has never been applied to other fields where different technological systems, such as BI, are used to represent the technological side of the model. Nonetheless, the model represents a step forward in studying human-technological interactions in naturalistic settings, something which other frameworks do not account for. Furthermore, the dynamic nature of the model means that its technological aspects can be altered to feature other technological components, although the model's restricted application to the military settings means that such an action is yet to be tested.

2.5 Summary

The literature suggests that BI systems provide significant insights into organisations and aid in better decision-making across a variety of fields. However, although BI software manufacturers heavily advertise their BI applications, their unique advantages and the supposed edge their products would give organisations, the literature on the true decision-making role BI plays within the industry is limited. Furthermore, most of the literature concerning general BI applications for decision-making in the O&G and other industries focuses mostly on rational decisions rather than on naturalistic decisions. In addition, the only model developed that considers the relationships between the cognitive processes associated with NDM and the human and technological systems of a decision is the dynamic model of situated cognition, and even this model has only been applied to tracing warfare situations retrospectively by the model's authors. Finally, the importance of SA has not been given sufficient attention in the field of management decision-making in industries such as the O&G industry. Evidence to support this claim lies in the fact that most of the techniques used to measure individual SA have been developed exclusively for use in the fields of aviation, aerospace and the automotive industry; areas where valid real-time

measuring would be impossible, and where expensive simulations or participant self-ratings are the only options available. Table 1 illustrates a summary of the literature that concerns this study and highlights the relevant gaps.

	Business Intelligence	Naturalistic Decision Making
Literature Summary	**1.** Most of the literature is focused on describing in the abstract what BI is and its components. **2.** The general advantages and the role of BI within other industries has also been highlighted but with no empirical evidence. **3.** Research has modelled organisational data for the optimisation of operations performances.	**1.** The value and distinction between NDM and RDM is clearly stated **2.** Significant research has been conducted on the development and understanding of NDM **3.** Different models of NDM have been developed with the most significant being Klein's RPD model **4.** The only NDM model that considers the role of technology in its application is the DMSC **5.** The application of DMSC has been exclusive to the aviation and medical industries.
Gap within the Literature	**1.** Empirical Research is needed to investigate what BI is really is, as well as **2.** What value it gives organisations in real world settings and what more can be done to further develop its importance.	**1.** The characteristics of the decisions faced in the O&G industry fit the characteristics of NDM, however, no research into the frequency of occurrence of these decisions in the industry are made and how are they dealt with. **2.** What role, if any, does BI play when these decisions occur (from an individual and organisational standpoint)?

Table 1 Literature summary and related Gaps

CHAPTER 3

METHODOLOGY

3.1 Overview

This chapter introduces the research methodology used for this study; the chapter is structured as follows: the first section provides an examination of the existing traditions relating to sense-making and information systems research, with a specific focus on the research philosophies and theoretical assumptions adopted in these fields. By understanding the implications of the different research perspectives, it is possible to make a more informed decision about which perspective should be adopted for this study, which in turn will result, along with the underlying assumptions of this study, in an important contribution to the practical research design that follows. The research design describes in detail a multiple case study approach of two multinational O&G organisations operating within different streams of the industry. An overview of the data collection and analysis methods that the researcher could have used to conduct this investigation are discussed with justification given for the methods ultimately chosen. The subject under scrutiny in this study is the decision-makers within these organisations and the major stakeholders involved in the development and management of the BI system. The latter part of the chapter provides an overview of the O&G industry streams (i.e. upstream, midstream and downstream), and a description of the organisations that participated in this study.

3.2 Philosophical Foundations

3.2.1 Overview

All research is based on some underlying assumptions made by the researcher, which in turn contributes towards its validity (Mayer, 1998). These assumptions are normally summarised and structured using the two philosophical branches: ontology and epistemology. Ontology is the philosophical study of the nature of being, becoming, existence, or reality, and identifying how this reality actually exists. Epistemology, on the other hand, is the branch of philosophy concerned with the nature and scope of knowledge and is also referred to as a *theory of*

knowledge. Specifically, epistemology is the study of knowledge and justified beliefs. Epistemology is concerned with what we consider to be knowledge and the ways and extent that knowledge can be acquired (Klein and Myer, 1999).

There have been a number of studies that have attempted to classify approaches to information systems and sense-making research, with academics largely in agreement that the underlying assumptions made by the researcher should be what drives the approach chosen. Furthermore, Klein and Mayer (1999) indicate that IS research can be classified as positivist, critical or interpretive depending on the underlying philosophical assumptions by the researcher.

IS research can be classified as positivist if the research provides a formal proposition, quantifiable measures of variables, hypothesis testing and the drawing of inferences about a phenomenon from a representative sample (Wong and Ellis, 2002). This generally means that positivist studies are primarily concerned with quantitative data collection methods. The essential difference between quantitative and qualitative research is the flexibility in the methods they use (Bryman, 2001). Generally, the data collection methods associated with quantitative are fairly inflexible. These methods involve asking all participants identical questions in the same order with the response categories which participants are asked to choose from often being fixed. The clear advantage of this approach is that it allows for meaningful comparisons between responses across participants and study sites. However, it also requires a high level of understanding and consideration to the selection of the questions and the best way to ask them to get the range of possible responses

On the other hand, interpretive research is when it is assumed that knowledge can only be obtained through social constructions, such as language, consciousness, shared meanings, documents, tools and other artefacts. Interpretive research focuses on the complexity of human sense-making as the situation emerges rather than having pre-defined dependent and independent variables (Kaplan and Maxwell, 1994). It attempts to understand different phenomena through the meanings that people give them (Deetz, 1996). Interpretive methods of research in IS are ‘aimed at producing an understanding of the *context* of the information system, and the *process* whereby the information system influences and is influenced by the context’ (Walsham, 1993, p. 4-5).

Finally, IS research can be thought of as critical research which aims to help create opportunities for realising human potential by critiquing the social conditions and system of constraints on the subject at hand (Hirschheim and Klein, 1994). To achieve this, critical theorists assume that people can consciously act to change their social and economic conditions. Critical theorists, however, also recognise that the ability to improve ones' condition is constrained by various forms of social, cultural and political domination, as well as natural laws and resource limitations. Consequently, the nature of critical and interpretive research designs aligns them more closely with qualitative data methodologies rather than quantitative.

It was decided for the purpose of this study that the most appropriate research paradigm would be interpretive research, because critical research shares the view that a subjective knowledge of the world is filtered by the experiences of individuals. The present study, however, is focused on complex human sense-making, as situations emerge and decisions need to be made in naturalistic settings. Therefore, the only way to gain access to knowledge in this setting is through the social constructions of individual participants.

3.3 Research Methods

3.3.1 Overview (Qualitative vs. Quantitative)

Research methods and research data are traditionally divided into two basic categories; qualitative and quantitative. The purpose of qualitative research is to guide the understanding of what participants means (Morrow & Smith, 2000). More specifically, according to Creswell (1998), qualitative research is defined as an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. In qualitative research, the researcher builds a complex, holistic picture of a situation, analyses participants' words, reports their detailed views and conducts the study in the participants' natural setting. Therefore, the qualitative approach would allow the researcher to study the phenomenon of decision-making in its naturalistic setting.

In qualitative research, the methods used are typically more flexible as they allow for spontaneous interactions between the researcher and the participants taking part in the study. The methods used often ask open-ended questions that are not necessarily worded in exactly the same way with each participant. These questions afford participants the freedom to respond in their own words, and these responses tend to be more complex than the responses

resulting from quantitative research methods. Additionally, in qualitative research, the relationship between the researcher and the participant is generally less formal and participants are given the opportunity elaborate upon their responses and in greater detail than would typically be the case with quantitative methods. This in turn allows the researcher to respond immediately to what participants say by tailoring subsequent questions to information that the participant has provided.

Mack et al. (2005) indicated that there is a range of flexibility amongst methods used in both quantitative and qualitative research. Moreover, that flexibility is not an indication of how scientifically rigorous a method is. Rather, the degree of flexibility reflects the kind of understanding of the problem that is being pursued using the method.

3.3.2 Qualitative Research Approaches

According to Orlikowski and Baroudi (1991), some of the most commonly used qualitative research methods and research designs used in IS research are case studies and experiments. Eisenhardt (1989) asserted that the case study is, by definition, a research strategy which focuses on understanding the dynamics present within a single setting. Yin (1994) described the case study as an empirical enquiry for the investigation of existing phenomena within real-life settings, especially when the boundaries between the phenomenon and the setting are not evident. According to Yin (1994), the case study is a research design where the research questions are more explanatory in nature and are mostly presented in the forms of *how* and *why* questions. Therefore, it is important to note that the case study can be either positivist (Yin, 1994), interpretive (Walsham, 1993), or critical, depending upon the philosophical stance chosen by the researcher. Walsham (1993) suggested that case studies can involve either single or multiple cases, and with several levels of analysis within a single study (i.e. embedded design). If research is focused on building a theoretical framework and its implications towards different cultural settings, multiple case studies of companies with distinctive identities are deemed necessary.

On the other hand, an experiment is an investigation of a phenomenon in which a hypothesis is scientifically tested (McLeod, 2012). A typical experiment involves an independent variable, which is manipulated; a dependent variable, which is measured; and any unnecessary variables are controlled for. A clear advantage of using experiments as a research method is objectivity as researcher's views and opinions do not have an effect on the

results of a study, which in turn increases the validity of the data, and minimises researcher bias. There are three known types of experiments undertaken in IS research; one is the laboratory experiment where an experiment is conducted in a controlled environment to ensure accurate measurements. However, a clear limitation of this type of experiment is the risk of the controlled environment leading to unnatural behaviours being produced by the research subjects. Another type of research experiment commonly used is the field experiment, which takes place in the real-life world of the participants and the researcher controls and manipulates the independent variables, although has no real control over any outside or extraneous variables. Finally, a natural experiment is another type of real-world research experiment which is conducted in the everyday setting of the participants and where the researcher has absolutely no control at all over the variables.

3.3.3 *Qualitative Data Collection Methods*

Interviews, participant observation and focus groups are some of the more common qualitative data collection methods. According to Kvale (1996), interviews in qualitative research seek to describe the meaning behind central themes in the real-world of the subjects. In other words, the main task in interviewing is to understand the facts and meaning of what participants say, aiming to elicit their views as portrayed in their own words in order to gain access to their experiences and feelings about a phenomena and social worlds. Interviews may be unstructured or semi-structured. Unstructured interviews are usually conducted in an everyday conversational style, in which participants take the lead in telling their stories, rather than having the researcher guiding the process. Semi-structured interviews are used to facilitate a more focused investigation of a specific topic, using an interview guide. These guides usually contain a list of questions pre designed in advance by the researcher to help guide the interview in a focused, yet flexible and conversational manner (King and Harrocks, 2010). Furthermore, using interviews, an in-depth investigation can be conducted on a specific topic and they are useful in facilitating follow up questions on previously undertaken research. According to Dilshad and Latif (2013), focus groups are facilitated group discussions that monitor group interactions to explore the research issue being studied; this use of group processes is what distinguishes them from individual interviews. Finally, participant observation is another useful data collection method used in qualitative research when investigating real-world settings. The observation typically takes place in the participants' natural setting or a location believed to have some relevance to the research questions. The method is unique in that it allows the researcher to approach participants in

their own natural environments rather than having the participants come to the researcher. Generally speaking, researchers engaged in participant observation aim to learn what life is like inside the participants' environment whilst remaining uninvolved in the process itself. When the observation is taking place, researchers ensure that they carefully and objectively record what they are observing. Other components of the method which are considered essential are the informal conversations and interactions that occur with members of the study population and should also be recorded in rich detail.

3.3.4 Qualitative Research Sampling Techniques

In order to ensure information richness, two key considerations guide the sampling methods in qualitative research: appropriateness and adequacy. In other words, qualitative sampling requires that researchers identify the appropriate participants who can best inform the study. It also requires adequate sampling of information sources (i.e. participants, locations, scenarios and the types of data) in order to fully address the research question and to arrive at a full description of the phenomenon being studied (Fossey et al., 2002).

To enhance the appropriateness of sampling and adequacy of information gathered, different sampling strategies may be used. According to Pope and Mayes (2000) *purposive sampling* is one of the most common sampling strategies: group participants are selected in advance relevant to a particular research question. Purposive sample sizes are often determined on the basis of theoretical saturation (i.e. the stage in the data collection where no additional data will add further insights to the research questions). Therefore, this strategy is considered most successful when the data review and analysis is done simultaneously with data collection. Another qualitative research sampling technique discussed by Pope and Mayes is quota sampling, where the researcher identifies the categories deemed important when designing the study and for which variation is likely to be involved. Each category is then divided into subgroups and the researcher pinpoints the element (i.e. people) deemed to be the focus of the research to include from each subgroup.

Finally, *snowball sampling*, which is also known as *chain referral sampling*, is where contact has already been established with participants within an organisation and these participants use their social networks to refer the researcher to other people who could potentially participate in or contribute to the study. Snowball sampling is often used to find and recruit

groups that are not easily accessible to researchers through other sampling strategies (Nkwi et al., 2001).

Fossey et al. (2002) highlighted the fact that the soundness of a study's sampling methods affects the trustworthiness of qualitative research findings. In qualitative research, readers evaluate the appropriateness and adequacy of a study's sampling strategies in light of the study's focus and aims.

3.4 Qualitative Data Analysis

In qualitative research, the data methods used (i.e. interviews, participant observation and focus groups) result in large amounts of words and transcripts. These words or statements need to be described and summarised. Good qualitative data analysis is distinguished by its focus on the interrelated relationship of the setting, group or person under investigation rather than the analysis of each of these parts separately; the events, thoughts and actions that are essential for interpretation. Furthermore, qualitative data analysis is a process that begins as soon as the data collection process starts rather than after its completion (Stake, 1995).

According to Lacy and Luff (2007), most qualitative data analysis typically goes through some or all of the following procedures, although the order of which these procedures are conducted may vary:

- Familiarisation with the data;
- Transcription of all recorded material;
- Organisation of data for easy retrieval and identification;
- Anonymising of sensitive data;
- Coding;
- Identification of themes;
- Re-coding;
- Development of provisional categories;
- Identifying of relationships between categories;
- Refinement of themes and categories;
- Development of theory and incorporation of pre-existing theories;

- Knowledge testing of theory against the data; and/or
- Report writing, including excerpts from original data when appropriate.

However, there are particular theoretical approaches to qualitative analysis that are commonly used and are important for designing research and for critically evaluating qualitative research evidence. The particular approach taken to any given study depends on many essential factors, most importantly the research question at hand, the time you have available for the study to be completed, and finally, the overall aims of the analysis play an important part when choosing a specific analysis approach.

3.4.1 Framework Analysis

Another approach to qualitative analysis is framework analysis (Ritchie and Spencer, 1994), which was developed in the context of applied policy research. Applied research aims under short timescales to meet specific information needs and to provide outcomes or recommendations based on these needs. Framework analysis shares many features in common with the more typical qualitative analysis stages discussed previously. The real benefit of this approach to analysis is that it provides systematic and clear stages to the analysis process so that researchers can be clear in advance about the process by which they will obtain their results from the data.

There are several key stages through which framework analysis can be conducted, with these being undertaken in a linear fashion. Sequentially following these stages allows for all of the data to be collected before the analysis begins. The key stages of framework analysis are:

- getting familiar with the data;
- identifying the thematic framework from the data;
- indexing and charting of the data; and
- mapping and interpreting the data.

3.4.2 Goodness and Trustworthiness

Qualitative research requires investigators to take an active role in the collection and interpretation of other peoples' opinions, and in this study their cognitive thoughts. However, for this process to be regarded as credible, researchers must exercise a high level of trustworthiness. Stake (1995) suggested that researchers need to understand their research in the same way the participants taking part in the research do, rather than imposing their own

assumptions which would lead to a narrow way of thinking. Furthermore, qualitative researchers believe that if a study is credible, it has to be conducted in an ethical and trustworthy fashion. Yin (2009) argues that a well done case study can be considered a complete study in and of itself, so long as it is well-written, draws upon a multitude of perspectives and is backed by reasonable and sufficient evidence. According to Merriam (2002), there are several key strategies that the qualitative researcher needs to follow to ensure their research is ethical and trustworthy:

- *Triangulation*: Using multiple sources of data or data collection methods to confirm emerging findings;
- *Member checks*: verifying the data by presenting it back to the relevant sources from whom it was collected ; and
- *Peer review*: Discussing with colleagues and/or supervisors the process of the data collection, the emerging findings and interpretations from the study.

In addition, Merriam (2002) recommends that researchers follow these additional guidelines to ensure a higher level of ethics and trustworthiness in their research:

- *Reflexivity*: Researchers should engage in critical self-reflection with respect to the assumptions, biases and their relationship to the study, which may affect the investigation;
- *Engagement*: Allowing for adequate time to collect data, so that it becomes saturated;
- *Maximum variation*: Purposefully seeking variation or diversity in the sample to allow for a greater range of application of the findings;
- *Audit trail*: Providing a detailed account of all the procedures used in carrying out the study; and
- *Rich description*: Merriam (2002) described this strategy as allowing readers to determine the extent to which the study matches the context of the research by providing rich descriptions.

In this study, to increase the trustworthiness of the study's findings, the researcher employed the strategies recommended above. The researcher ensured triangulation by using multiple sources of data to confirm emerging findings by taking a multiple case study approach, which included participants with different demographics working in different streams of the industry. Member checks were performed by sending participants a copy of their individual interview transcript and verifying the accuracy of the content. Peer review was performed by

the thesis supervisor and research colleagues in order to increase the dependability of the study's findings. An audit trail including a detailed explanation of the data collection and analysis methods and how decisions were made throughout the study was conducted. Finally, to enable other researchers to make decisions about the transferability of the results of the present study, the researcher used a rich, thick description to ensure readers understood the extent to which this study could be generalised.

3.4.3 Guidelines for Interpretive Research Conduct

Klein and Meyers (1999) proposed set principles for the conduct and evaluation of interpretive field researcher studies. The authors derived these principles from classical philosophical findings that contributed heavily to the study of interpretivism. The authors indicated that the application of these principles would help researchers to defend their work by appealing to principles that are firmly grounded in at least one major direction of interpretive philosophy.

1. ***The Fundamental Principle of the Hermeneutic Circle***

According to Klein and Meyers, the most fundamental principle when evaluating interpretive research is that of the hermeneutic circle. The authors indicate that the principle is foundational to all interpretive work of a hermeneutic nature and is in effect a meta-principle upon which the rest of the proposed principles expand. The idea of the hermeneutic circle suggests that the researcher would be able to understand a complex problem from preconceptions about the meanings of its parts and their interrelationships.

2. ***The Principle of Contextualization***

The second principle is the principle of contextualization. The authors indicated that this principle requires critical reflection and elaboration on the context in which the situations under investigation emerged to give the readers a lens into how these situations emerged.

3. ***The Principle of Interaction Between the Researchers and the Subjects***

This principle requires the researcher to evaluate to what extent the interaction between the researcher and the study subject helped in the acquisition and construction of the data.

4. ***The Principle of Abstraction and Generalization***

This principle requires the idiographic details revealed by the data interpretation to theoretical, general concepts that describe the nature of human understanding and social action.

5. ***The Principle of Dialogical Reasoning***

This principle requires the researcher to be sensitive to possible contradictions between the preconceived theoretical ideas guiding the study at hand and the actual findings from the research.

6. ***The Principle of Multiple Interpretations***

This principle requires the researcher to be sensitive to possible differences in interpretations among the participants as typically expressed in multiple narratives or stories of the same sequence of events under study.

7. ***The Principle of Suspicion***

This principle requires researchers to be sensitive to possible systematic biases in the actions of the participants under observation when dealing with the decisions faced.

Each of these principles was considered as a guideline during the construction of the research design for this study.

3.5 Research Design

3.5.1 Practical Research Approach

This study aims to understand how O&G executives make naturalistic decisions using BI: the nature of the research question in itself dictates it being of a qualitative nature. Furthermore, it was decided that a multiple case study approach was best suited to carry out this investigation as it would allow for greater diversity not only in the characteristics of the participants from each organisation, but also for an investigation of two different BI systems with potentially different applications and data sources. Therefore, two O&G organisations operating in the upstream and downstream sectors of the industry were approached and individuals within these organisations were the participants in the data collection stage of this research.

For this study, purposeful snowball sampling was used in order to recruit the organisations and individual participants from within them. Initial contact was established with each organisation, which led to referrals to other individuals and subsequently an agreement with individuals suited to the research to take part in the study. The participants were chosen because of their knowledge or experience. The participants sampled for this study had to be selected carefully, taking into account restricting issues, such as access to the organisation and time management. The research uses naturalistic decision making as a mid-level theory to explain how naturalistic decisions are made in the O&G industry; therefore, considering the need to trace the flow of the information when collecting the data, it was decided that a modified version of the dynamic model of situated cognition should be used to analyse this process. The modification to the model was necessary to allow the technological component of the model to include: all the data collected by the organisation and integrated into the system (oval 1), the data requested by each participant at each stage of the decision-making process (oval 2) and the BI tool(s) used by the participants at each stage of the decision-making process (oval 3). Moreover, this modification will ensure that all the relevant data and tools used by each participant are traced whilst keeping the dynamic nature of the model. The modified model is presented in Figure 6.

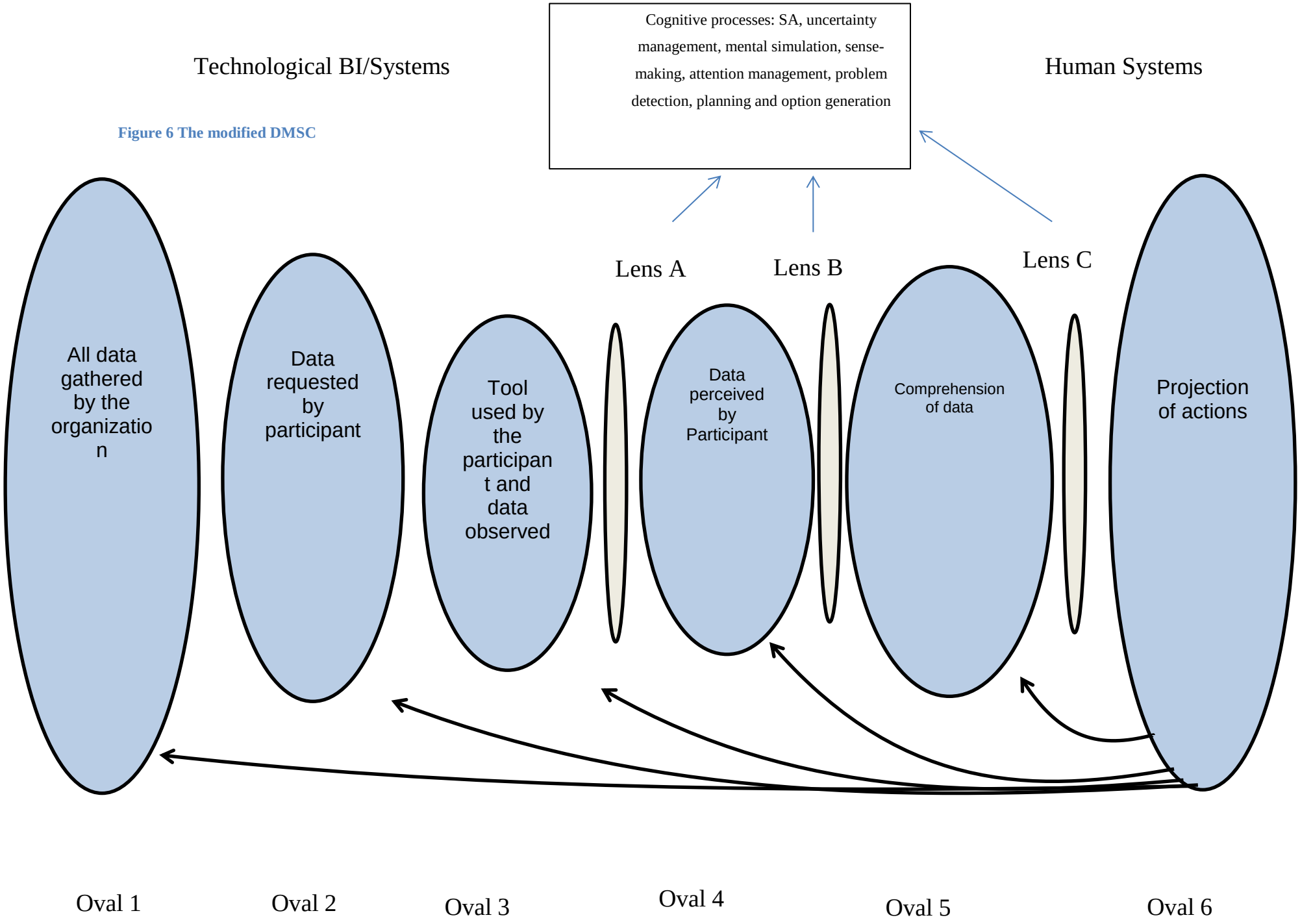


Figure 6 The modified DMSC

- For the technological side of the model (the first three ovals): the BI Project Manager in each organisation. This included the one BI Project Manager from each organisation.

- For the human side of the model (the final three ovals): individual decision-makers in the organisations who use BI in their natural settings and are regularly faced with naturalistic decisions. This includes 12 analysts within each organisation.

There were 21 participants observed from Company A (Upstream sector), with the same participants used in Scenarios 1 and 2, whilst participants 5, 6 and 11 were the only participants who took part in all three Scenarios.

There were 12 participants observed from Company B (Downstream sector), with the same participants used across all Scenarios (4, 5 and 6).

3.5.2 Research Data Acquisition Strategy

Taking into account the K&M principle of the hermeneutic circle which suggests that the researcher would be able to understand a complex problem from the meaning of its parts and interrelationships, the researcher decided that for this study the research data acquisition methods were broken down into individual stages in order to satisfy the aim of the research study which was to understand the role of BI in the oil and gas industry when dealing with naturalistic decision. Each stage of the data acquisition process helped in the general understanding of this aim.

In order to understand how decision makers in the industry are using BI, it was important to understand the unique BI capabilities and architecture for each organisation and how they differ, which might in turn explain how decisions made might differ. Therefore, the initial stages of the research involved the researcher investigating the BI system used by each organisation. This initial data was collected using a semi-structured interview with the organisations' BI project managers. These interviews helped gather information on the organisations' BI capabilities, the BI tools used by participants in this study, and what tools were available to them in their daily natural work setting.

The second stage involved the researcher entering each organisation and observing individual decision-makers in their natural settings. Whenever a situation or problem arose with naturalistic characteristics, the senior manager on site would inform the rest of the decision-

making team of the issue and a short discussion of the problem would ensue. Following K&M's *principle of contextualization*, the researcher observed and recorded these interactions in detail, ensuring that the circumstances that led to each scenario emerging were fully reported to give the reader a solid base of understanding the situations, the reasons for these situations occurring and how they continued to develop during the decision making process. Furthermore, this helped the researcher understand at an early stage how individual decision-makers viewed the situations differently and why, in a group setting without any BI data playing a role in the formation of these views. This stage also aided in identifying the central goal that the organisation wished to achieve in the process of solving the situation or problem at hand.

In the third stage, the researcher allocated each participant an individual time slot (coordinated in conjunction with the department manager) in order to observe each participant individually. Participants were not permitted to interact with one another after their sessions with their colleagues or to discuss the problem at hand. This was essential for two reasons: the first being that it allowed the researcher to continually observe each participant individually; and the second was to quarantine the participant's knowledge development and understanding of the situation after using the BI system to influence other participants whose sessions had not yet been conducted. At this stage, the researcher would be able to gather demographic information about each participant, including their age, level of experience in the role and area of expertise.

During the third observational stage, each participant's interactions with the system and data were recorded and each participant was encouraged to verbally describe to the researcher how they were using the BI to make a decision about each specific problem. The researcher was particularly interested in the following actions:

1. If the participant had encountered a similar experience in the past (mental cues);
2. The sequence of the participant's data requests from the system and which BI tools they used;
3. How efficiently the system was utilised;
4. If the data was available or relevant;
5. Whether any system errors occurred;

6. Whether the data changed the participant's initial opinion from the focus group stage; and
7. What final decision the participant recommended and why.

The researcher was given permission to ask any questions during the sessions if anything was unclear; during this stage the researcher considered K&M's principle of *interaction between the researchers and the subjects* to ensure that a healthy level of interaction between the participants and the researcher occurred without compromising the flow of the analysis observed. This interaction gave the researcher the opportunity to find insights into the data that would have otherwise stayed uncovered, such as the unique feelings or struggles of the participants when facing the naturalistic decisions. Furthermore, the researcher considered K&M's principle of suspicion when observing the decision makers, to ensure any biases were recorded.

A fourth stage, after each session, was also conducted. This stage involved the researcher observing a second group meeting between the participants and the manager. The participants discussed their recommended decisions and provided justifications for these decisions. The researcher again considered K&M's *principle of contextualization* as a guideline when recording the interactions between the manager and the participants, seeking to identify how and why the manager chose the final decision. The collected data was sent for review by the participants to check that it accurately represented their activity at the time of the observation. The researcher continued monitoring the decision outcome in order to understand who recommended the better decision in each scenario and how.

In the fifth and final stage of data collection, the researcher monitored the level of success of the decision for the organisation. This was done by conducting a final semi-structured interview with the manager through a phone conversation, ensuring that the combination of these parts would help complete the picture of the role of the business intelligence in the oil and gas industry when dealing with naturalistic decisions.

The different stages of the research data acquisition strategy are presented in Figure 7.

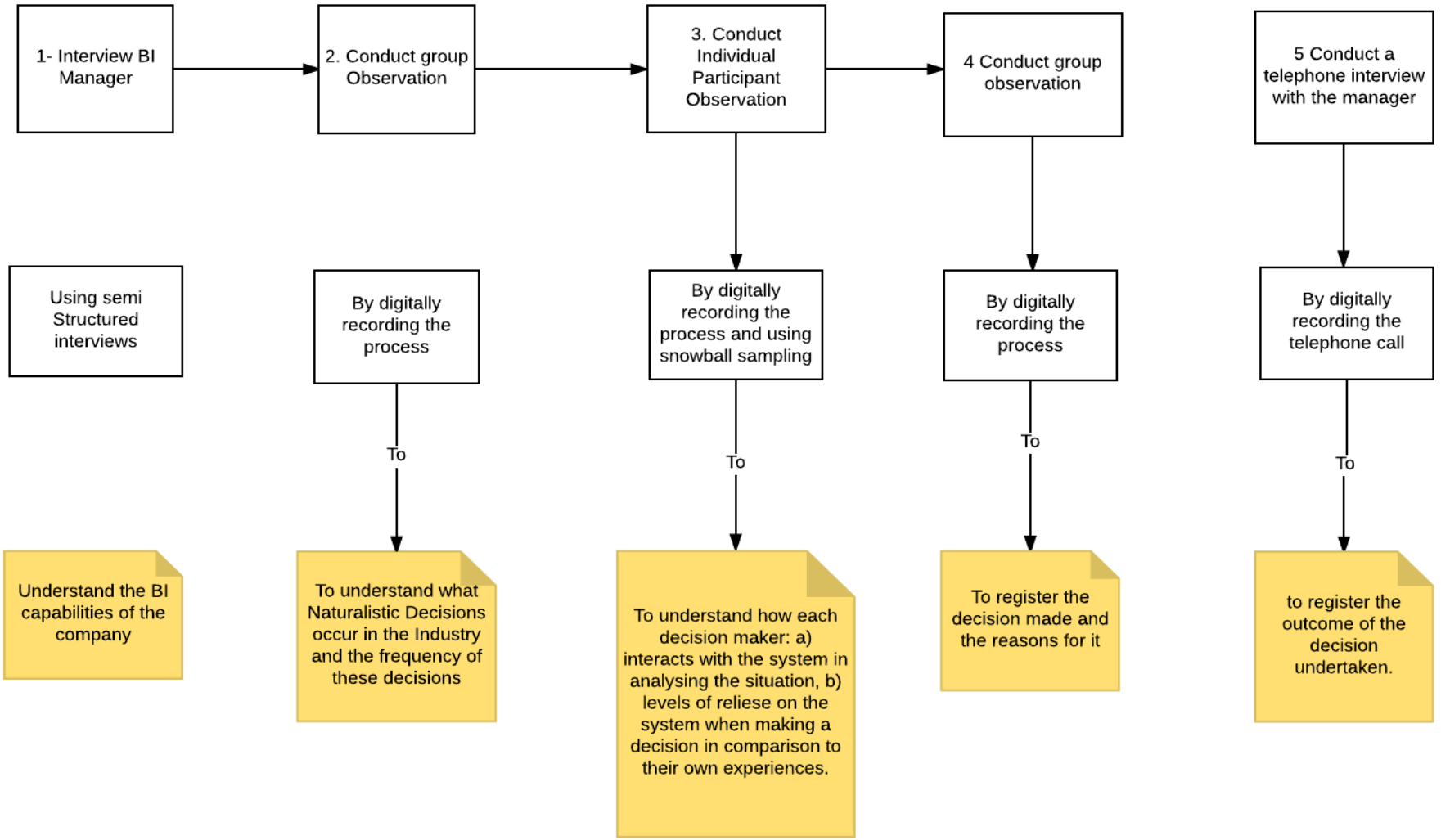


Figure 7 Data Acquisition Stages

3.5.3 Research Data analysis

The data gathered through each stage of the acquisition stage went through rigorous data analysis steps using a combination of standard data analysis techniques discussed by Lacy and Luff (2007), with multiple coding methods applied to each stage, to ensure the true value and the story within the story of the data was exposed. Therefore, the design of the analysis followed K&M's *principle of Abstraction and Generation.*

The analysis process was divided into two stages, an initial and a retrospective stage. The initial analysis stage focused on analysing the data collected at each stage of the data acquisition process. The retrospective analysis was conducted at a more reflective point, once the outcome of the naturalistic decisions observed became apparent. The following sections discuss each of these stages in more detail.

Initial analysis:

The analysis at this stage is focused on analysing the data gathered at each stage of the data acquisition process. The data collected during *the first stage* of data acquisition, which was in the form of a semi structured interview with the BI manager, was designed to understand the company's BI capabilities and architecture; the analysis used pre-determined narrative codes to analyse the interview transcript. Multiple pre-determined codes were used for the analysis of the data gathered during stage two of the acquisition process, which was in the form of a group observation presenting the naturalistic decisions that face the companies. These included narrative codes describing who the key stakeholders were involved in the decisions faced and the general factors that influenced the decisions. Emotion coding was also applied to analyse the observations of the feelings or anxieties of the individual DM at an early stage of the process.

The third and most complicated stage of this analysis process was the analysis of the data gathered during the individual participant observations. The analysis considered what the researcher wanted to know from the observation before it started, therefore, multiple pre-determined coding methods were applied to satisfy the researcher's curiosity. These included attribute codes to register each decision maker's personal information, in vivo codes to register what the participants' feelings towards the decisions faced throughout the process were, process coding to analyse what each decision maker did throughout the DM process, data analysed, tools used and sequence of events. The last of these predetermined coding

methods used during this process was narrative coding to understand what decision the decision maker reached to solve the naturalistic decision faced and the justification for recommending this decision.

The above analysed data from each individual DM's observation transcript was then organised into summary tables that present at three different stages of the decision making process (start, middle and final) a summary of the data that emerged from these codes in the participant's own words. This data was then further analysed with the use of cognitive mapping to draw out each participant's individual cognitive maps, this technique would add clarity and structure to the collected data and help to hone in on each participants' cognitive process. When constructing these summary tables and maps, the researcher was sensitive to possible differences in interpretations between the participants as described by K&M's *principle of multiple interpretations.*

According to Ackermann et al. (1992), cognitive mapping is a technique that has been used by researchers across a variety of fields when working on tasks such as assisting in an interview process by increasing understanding and generating themes, assisting with the structuring of complex or messy data for problem-solving and managing large amounts of qualitative data after the interview process. The technique has been developed overtime since it was first founded based on the principles of George Kelly's theory of personal constructs (Kelly, 1955). The original theory suggests that individuals develop personal constructs about what the world is like in its current state and use these constructs in order to make sense of their observations and experiences in order to predict how it will be in the future.

Furthermore, Ackermann et al. (1992) suggested that cognitive mapping allows researchers to understand how decision-makers perceive problems by representing how the decision-maker cognitively processes the problem. This involves identifying where the key issues of the problem lie, their perceived aims and objectives in solving the problem and what options the decision-maker has identified. This process also involves identifying what options have already been explored and whether new options need to be considered or explored further. The resultant map also allows the researcher to identify any issues that the decision-maker faced in the process, such as decision dilemmas, feedback loops or conflicts. These options are the themes or concepts that are identified from the data collected by the researcher. Individual maps can then be compared for further analysis.

However, Ackermann et al. (1992) described the process of generating a cognitive map as a skill and, like any other skill, it requires practice for the researcher to master. The process is also time consuming and challenging, as identifying the key issues *themes/concepts* from the data whilst maintaining ownership over the concepts to the participant requires a great deal of patience. Furthermore, there is no right or wrong way of generating a map as it depends on the researcher's understanding and level of influence over the map, the problem faced and the research objective to begin with. The following guidelines were used in constructing each individual cognitive map, based on Ackermann's techniques:

1) Identifying and separating the sentences from each transcript for each participant into distinct phrases which will be 10-12 words long;

2) Building a hierarchy of goals (in this case a central goal), strategic directions and options available and taken for each direction. These will be the concepts of the map;

3) Numbering each concept by its occurrence in the decision making process;

4) Connecting each strategic direction followed by each participant to the option(s) taken by the participant;

5) Colour coding the concepts by the BI tools used at each stage of the process;

6) Coding the concept shape based on whether it has been efficiently achieved using the BI tool or not; and

7) Presenting the map to each participant after development to ensure that it is representative of his/her own cognitive thinking at the time of the process.

The analysis undergone on the data collected during *the fourth stage* of data acquisition (participant observation to register decision outcome) also used multiple pre-determined codes to capture the data sought at this acquisition stage. Narrative coding was used to register the decision made at this stage of the process. Emotion coding was used in order to capture whether there are anxieties or emotions associated with the decision taken and how strong they were. Finally, value coding was used to register any values or beliefs that influenced the course of action taken by the company.

The final stage of this initial analysis focused on analysing the data collected during the fifth stage of data acquisition, which was in the form of a semi-structured interview that would determine the outcome of the final decisions taken by the companies. The analysis used pre-determined codes in order to analyse what the outcome of the decision was, and the level of satisfaction with this outcome. Figure 8 illustrates the data analysis steps undertaken at each set of data collected during the data acquisition stage:

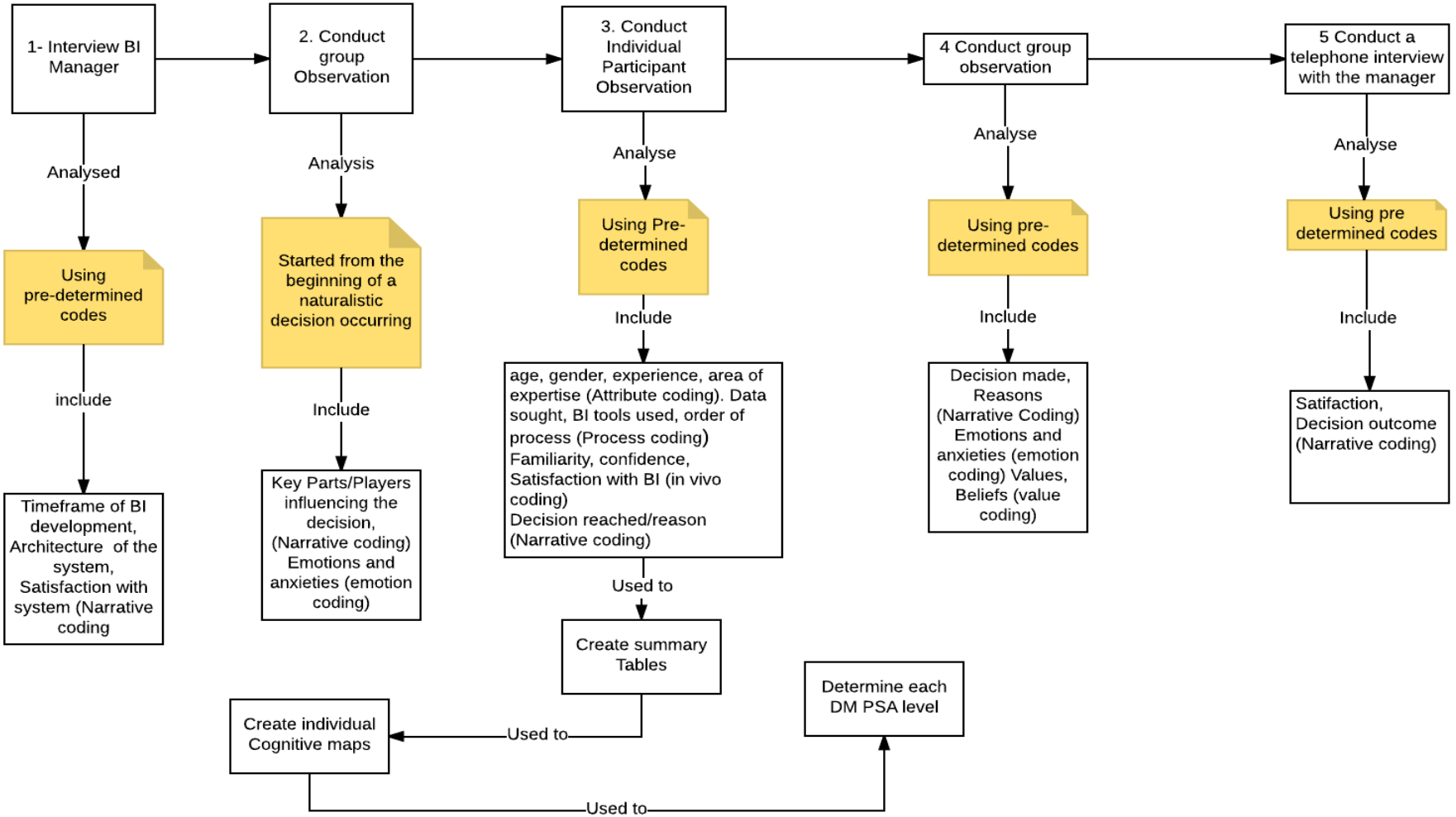


Figure 8 Initial Data Analysis Stages

Retrospective analysis

The previous stage of data analysis tries to make sense of the data collected during the research acquisition stage. This stage of data analysis takes a more reflective strategy in which the researcher tries to bring together the individual cognitive maps and summary table in order to measure the individual SA awareness levels of each Participant. The measuring technique used in this research is similar to Endsley's SAGT; however, as this technique uses simulation and problem freezing to measure individual PSA levels, it would not be suitable for this study.

The summary tables and individual cognitive maps generated from each participant will then be combined to undergo further analysis by measuring the levels of SA for each individual participant. The technique developed measures two distinct SA levels: Perceived Situational Awareness (PSA) and Actual Situational Awareness (ASA).

The participants' PSA levels are measured using each individual participant's own words:

a) The level of familiarity to the decisions or problems faced and if and when it changes. To establish this point the researcher needs to ensure that verbal communication is used to understand the mental cues of each participants in judging their familiarity with the situation in hand

b) The level of confidence/uncertainty in what they did throughout the decision-making process.

The researcher ensures through communication with the participant that he stays informed from the start and through the different stages of the analysis of the levels of these key points and any changes to them, recording the reasons for these changes. The measurement technique is applied throughout the 120 minutes in which the individual participant observation took place and is measured on a scale of 1 to 10.

The PSA levels intend to show at what level the participants themselves see their SA levels during the decision making stage; however, the levels are judged by the researcher based on the data collected during the observation. Therefore, each individual participant will be sent their measured PSA levels and the data used to measure them for review. This ensures the validity of the measuring technique against researcher interference.

The ASA of each participant is more advanced analytically in nature as it uses each PSA level and compares it to what we call the 'ground truth'. The ground truth consists of the data gathered at stage 5 of the decision acquisition process, which establishes what the correct decision was, which data was relevant in making the decision, what external factors should have been considered when making a decision and finally, what tools should have been used to efficiently analyse the situation. Once this initial step is conducted, the individual levels measured will then be cross referenced across against each other to reach a higher level of accuracy between the participants. The individual ASA levels are applied throughout the 120 minutes in which the individual participant observation took place and are measured on a scale of 1 to 10. Figure 9 illustrates the process of analysis at this stage.

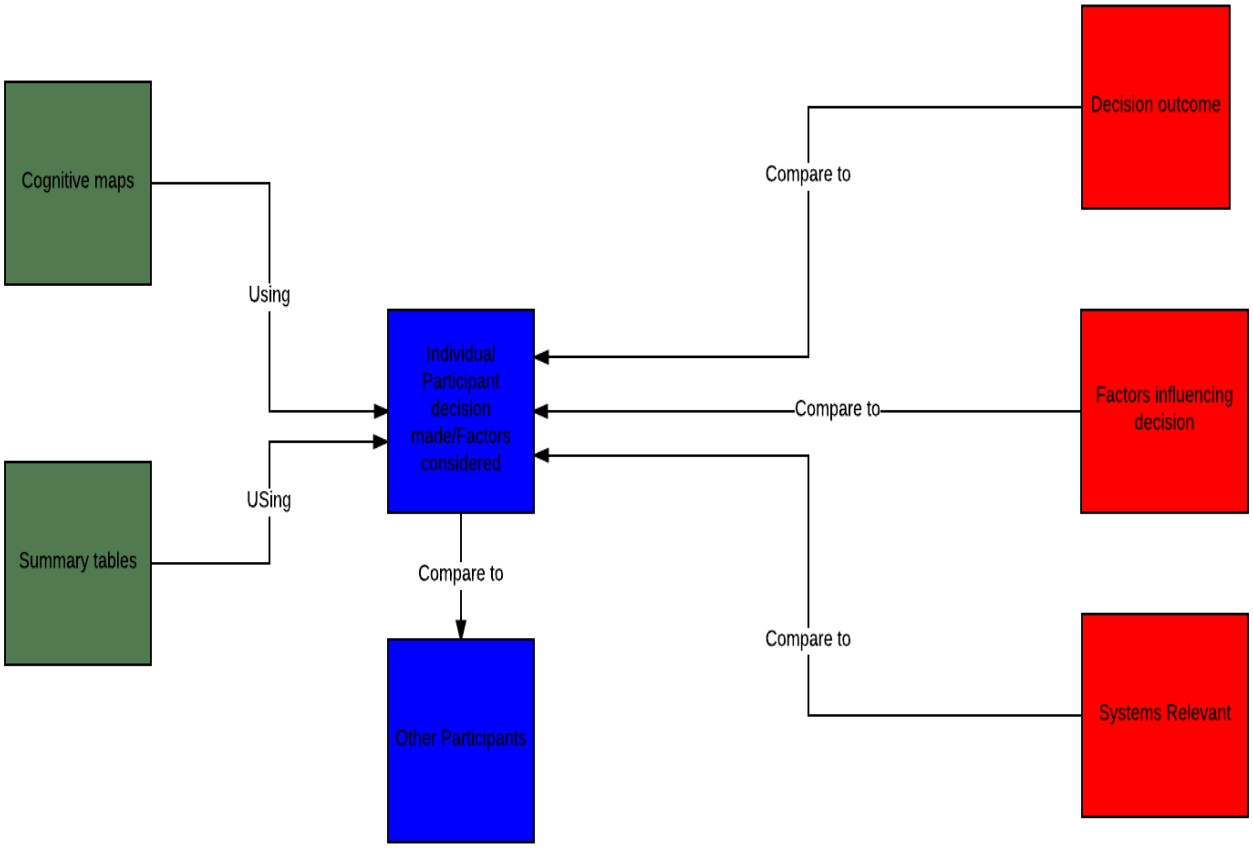


Figure 9 Retrospective Analysis Stages

3.6 O&G Overview

This section provides an overview of the operations of the companies that took part in the study which would clarify the different sectors of the O&G industry (upstream and downstream).

3.6.1 *Company A*

Company A owns refining and O&G processing companies, operating locally and internationally, to serve local customers at their bases. The company has partnership

agreements with service companies which carry out oil well drilling and work over operations, provide all drilling materials and equipment, lay and maintain O&G pipelines, build and maintain O&G storage tanks and carry out related technical and economic studies. They also provide the sector with other services, such as catering, procurement of materials and equipment, training and employment of foreign employees.

3.6.2 *Company B*

Company B operates in the downstream sectors of the industry and is a subsidiary of Company A. Company B is engaged in the supply, trading and shipping of natural gas, liquefied natural gas, electricity, fuels and chemical products. Through refineries and chemical plants, the company processes crude oil and other oil-based feedstock to produce fuels, lubricants and chemical products that are supplied to wholesalers or through retail networks or distributors. Furthermore, it operates in engineering, oilfield services and construction offshore and onshore, focusing on the execution of technologically-advanced mega-projects.

3.7 Summary

To summarise, this chapter outlined the research methodology adopted in order to fulfil the core objectives of the present study. It provided detailed insights into the research philosophy and design, described the industry and organisations involved in the study, and presented the planned data collection techniques. Furthermore, the data analysis methods used in the study have also been discussed in detail. This study relies on qualitative methods and takes an interpretive approach to analysis. Using a multiple case study approach, this study aims to develop a higher level of understanding of the research problem and arrive at valid theories to contribute to the literature. Furthermore, the study employs multiple data collection methods to achieve triangulation.

CHAPTER 4
UPSTREAM SECTOR DATA ANALYSIS

4.1 Overview

This chapter presents the data collected from Company A, which operates in the upstream sector of the industry, and the analysis stages described in the research strategy. The chapter includes three different upstream scenarios where the company had to make naturalistic decisions. The data and analysis for each scenario is presented consecutively. The chapter is structured as follows: an introduction to the site where the research took place, an overview of the company's BI system and its capabilities as described by the BI manager of the company (Data Collection Stage 1), an introduction to each of the selected scenarios or problems observed that meet the characteristics of naturalistic decisions, data analysis from the observation stage (Data Collection Stage 2), the focus group which led to a decision taken (Data Collection Stage3), an analysis of the level of reliance on the BI tools by each participant, the decision outcome, and finally a retrospective analysis of each participant based on their decision recommendations and decision outcome.

4.2 Company A Site

Data collection took place in the company's onsite marketing warehouse, located within one of the company's major production oil fields in North Africa, where the company operates in partnership with a second party. The office has moved to this location due to a turbulent political environment in the country where the company operates. The analysts taking part in the organisation spend 28 day rotations in the field. The office houses one senior manager and a group of 12 analysts (i.e. decision-makers) with various levels of experiences. The senior manager indicated the company was used to adapting to unstable political situations, although such situations were hardly ideal.

4.3 Stage 1: Research Analysis

The first stage of the data analysis aimed to investigate the BI capabilities of the organisation. This was done using a semi-structured interview, which took 45 minutes to complete with the BI Project Manager. The participant has been the BI Project Manager for the company for the last 7 years and was part of the IT department at the organisation when the BI project was first adopted by the organisation. As such, the BI Project Manager had witnessed first-hand the hardware and software development of the system throughout the years. The interviewee described the BI capabilities of the organisation, indicating that the company invests heavily in ensuring that it stays relevant from a technological standpoint in order to achieve whatever marginal edge it can over its competitors. The interviewee indicated that the organisation was very proud and satisfied with the current setup that it has in place and that the BI Management Department works very hard to ensure that the systems run smoothly and that end-users have the most up to date and efficient data possible. The BI Management Department aims to provide data that would rival any of its competitors, even though the uncertain nature of the industry means that on some occasions the data might be deficient. Furthermore, the BI systems in place have an integrated set up and users are able to combine data from across different platforms in order to get the highest levels of insight from the intelligence available. The system is a purchased collection of BI tool manufactured by a highly renowned and respectable BI solutions provider; additionally, the system has been tailored in-house to suit the company's needs, including the following:

- *Incident Management Tool*, which can be utilised to investigate any on-field or political incident that might affect the organisation and assess any media or local authority risks the company might face and specific guidelines on how to behave if such an incident was to occur;
- *Environmental, and Health and Safety Management Tool*, which can be utilised to calculate and assess any environmental or health and safety risks that might occur if an incident takes place that might affect the safety of personnel working for the company, any members of the general public, the environment or damages to

company property. Furthermore, the system helps the company provides guidelines on how to deal with any situation if an incident took place;

- *Risk Management Tool*, which can be utilised to assess and contain the levels of risk for any giving situation;
- *Simple Finance Tool*, which can be used when conducting standard financial calculation before making a decision;
- *ERP Tool*, can be utilised to conduct different internal processes;
- *CRM Tool*, this can be utilised to deal with interactions between current and potential customers; and
- *Multi-Resource Scheduling Tool*, which can be utilised to aid in the assessing, planning and scheduling of different resources from start to the completion of different company tasks such as maintenance works.

Each tool is assigned a colour code to help identify when it was used at each stage of the decision-making process, as displayed in the cognitive maps.

4.4 Scenario 1

The first naturalistic scenario related to a leak in one of the crude oil storage tanks in the upstream operations. The situation first came to the attention of the marketing department when the operations manager in the O&G production field reported (after a standard storage tanks maintenance check-up) a leakage compromise with Storage Tank 2. The marketing and sales manager called an urgent meeting for all the business analysts. The manager explained that crude oil produced from drilling the well on site goes into what is called a *drop well*, which then feeds into two storage tanks that are connected to the local port via an underground pipeline. The oil field in question produces about 300,000 cubic metres of oil every day, the company has already sold the next month's crude oil expected to be produced to customers. The storage wells can only hold about 600,000 cubic metres of crude oil, with customers already giving timeslots to collect the oil from the port using their own vessels (although they normally hire vessels from shipping companies). The problem the company is currently faced with is that it can no longer store the maximum quantity as a result of the tank being compromised and it has already received payments

from the buyers with the quantities being sold. What complicates matters further is that the company in most circumstances has, as part of the transactions, purchased gasoline and diesel to be sold locally from the buyers. This could lead to local pressure from the local authorities and the public if a shortage of these essential everyday products is not available for the public.

4.4.1 Stage 2: Data Analysis

The manager gave a time frame of 2 days for a decision to be made, adding '*the ultimate goal or required outcome to the problem is to maximize as much profit as possible and not take a big loss at this moment*', as the price of crude oil had plummeted over the past few months and profit margins are at a decade low. Analysts were asked to analyse the situation separately and in turns. This would allow the researcher to observe how each participant went about devising a solution to the problem at hand.

4.4.2 Stage 3: Data Analysis

The study began with the gathering some general demographic information about each participant, including their age, level of experience in their current position and their professional background or area of expertise. The researcher gave a unique number to each participant in order to ensure their anonymity as agreed in the confidentiality agreement. Participants then confirmed the validity of the demographic data by signing the consent form presented to them. The following table (Table 2) represents a breakdown of the information gathered in this step.

Participant	Age	Experience	Area of expertise
S1P1	35	5 Years	Business
S1P2	48	9 Years	Engineering
S1P3	60	15 Years	Trading
S1P4	28	2 Years	Business
S1P5	53	15 Years	Marketing
S1P6	30	2 Years	Marketing
S1P7	56	17 years	Business
S1P8	50	15 Years	Marketing
S1P9	35	5 Years	Engineering
S1P10	42	8 Years	Business
S1P11	52	13 Years	Engineering
S1P12	54	20 Years	Trading

Table 1 Scenario 1 Participants' table

The observation, with all 12 analysts, was audio recorded from start to finish with the researcher continuously taking notes and asking questions from each participant throughout the process. This meant that the data analysis started in each case as soon as the live observation started with each participant. Participants justified their initial actions when using the BI tools they had available, indicating:

- to what level they understood the problem they were facing,
- were aware of what was happening and how the problem could be solved,
- whether they had any previous experiences with similar situations, and
- whether their professional backgrounds somehow related to the current situation (i.e. the level of each individual's SA).

The researcher highlighted this data as it was crucial to the overall purpose of the study and monitored any shifts this this level throughout the process.

Following the guidelines for good qualitative data analysis, the researcher focused on getting familiar with the data collected from each participant and going over it was clearly

understood. Whenever gaps in the data appeared, contact was made with the relevant participants in order to fill these gaps. Individual decision process transcripts were then drawn into cognitive maps by following the cognitive mapping guidelines outlined earlier. These maps were used to help breakdown the data into different decision concepts and to highlight the flow of the decision process for better analysis. The full list of the maps can be found in the appendix

The following tables summarise each participant's decision-making process at four different stages during the observation. The first stage includes extracts from each participant's transcript, describing their initial thoughts on the problem and their initial actions in solving it. The second stage includes the outcomes of the initial actions taken and any changes in the direction of solving the problem. The third stage represents the outcome of the second stage and overall thoughts on the problem as described by the participants themselves. The last stage represents the decision that each participant recommend to solve the issue. The tables also include the BI tools at each stage of the process. The tables were constructed to aid in the development of the participants' cognitive maps and to highlight their PSA levels throughout the decision-making process. Table 3 includes participants 1 to 6, whereas table 4 includes participants 7 to 12

	P1	P2	P3	P4	P5	P6
Stage 1 perception	•*"I have never come across a tank compromise situation"* •*"the relevant part right now is to attempt to understand when this compromise will start affecting production"* •*"any production scenarios that could help solve this problem?"*	•*"I probably understand what is happening"* •*"had a previous experience where some form of compromise took place"* •*"firstly want to know if other fields can take the production load"* •*"to change the shipping port for any already agreed deal, the costs for the buyer change dramatically the shipping costs, lay-can and dead weight options are normally a big stumbling block"*	•"there is a solution to any problem, these things happen a lot" •"I've had experiences in the past where shipments were cut off due to wars or natural disaster" •"this situation is no different, the keys to solving this problem is negotiating and leverage"	•"I might not have the most experience in this industry, however, I do have a relatively good understanding of what to do in a crises situation" •"Relatively speaking I understand what is happening here to some degree, I know how to negotiate a good deal and that's all that is needed" •"I want to investigate the terms of these contracts fully, and the level of historical purchases each buyer has with the company, then I would be able to be more confident in what to do"	•"Setbacks in production are very common, the production operation relies heavily on mechanics with human aid, therefore, error is to be expected" •With my marketing experience I understand what needs to be done, there is no need to panic at all, and the situation should be smoothly resolved• I can solve the problem by negotiating with the clients whilst understanding the timeframe of the tank being fixed and the cost of the operation"	•"I have only been recruited to the com recently, I have spent the last couple of y working very closely with my senior anal (P5)" •"I have seen similar production issues in past and believe that a deal could be rea to get the best deal possible considering circumstances and a repair cost and sche plan to know when the production will b to speed again which will make me negotiate better"
PSA at stage 1	*Medium*	Medium	High	Medium	High	High
BI Tools used at this stage	*ERP*	ERP Simple finance CRM EHS Management	CRM	ERP	CRM ERP and Multiresource Planning Simple finance	ERP and multiresource Planning Simple finance
Stage 2 perception	•"understand how much this will cost us in order to understand the problem which will help minimise these costs" •" biggest issue I reckon will be cost of shipping from multiple locations" •"answer could be to look at increasing production in the oil other fields" •"worrying about the risk of our competitors taking our clients from us"	•"at the moment I am running out of ideas" •"I think we should focus more on understand the problem cause" •"risk of such compromise could damage the company financially more than anything than taking a loss" •"issues with the local authority, environmental concerns could arise, not to mention financial costs, therefore, shutting down production could be an a better option to minimise the losses in the long term"	•"I have a good and long standing relationship with most of our current buyers and other players within the industry" •"I think I can calculate a good deal to offer them "	•"Looking at the cost of production, I am not sure management or the buyers would be happy with the offer I recommend" •"I don't think that the ultimate goal could be achieved and we might up losing the buyers to our competitors" •"I do not understand how a simple leak could lead to costing us so many loses I will contact the field operations manager to see"	•"First I need to make a first offer which is only a strategy to start negotiating from a low ceiling" •"The real offer, is what I call a shipping costs sharing offer this involves sharing the costs of the shipments for quicker cargo pick-ups from the ports" •"I need to calculate the costs of such offer, understand shipping logistics of the lay-can timeslots and available cargo specifications that might occur from vessel death weight issues"	•"I am not sure if the offers I have calcula are going to impress management" •"The best option at the moment would negotiate to the best of our abilities"
PSA at stage 2	high	low going high	Medium	Low	High	Medium
BI tools used at this stage	ERP Risk management	Incident Management Risk management EHS Management	CRM Simple Finance	CRM Simple finance Risk Management	CRM Simple finance EHS Management	CRM Simple Finance
Stage 3 perception	•"the best possible option is to negotiate with the buyer so we don't lose them" • "there are different ways to negotiate for both sides to" •"to minimise the costs we have to look at the lay-can and dead weight options	•"having had a situation similar in the past, I believe that it is very unlikely that any environmental or financial risks could occur which would ultimately mean no local authority risk" •"with so little proof of real risk"	•"it is important to keep the same buyers" •"our competitors might also jump in and take them from us is a major risk" •there is no other option, only then would I contact any new buyer but I am extremely confident in negotiating a good deal with the existing buyers"	•"The situation could lead to a big financial risk I am starting to understand the situation better now" •"I need to assess the financial risk in order to estimate the costs of such risk compared to the cost of agreeing a deal with the buyers or the risk losing them to a competitor"	•"I am going to prepare multiple offers for the buyer, starting from a low ceiling and going up to the maximum we can give" •"In the case of no deal, I would just find a new buyer"	• "If he offer is not agreed, I think the onl solution would be to find and negotiate new buyer"
PSA at stage 3	Medium	High	High	Medium	High	Medium
BI tools used at this stage	CRM Simple Finance EHS Management	Risk Management	CRM Risk Management Simple finance	Incident Management Risk Management	CRM Simple finance	CRM Simple Finance

Table 2 Scenario 1 (P1 to P6)

	P7	P8	P9	P10	P11	P12
Stage 1 perception	*•"The moment I heard of the compromise leak I remembered a similar situation in the past" •"luckily this experience makes me confident of the tasks needed to make the best possible decision" •" The cause of the compromise is what is needed to understand the problem"*	*•"I feel relatively confident in the situation can be resolved, I have had experiences in the past of some sort of production compromises, but never this complicated" •"The best course of action would be to first understand the time-fame and cost of the compromise repair and prepare an offer for the buyers"*	*• "A tank compromise leak can be due to different causes I try to keep tap on the operational part of the company as that is where I used to work, therefore" • "I definitely have an idea as to what happened"*	*•" Problems are part of our industry just like any industry, the key to solving any problem is negotiating" • "I am confident I would be able to negotiate a good deal that would satisfy management and our buyers how much you are able to negotiate depends on how much leverage you have, in this situation, the leverage we have is the shipping, if we can somehow find a way to reduce the shipping costs, increase the lay-can options and sort out the death weight logistic we would be manage to offer the buyers our best"*	*•"I feel in my comfort zone with this problem, my experience and knowledge on the subject matter gives me a great edge in understanding the situation and the potential outcomes of different courses of actions to achieve the goal of the task" •"The first action to be taking is to understand the repair plan and costs"*	*•"I have come across different compromi situations to some degree I understand w needs to be done more information is ne to make a more informed decision" •"What is needed t is to understand whet the terms of the contract with the buyers allows for any leeway" •"We need to calculate what is the maxi discount offers we can offer and negotiat with the buyers"*
PSA at stage 1	High	Medium	Medium to high	High	High	medium low
BI Tools used at this stage	Incident Management	ERP and multiresource Planning Simple Finance EHS Management	Incident Management	CRM EHS Management	ERP and multiresource Planning Simple Finance	ERP CRM Simple Finance
Stage 2 perception	*•"In my previous the cause of the compromise was due to change in the maintenance contract if this situation is the same" • "The only risk that needs to be investigated is the financial risk of shutting down the production compared to any possible offer made to the buyers"*	*•"The next stage would be to prepare a deal with the customer, however as the shipping costs and lay-can and death weight logistics are extremely costly and generally frustrating to the point where no deal seems good enough to satisfy both parties" •"Part of the job is solving problems, however, it is almost impossible to solve problems without having more information" •"I believe that a full investigation into what happened to tank and the consequences needs to be investigated to fully appreciate the situation"*	*•"What worries me most is the consequences, from my experiences working in the field" •"Thee risks from such a compromise could be severe" •"Environmental and local authority risks could taint the company's reputation if materialised and the short term and long term risks for such a problem could also cost us dearly"*	*•"After establishing the leverage and the logistics" •"I can now prepare multiple offers the buyer might accept; this is going to be tricky as the logistics are a big stumbling block." •"if there is no deal struck then there is real risk of losing the buyer to competitors which represents a big financial risk as well"*	*•"Now I need assess the level of risk the compromise could lead to, from my previous experience in the field" •"I have seen that the environmental consequences of such a compromise and I know better than to take them lightly"*	*•"After calculating the issue the best offe ludicrous to accept and the risk assessme needs to be conducted in order to unders what are the chances and costs of losing buyers." •"Maybe lessons could be learnt from thi gloom situation by understanding the ro the problem in order to avoiding it happ again in the future."*
PSA at stage 2	High	Low	medium to high increasing	Medium	High	Medium
BI tools used at this stage	Risk Management	Simple finance inceident management	Incident Management EHS Management Risk Management	CRM Risk Management	Incident Management EHS Management Risk Management	Incident Management EHS Management Risk Management
Stage 3 perception	*·"Now I need to compare the costs of shutting down production is incredible" ·"Conidering the low risk of the compromise that any reasonable deal agreed with the buyers is a far better option"*	*•"Having looked at the cause and potential risks of the compromise, I believe that it is better to take a massive short term loss and be safe" •"The risks if materialised could lead to problems far greater than the losses from halting production until the repairs are complete"*	*•"The risk is real, some of the details are yet to be available on the system and confirmed due to the protocols in place and the fact that they are time consuming" •"Any decision taken other than shutting down production fully until a full investigation and assessment of the risks and cause are complete is unwise to say the least and could lead to a high levels of financial and legal costs"*	*•"The deals I have in place might not be ideal but the buyers under this time pressure they are facing would probably be tough to negotiate with but would ultimately agree" • "I am confident that here is always a deal waiting to happen in these situations."*	*•"The risk of the compromise is highly unlikely at the moment and cost of shutting down the production process is a very wild overreaction" •"Based on the data available and the circumstances I believe that the next course of action is to negotiate a deal with the buyers, the cost of such a deal would be less than ideal to both parties but is going to be significantly better than halting production" •"I am not sure if such a deal could be struck under the circumstance"*	*•"Even without concrete evidence the compromise risks are potentially catastr and therefore need to be addressed urge •"When compared to the losses from any potential deal or with halting productio compromise risk is far greater."*
PSA at stage 3	High	High	High	high	Medium	High
BI tools used at this stage	Simple finance CRM	Risk Management Incident Management EHS Management	Simple finance Risk Management	CRM Simple finance	CRM Simple Finance	Simple Finance Risk Management

Table 3 Scenario 1 (P7 to P12)

4.4.3 Stage 4: Data Analysis

During this stage of data analysis, the researcher recorded the interactions between the participants and the senior manager who is ultimately responsible for making the decision. Each participant presented their recommendations and justifications for their decisions. Participants 1, 3, 5, 6, 10 and 11 gave the exact same recommendation, which was to negotiate. P5 recommended offering discounts and contingency offers in case the offers were rejected along with a list of potential buyers in case no offer was accepted by the buyer. Participant 4, 8, 9 and 12 argued that the risk of the compromise could lead to

substantial damages from different angles and that continuing production under such circumstances was unwise. While participants 2 and 7 indicated that they shared the same level of initial concerns, due to their previous experiences working in the production stream, they considered these risks as being unlikely to materialise and ultimately agreed with the first group of analysts who recommended negotiating with the buyers.

The decision-maker indicated that under the current circumstances the cost of shutting down production based on a very low level of risk, a view which is backed by a couple of analysts with previous experiences similar to the current situation, was untenable. Consequently, the decision-maker decided to negotiate a deal with the buyers to solve the problem and the manager appointed P5 to be the lead negotiator on behalf of the company. P5 would negotiate with the buyers and ensure that a deal was reached, with finding a new buyer being kept as a reserve plan should no solution be agreed upon.

P5 ultimately reached a decision with the buyer to sharing the cost of shipping the cargo in half the time originally agreed. Furthermore, the buyers insisted that instead of buying the product at the price for the specific month when the field was compromised, they would pay the price of the following month. P5 indicated that the buyers had probably predicted a drop in the price of crude oil for that specific month, indicating:

> *...they are heavily gambling on the situation. Under the current political situation in the area, anything can happen; an oil field might get burned by some Islamists in a Middle-Eastern field, or a strike might take place in a different one.*

P5 recommended to management that they agree to the deal. Therefore, a final deal was reached with the buyer.

4.4.4 Initial Post-Decision Data Analysis Level of Reliance on BI Tools Analysis

When analysing participants' reliance on BI, a few issues need to be taking into consideration. The first is that the CRM tool was not used by any of the participants during the observational stage, as the instructions were to come with a recommended decision to solve the problem. However, all lines of communication between the analysts and the

buyers were forbidden. But as seen from the cognitive maps, the tool was included when participants indicated that communicating with the buyers using the system and presenting them with offers and counter offers is the course of action they would take at that stage of the process. Given, however, that the ultimate decision taken was to negotiate a deal with the client, the CRM tool became essential in conducting this task, and as each participant was a part of the department, they had to monitor the negotiating process closely. P5 spent approximately 30 minutes conducted the negotiation and interacting with the buyers using BI data. This time was confirmed by other participants who were monitoring the interaction. The level of reliance by each participant on each system is shown in Figure 10.

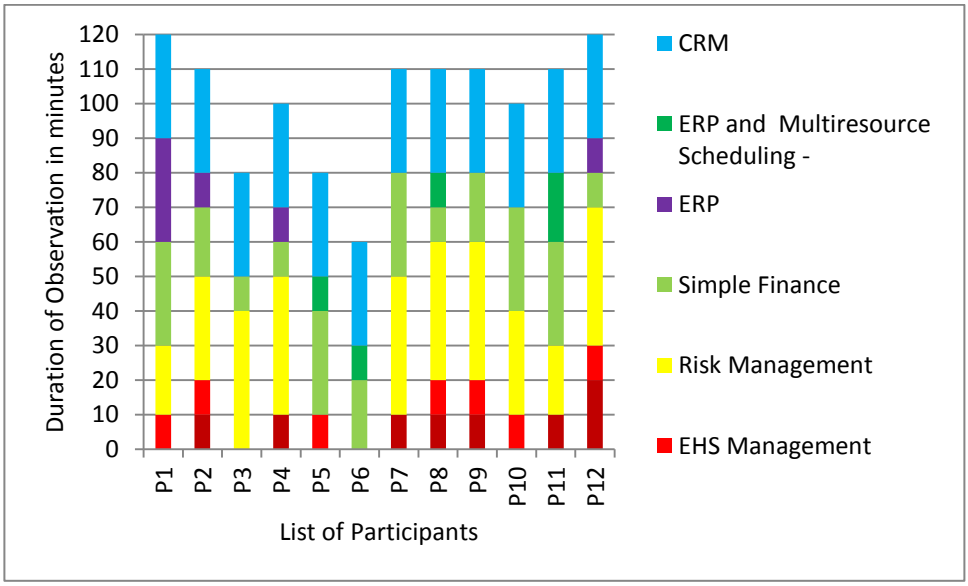


Figure 2 Stacked graph showing the level of reliance on each tool by each participant (including CRM).

After taking into consideration the aforementioned data, it was decided that since the CRM system was only used as a hypothetical interaction during the observational stage, it represents no real value to the study at this point. Therefore, it was decided that only the tools used during the observational stage were to be included in the level of reliance analysis stage. The analysis of this point is summarised in Figure 11.

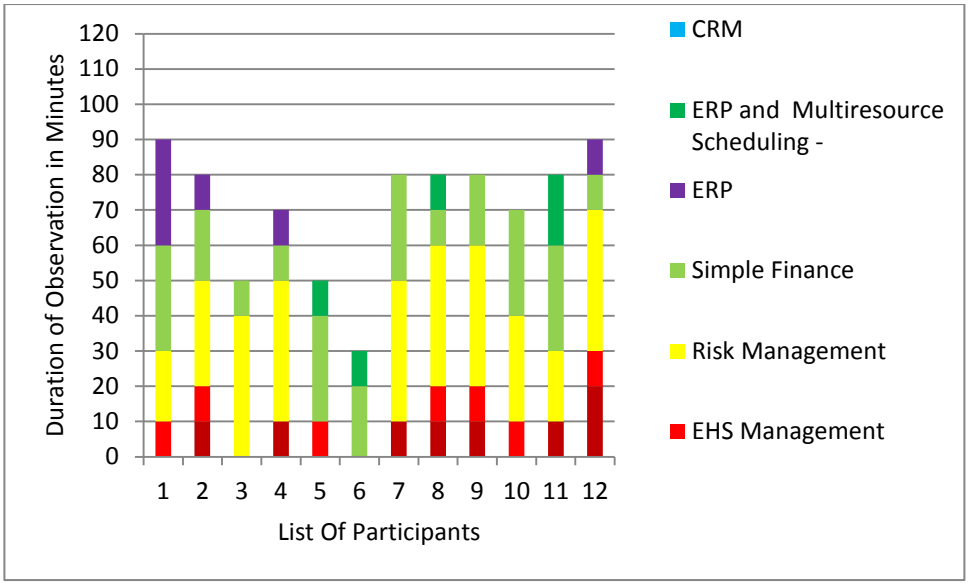


Figure 3 Stacked participant usage graph of BI tools

4.4.4.1 Level of Reliance Based on Decision Recommendations

As shown in Figure 11, none of the participants (even when excluding the CRM tool) had used all of the tools available to them at the time when conducting the analysis. Furthermore, when looking at the level of reliance on tools as compared to the decision recommendations given, what stands out is that participants 1, 3, 5, 6 and 10, who were absolutely sure that negotiation was the only way to solve the problem, spent an average of 1 hour using the system. Conversely, participants who were against negotiating and advocated shutting down production (i.e. participants 4, 8, 9 and 12), spent an average of 80 minutes using the system. In breaking down these figures, it is interesting to note that the participants who recommended shutting down production all spent 40 minutes assessing the risk of the compromise using the risk management tool; whereas, the pro-negotiation group used the Finance Management Tool, but only to assess the risk of losing the buyers to rival competitors. Participants 2 and 7 both spent 80 minutes on the system in a similar way, using the risk management tool to assess the risk of the compromise, but found no evidence that the risk would materialise and recommended negotiating backed by their experiences from what they perceived to be similar situations.

4.4.4.2 User Efficiency of the BI Tools

As mentioned in the beginning of this chapter, the BI Project Manager took great pride in the efficiency of the company's BI system and the level of integration of the applications. Therefore, the researcher deemed it interesting to analyse the level of user efficiency whilst using the system. This was done with the aid of the cognitive maps. The researcher set a concept style in the map, whenever a participant struggled to integrate two sets of data from different tools, the map showed the style of the concept at that particular stage in an abnormal style to the rest of the concepts. It was found that participants 1, 2, 4, 11 and 12 had efficiency issues when utilising the system. When looking at the demographic data in Table 4, it shows that participants 1 and 4 are relatively inexperienced with the company as compared to the other participants. The remaining participants who struggled, agreed that they were not entirely technology friendly. The participants who did not struggle with any issues in most cases, however, either fell in the average age, had a high level of experience or their usage of the system was low (i.e. P3, P5 and P6). Nevertheless, it was evident that no clear issues were encountered by any of the participants.

4.4.5 Decision Outcome

By keeping in contact with the organisation, the researcher continued to monitor the decision closely. The researcher was eventually contacted by the senior manager who provided the researcher with a detailed decision outcome. The manager explained that the decision taken carried with it a level of risk, but that given the timing of the problem the company had no choice but to accept the conditions of the buyers for the pricing to be set for an advanced month. However, the manager explained that this level of risk eventually benefited the company, as political disturbances in the region meant a shortage of the company's class of crude oil and the prices for the month chosen by the buyer increased significantly for the first time in months. The manager explained that this situation happens and there is a risk for every decision taken as the industry operates in an uncertain environment.

The manager, however, indicated that in retrospect the decision taken was not the correct one; the manager explained that the compromise at the time of the decision was at an early

assessment stage and the department did not as yet have all the details regarding the risk of contamination from the leak to the rest of the tanks. The manager explained that 5 weeks since the initial discovery of the compromise, the investigation into the leak found that high levels of air entered the tanks along with other substances due to sand storms, which ended up contaminating the crude oil within the tank and the tank connected to it (i.e. Tank 1). The manager said that, in retrospect, the organisation should have exercised greater caution, but as the level of risk was very low and the lack of details available at the time, shutting down the field seemed a costly overreaction. The company now faces massive loses in this field as the repair process should take a few months and some of the product sold to different buyers is already contaminated and may have changed specification.

4.4.6 Retrospective Analysis

The previous section discussed the analysis based on the decision taken by the company in response to the problem at hand. In this section, individual participants' reasons for their recommendation will be reviewed and comparisons made between participants' PSA during the process and their retrospective ASA.

For this analysis, participants are divided into three groups; the first group includes participants who recommended negotiating, the solution which was chosen by management as being the better decision at the time, but which in retrospect turned out to be worst. The second group includes the participants who initially considered the risk of the compromise to have been significant, but in the end felt that it was not significant enough and therefore recommended negotiation as well. The final group includes participants who strongly recommended the shutting down production due to what they deemed to be a high level of risk, which in retrospect turned out to be the better decision.

4.4.6.1 Group 1: Retrospective Analysis

This group includes participants 1, 3, 5, 6, 10 and 11. The initial analysis of BI tools and a justification for their choice of recommendations has already been stated in the previous section. Notwithstanding, apart from P11, none of these participants considered shutting down production or even considered the risks associated with the compromise. P11, whose

background in chemical engineering, initially considered only the environmental risk to be a problem, based a similar previous experience of a tank having been compromised. However, by not investigating the risks, the participant allowed their comprehension of the situation to be affected by their narrow way of thinking. Although PSA decreases at the end of the task, this decrease was unrelated to any doubts within the participant about recommending the wrong decision, but due to the low levels of confidence on the participant's part about being able to negotiate a deal that would achieve the goal at hand.

With regards to participants 1, 3, 5 and 6, due to their levels of confidence, their PSA levels were the polar opposite of their ASA levels throughout their investigation. P5 and P6 had similar PSA and ASA levels, the only difference being attributes to the higher levels of experience for P5, who's PSA was extremely high throughout the process and their ASA was slightly higher due to them being more familiar with their role and tools. This lack of experience meant that P6's PSA dropped slightly as their confidence in negotiating the best possible deal dropped.

The final participants left in this group, P3 and P10, were from background unrelated to engineering, therefore, they never appreciated any level of risk apart from losing the buyers to rival competitors. High levels of experience were evident in both P3 and P10, however, P3 showed minimum use of the BI tools with an identical shift in both cases in confidence only when this risk was deemed to be plausible. This risk was partly responsible for the participants' drop in PSA at that stage, but it recovered again after calculating the offer that the participants deemed to be good enough to solve the problem. P1, on the other hand, was relatively young age and had less experience as compared with other participants, which in turn led to them having a higher level of BI tool usage. In retrospect, this higher level of BI tool usage can be explained by way of the situation being foreign to the participant. However, this higher level tools usage did not make up for not understanding or knowing the risks associated with such a leak, which meant the PSA levels of the participant fluctuated as they began to comprehended more data. Notwithstanding, none of this data was relevant in terms of guiding them towards reaching their decision. Figure 12 illustrates the different PSA levels of the participants in this group, on the other hand figure 13 illustrates the ASA levels of the these participants throughout the process

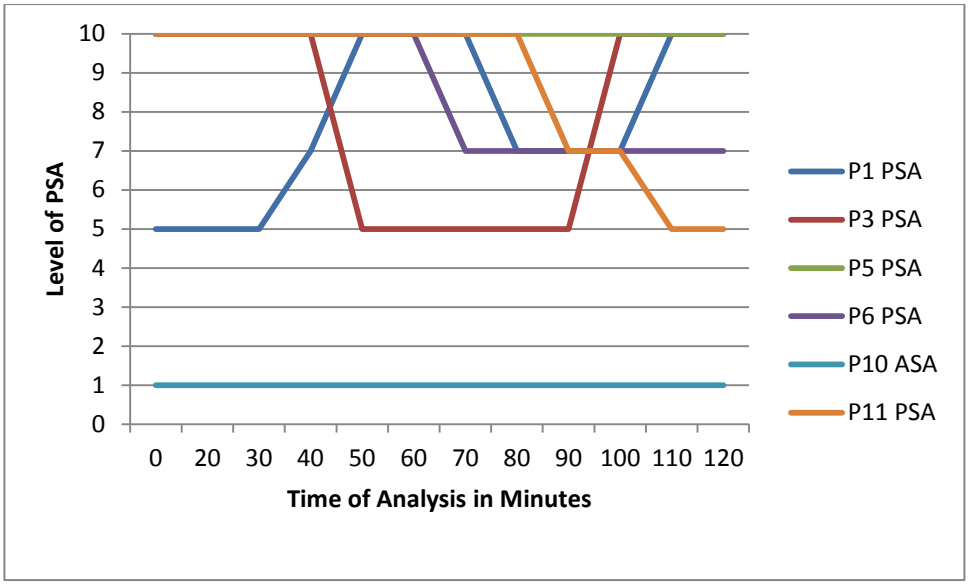


Figure 4 Scenario 1 Group 1 PSA Levels

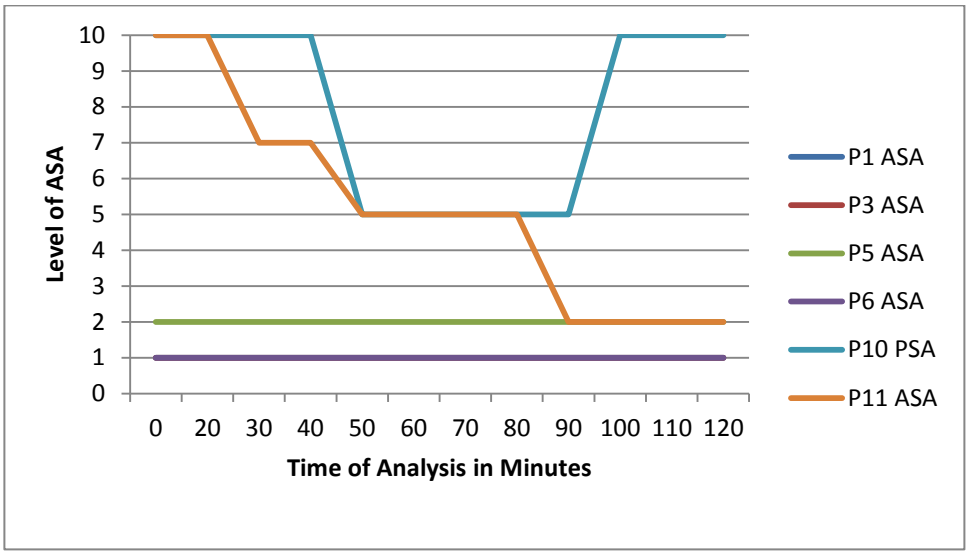


Figure 5 Scenario 1 Group 1 ASA Levels

4.4.6.2 Group 2: Retrospective Analysis

The second group of participants in this retrospective part of the analysis includes P2 and P7. As mentioned in the previous section, these participants, at some stage in the process, took into consideration the risk of the compromise. In the case of P2, the participant initially thought they could solve the problem by looking for production solutions that

would result in an opportunity for the leak to be repaired, however, in the middle of the process they decided to investigate the causes and risks of the leak. Based on a previous experience of a similar situation to the one at hand, the participant thought that it was very unlikely that anything untoward would occur. Moreover, nothing was on the system yet and no further information was available; therefore, P2 reluctantly decided to recommend negotiating, as he did not have the required skill to carry their preferred task, meaning that their PSA did not shift. P2's PSA versus ASA levels are illustrated in Figure 14.

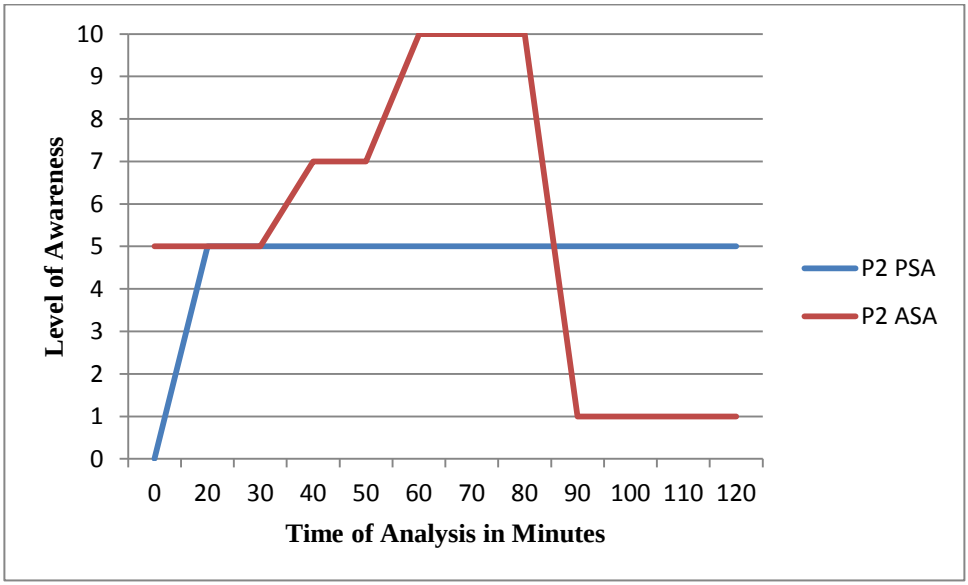


Figure 6 Line graph illustrating PSA vs. ASA for P2

With regards to P7, the participant did not have a background in chemical engineering, but they did recall a similar situation in the past, and based upon that prior experience and after an assessment of the financial risk, the participant recommended that the problem be solved by negotiating with the buyer. The participant explained that the cost of shutting down operations far outweighed the low levels of risk to the project. The participant's PSA stayed high throughout the process, whereas their ASA began to gradually dip once they reached the perception stage of the process. Figure 15 illustrates P7's PSA and ASA levels during the process.

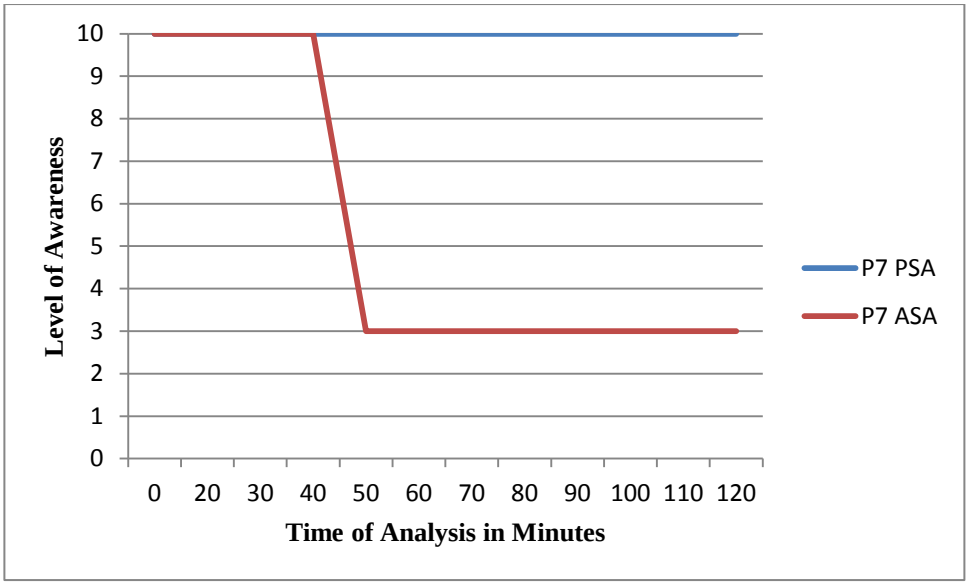


Figure 7 Line graph illustrating PSA vs. ASA for P7.

4.4.6.3 Group 3: Retrospect Analysis

This group consists of those participants who recommended the decision which, in retrospect, turned out to be the better option: to suspend operations pending repair of the leak. These participants included P4, P8, P9 and P12. The interesting thing about this group is that it included only one chemical engineer, who was known for their expertise in product contamination issues. P9 started off pretty confident, with a close to very high PSA; however, the participant contemplated no other options besides shutting down production until a full investigation and repair could be conducted.

On the other hand, P4, P8 and P12 all shared similar scenarios; they all initially followed their areas of expertise and thought the situation could be resolved by preparing a reasonable offer that would suit both parties. However, the costs of such any offer seemed incredibly high, which led to frustration or knowledge-seeking that resulted in understanding the risks that compromise could lead to. The major difference between these participants, however, is that while P8 and P12 understood all the risks that might occur from the leak, P4 focused only on the financial risks of such a compromise, deeming the risk as being sufficiently unlikely to avoid taking further risk, which led to these participants recommending what was, in retrospect, the correct decision. The PSA and ASA

levels of all three participants increased as the risks became increasingly apparent to them. However, P4's ASA did not reach the highest level because they did not perceive or comprehend any other risks that might have resulted from the situation. Figure 16 illustrates the different PSA levels of the participants in this group, on the other hand figure 17 illustrates the ASA levels of the these participants throughout the process

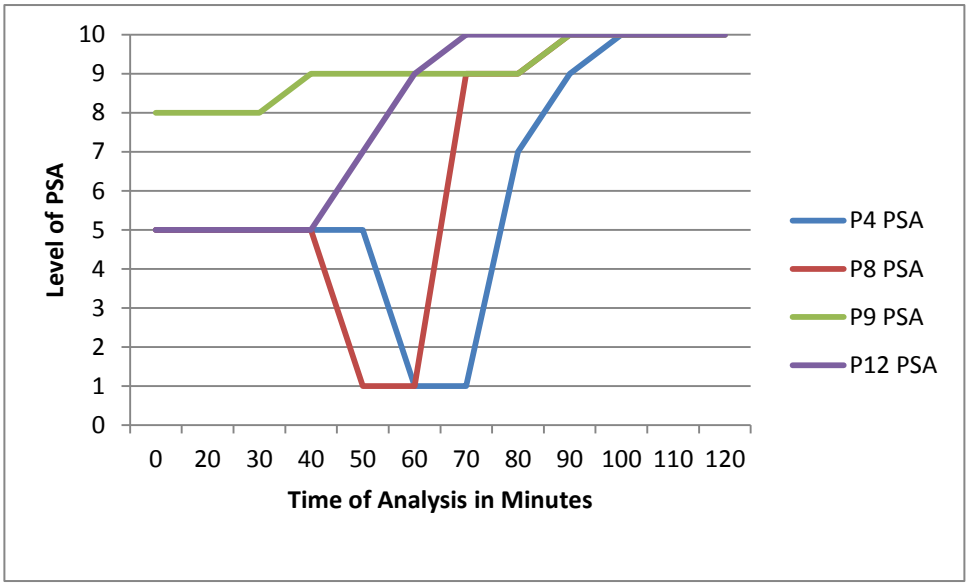


Figure 8 Scenario 1 Group 3 PSA Levels

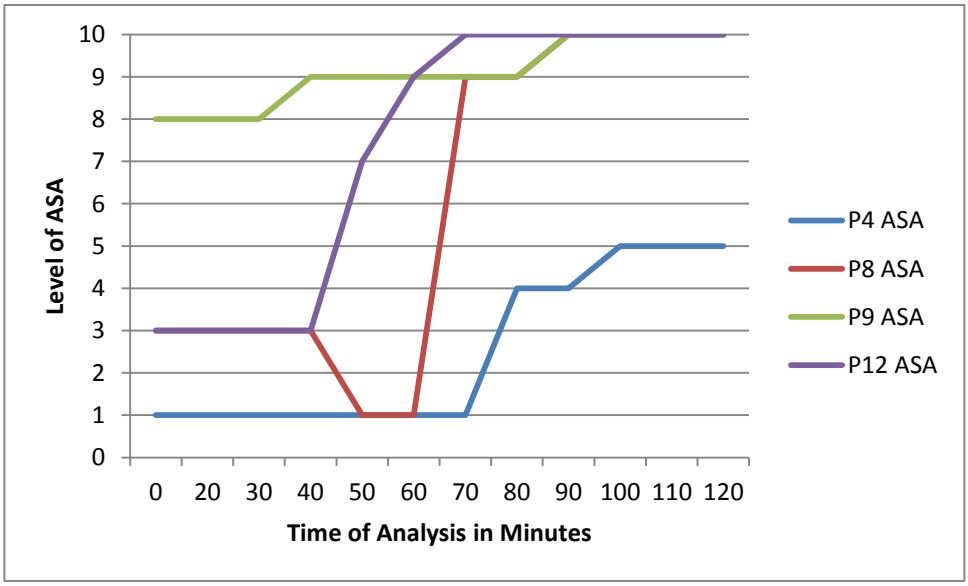


Figure 9 Scenario 1 Group 3 ASA Levels

4.5 Scenario 2

Scenario 2 relates to the sale of contaminated crude oil sold by the company to multiple clients. This scenario came as a big shock to the company and was a consequence of the decisions and outcomes of Scenario 1. The first sign of trouble came when it received a call from one of its customers indicating that the crude oil it received did not match the quality specifications of the product. The company at first did not recognise the products as being contaminated and said that an initial analysis should have been carried out before the carriers evacuated the port; however, this was not possible given the dangers presented by the current political situation surrounding the port. Additionally, both companies have been doing business for quite some time without any such issues, meaning that none of them had thought to carry out these routine analysis checks. Approximately 48 hours later, whilst the company was trying to conduct an investigation into the matter, the management began receiving more calls from other companies with the same issue. The company was forced to make another difficult decision in order to negotiate with the buyers and minimise their losses as best as possible under current circumstances.

4.5.1 Stage 2: Data Analysis

The senior manager decided that the analysts who were involved in Scenario 1 would have a better understanding of the problem at hand due to their involvement in the decision that led to this problem, therefore calling these individuals back in. The manager explained the situation in full and again asked that they ensure that they minimise the costs to the organisation as best as they could, but to exercise a higher level of caution as the company could not afford further setbacks. Therefore, the goal of the task was declared to be '*to minimise long-term losses rather than make huge profits*'.

4.5.2 Stage 3: Data Analysis

As the participants in this scenario are the same as in the previous scenario, the same information will suffice. The researcher again observed each analyst separately under the same conditions set in the research strategy and the following tables present a breakdown of the participants' decision-making processes at three different stages, the tools used at each

stage and their PSA at each stage. The data from these tables was subsequently used to create each individual cognitive maps for each participant. The full list of the maps can be found in the appendix.

	P1	P2	P3	P4	P5	P6
Stage 1 perception	•" When trying to minimise losses cautiously it's important to first understand what the maximum amount of losses were" • "During the compromise stage I felt that the situation was too technically for my expertise, I feel that now I can look at it from a more expert point." • "Finding a solution that would minimise out losses seems difficult to achieve. So first I need to look at the original situation and look at all the shipments sold during that time and the clients affected."	• "Whatever happens we are going to lose money, the situation is clear" • "What I need to do is to quickly predict whether we can replace the shipment and whether it is at all possible and the cost of such an operation as this shipment will be free, therefore, some kind of agreement on this should be reached with the client to understand our predicament."	• "The original scenario didn't turn out as good as I have expected, however, I am confident of solving this problem, I have a couple of action which could turn out to be good." • "First I want to see who the customers are." • "I am also requesting data on the contaminated product as we still haven't received any, I am not very technical with chemical contamination, and however, there is value to a product that has been contaminated."	• "The initial scenario puts us in a huge mess, had we taken caution we wouldn't be in this situation." • "I think the first thing to do is to try to investigate, who we owe and how much, by getting these figures we can look at the costs."	• "The problem looks more complicated than it is, however I am certain we can solve it, the central issue here is to look at the finances." • "First we need review all the shipments sold in the period and there costs." • "Then we need to look at the risk of losing the clients if we can't satisfy their orders and then prepare an offer for them."	• "Clearly all that we can do now is make the best of the problem by just negotiating" • "First we need to review al the shipments sold at the period, and calculate their costs"
PSA at stage 1	Medium	High	High	Medium	Medium	High
BI Tools used at this stage	ERP Simple finance CRM	ERP ERP Multi-resource and planning Simple finance	CRM	ERP CRM Simple finance	ERP Simple finance Risk management	ERP Simple Finance
Stage 2 perception	• "Even though we had a production compromise during that period, increasing the lay can period to tackle the issue meant that shipments were sold at a normal rate, therefore the client list in standard." •" We need to look at the timeframe that it would hypostatically take us to make up these shipments while this current fields is ship down, from our products and if that is not plausible, we need to look at the cost and availability of replacing it from the open market and for how long this might continue."	• "I don't think that the timeframe and cost would please the buyer and if we can't satisfy them then we face real risk of losing them to our competitors in the long term and a loss to our market share as well." • "The only option I have left is to try and look at the open market which again would probably be massive under the circumstances as companies would rather jump in and look at it" • "We also haven't really been giving much information on the product contamination levels, sometimes it can lead to advantages but it would be unlikely I would assume. Therefore I think that I need to review the problem"	• "I am going to individually analyse the costs of the deals we made with each buyer individually and also look at the risk of losing them and any competitor risk which might arise in order to see how best to negotiate with them individually as we might save some of the losses from one to compensate for higher losses from others."	• "After getting this data, we can now look at how we can make up the quantity, this can be estimated by looking at how much can be made up internally by production in other fields and their costs, weighted against/added to how much we can buy from the open market and the risk of losing the clients"	• "Before giving them the offer, I would look at the value of the contaminated product" •" if there is any value in it, then we can go through the logistics of clearing it for trade."	• "Then we need to conduct ris analysis to see the chances of losing the clients if we can't ma up their orders"
PSA at stage 2	Medium	Medium	Medium	High	High	Medium
BI tools used at this stage	ERP multi-resource and planning ERP Simple finance	Risk management Simple finance ERP Multi-resource and planning Incident management	Simple finance Risk management	ERP Multi-resource planning Simple finance Risk management	Incident management ERP	Risk management
Stage 3 perception	•" Either way the situation will lead to high losses from a financial point of view and when weighted down against the risks of losing our clients and competitors gaining an edge on us, seem to be the only way forwards" •" I think we unfortunately we have no option but take a huge loss"	• "The contamination led to the product somehow change to the point where it became similar to a product produced by a country that had been banned from international oil trading and this meant that the buyers could not refine or resell the product without international clearance." • "I have requested the shipment logs and will request a clearance certificate, which would mean we can trade the product as we can prove that it was not bought from the specific country." • "I think after receiving the info we can use it a strong bargaining chip to solve the issue and negotiate a good deal"	• "The costs for any deal we might agree are massive." • "After receiving the contaminated data analysis, I think this should at least make us minimise these losses." • "I think I can solve the problem by understanding the value of the product and going through all the necessary paperwork to try and sell or use it as bargaining chip in negotiating a better deal."	• "The only solution to the problem seems to me to be in the form of negotiating with the buyers just to minimise the loses"	• "Luckily there is good value in the product contaminated" • "I am now going to prepare a second bid for the clients by adding the value of the product to the finances done previously, which would then give us the final maximum offer which we can negotiate."	• "The risk is very high and the cos it when compared to the cost of the product we are left with a real prob • "I think the only way forward is negotiating and taking a loss"
PSA at stage 3	High	High	High	High	High	High
BI tools used at this stage	Simple fincance Risk management	ERP Simple finance CRM	Incident management Simple finance ERP CRM	Risk Managment	Simple finance CRM	Simple finance CRM

Table 4 Scenario 2 (P1 to P6)

	P7	P8	P9	P10	P11	P12
Stage 1 perception	• *"This situation is very straightforward, all that is needed is just simple finance and risk management"* • *"I think first we need to look at what happened and how much we need to compensate"*	• *"I have had a similar situation in the past"* • *"This situation could turn out to be good, however we first need some proof"* • *"The first thing I need is to review our customer list, and pick the smallest size client for the analysis data, they would be eager to reply quickly as they are anxious to get the problem solved as quickly as they can"*	• *"The answer could be in the contaminated product but I am not sure"* • *"I want to first look at this data and see if the product holds any value"*	• *"I am not sure exactly how to proceed."* • *"I think the best thing to do is to first look at the original problem, all the client and shipments involved and the costs associated with each client."* • *"Furthermore, to get a grasp of the issue I want to see if we have the capability to replace the shipments for the buyers internally or externally."*	• *"In this industry value can be gained from any product, therefore, I am confident that the original product could help solve the problem"* • *"But I first want to see its makeup and then make a decision on it's real value"* • *"In the meanwhile, I want to see the original records, see if we can or can't replace them internally and the level of risk if we are not able to do so, which might materialise from our competitors taking advantage or the clients themselves abandoning us."*	• *"I have a had a similar situation in the p and I learnt that sometimes in business y have to know when problem create mista* • *"The first step in trying to minimise our term loses is to understand how much th immediate loses are going to be"* • *"This will be done by reviewing all the shipments sold during that period, the cl list, the cost of each shipment and calcul by when and how much can we replace t shipments internally. Taking into accoun commitments for future deals"*
PSA at stage 1	Medium	Medium	Medium	Low	Medium	High
BI Tools used at this stage	ERP	CRM	Incident management ERP	ERP CRM ERP multi-resource planning Simple finance	Incident management ERP ERP multi-resource and planning Risk management	ERP CRM Simple finance ERP multi-resource planning
Stage 2 perception	• *"Then we need to look at the timeframe of replacing the shipments, there is no point in looking at replacing it internally, the original situation was risen because of this problem in the first place"*	• *"After receding the data, I am pleased to see that luck is on our side, we can fix this problem by certifying that the product was produced by us and then we would be able to trade it as we please"*	• *"The product might hold some value but I first want to see the costs of the originally sold cargos"* • *"I also want to determine the risk of our clients moving on if we can't satisfy their orders."*	• *"The situation at the moment looks very bleak, we don't have enough volume to replace the shipment, and financially the open market price compared to the prices we sold is a lot higher which makes the loses even bigger. "* • *"If we don't find a solution we will be under a huge financial risk from our competitors interfering and our clients switching sides as well"* • *"Again I am not sure how to proceed; I guess I would want to look at what will happen to the original cargo and what is going to happen to it"*	• *"The chances of us replacing them physically are non-existent, we might try to look at the chances of us replacing them externally but I assume that would be very costly"* • *"The best hope left is that the contaminated product turns to have some significant value"*	• *"We have no ways to replace these shipments as if we give what we produce will face the same problem with the buye are already committed to and the financ loses will be similar."* • *"This would lead to a real risk in term o losing both sets of clients either way we g and not to mention the risk of losing an e to our competitors."*
PSA at stage 2	High	High	medium	Low	Medium	High
BI tools used at this stage	ERP multi-resource management Simple finance	Incident management ERP	Simple finance Risk management	Simple finance Incident management Risk management	ERP multi-resource planning Incident management	Simple finance Risk management
Stage 3 perception	• *"The costs of buying the shipments in the open market is huge"* • *"However when we look at the risk of our clients leaving us then we can see it is very high and cost of such a scenario when compared to the cost of replacing the product is costlier long term"* • *"Therefore, the best option is to negotiate the best possible deal with the client and take whatever losses we have to pay."*	• *"After getting the clearance, we just have to evaluate the market price of the product in the open market and either sell it to a different buyer or pay the difference of its cost to whichever buyer would like to keep it. "*	• *"The level of risk if the clients are not satisfied is very high"* • *"However I am confident that the contaminated product will be cleared for trading and we would be able to calculate and negotiate a financial deal that would eliminate this risk"*	• *"Luckily the original cargo data showed that the shipment has value, something the clients failed to mention previously"* • *"I think we can now look at the situation with hope, if we can manage to clear the cargo to be traded internationally we would be then to calculate a better financial deal for our clients and negotiate on a more solid term"*	• *"I am yet to receive the analysis but i don't estimate any issues with clearing it internationally if it turn out to have value"* • *"I think the best solution luckily is to negotiate with the customers using the product after establishing its value in the open market, if it has no value then we have no option but to take loses"*	• *"The only way forward is to look at the market, calculate the cost of the product there and just sacrifice the losses from it move on"*
PSA at stage 3	High	High	High	high	High	High
BI tools used at this stage	Simple finance Risk management CRM	Simple finance CRM	ERP Simple finance CRM	ERP Simple finance CRM	ERP Simple finance CRM	ERP Simple finance

Table 5 Scenario 2 (P7 to P12)

4.5.3 Stage 4: Data Analysis

During this stage of data analysis, the researcher recorded the interactions between the participants and the senior manager who was ultimately responsible for making a decision. Each participant presented their recommended decision and justification for their decision. P1, P4, P6, P7 and P12 all thought that the only option the company had left was to admit that it had made a mistake and to endure whatever losses it had to. They thought that there was no getting away from problem at hand without taking a big loss if they were aiming to minimise their long-term losses by angering the company's customer base which represents a substantial risk. P12 indicated that, based on prior experience, the risk of losing clients to the company's competitors was very strong. On the other hand, P2, P3, P5, P8, P9 andP10 all argued that the company did not have to take any loses, indicating that the contaminated products still held strong market value. P3, P5, P8, P9 and P10 all indicated that they suspected from the start that the product held some value, especially given that the clients were reluctant to provide the company with their analysis to prove contamination. Having performed their own analysis of the product, they saw that the crude oil sold to the clients held real market value. P11 also agreed with this line of thought, but indicated that they were yet to view the analysis. Furthermore, the participants explained that the only delay in their solution was the time needed to clear a certificate for the product, which was likely to take some time as the product specifications had changed so dramatically that it looked identical to a product produced by a country currently under an international oil trading embargo. However, P11, who was an experienced engineer, indicated having no doubt that the certificate would be issued, especially with the evidence that the company had.

The manager thanked the analysts for their work and appreciated the input of the participant who outlined the risks of the situation turning sour with the clients as these risks need to be taken seriously. The manager indicated that the company would likely have no other choice but to take a big loss on the shipments sold, however, with the evidence of the value of the contaminated product, this loss might be mitigated. Having also taken into consideration the risks faced by the company whilst the situation remain unresolved, the final decision was to inform all clients of the value of the product and offer them the option to buy the

product at market value themselves and to minimise antagonising the any further. Any client declining to buy the contaminated product or wait for the certificate to be granted would be sent a replacement shipment for the original order from the open market and the contaminated shipment will be collected by the company to be traded on the open market.

Transcripts of this session were sent back to each participant in order to check if the data was representative to their thoughts and activates at the time of the data collection and the decision analysis process.

4.5.4 Initial Post-Decision Data Analysis

4.5.4.1 Analysis of Level of Reliance on BI Tools

When analysing each participant's level of reliance on the BI tools available to them, the CRM tool was only included when used for a non-negotiating task, like in Scenario 1. Communication with the clients was forbidden by the manager until a final decision and plan was collectively reached. Therefore, the BI tools used by each participant and the approximate time used during the observation of the scenario analysis are presented in Figure 18.

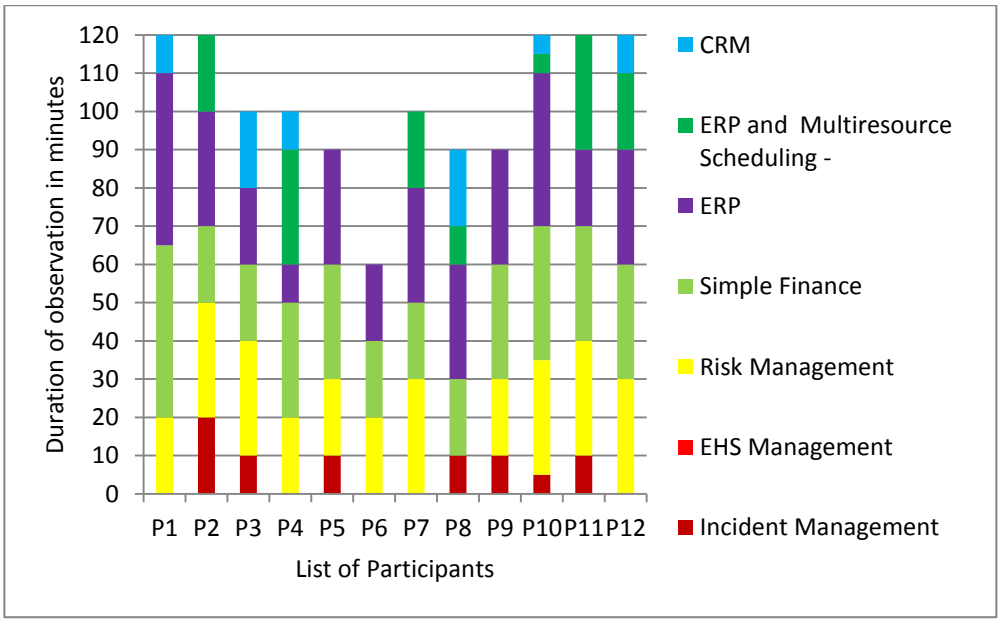


Figure 10 Stacked participant usage graph on BI tools

4.5.4.1.1 Level of Reliance Based on Decision Recommendations

As the graph above (Figure 18) shows, none of the participants (even after excluding the CRM tool for negotiation purposes) had used all of the tools available to them at the time when conducting the analysis, with P10 using the most tools during the task. Furthermore, when looking at the level of reliance on tools as compared to the recommendations being given, the glaring difference is that none of participants (i.e. 1, 4, 6, 7 and 12) who recommended that the only option for the company was to take a financial loss and compensate the clients on the price of the shipments, had used the incident management tool. Only those participants who saw value in the contaminated product had used the incident management tool. Furthermore, these participants had spent the majority of their time using the tools, analysing the risks of losing the buyers and calculating the most feasible and cost effective ways to replace the shipments or compensate the buyers. Finally, it is obvious that most participants during this task had relied heavily on the use of the BI tools as most participants had spent a minimum of 90 minutes using the tools, apart from P6 who only spent 1 hour with the tool and used the least number of tools (i.e. 3) during that time.

4.5.4.1.2 User Efficiency of the BI Tools

Since the participants who analysed this scenario are the same participants who analysed Scenario 1, it was interesting to see any changes in the level of user efficiency of each participant. The individual cognitive maps generated show that P1, P10, P11 and P12 had efficiency issues when using the system, which are highlighted in the abnormal styles used in the cognitive maps. These issues were present when the participants tried to combine data for analysis using two different tools.

The obvious difference between the participants' efficiency levels in this scenario compared to Scenario 1 lies in the fact that P10 had efficacy issues in the Scenario 2, but not in Scenario 1. Similarly, P2 and P4 had issues in Scenario 1, but none in Scenario 2. This difference can be explained by indicating that all three participants (P2, P4 and P11) had efficiency issue in using the tools. However, this problem can only be detected when the participants try to combine data for analysis from different tools, which is something

that P2 and P4 did not attempt to do in this scenario and P11 did not attempt to do in Scenario 1.

4.5.5 Decision Outcome

By keeping in contact with the organisation, the researcher continued to monitor the decision closely. The researcher was eventually contacted by the senior manager who provided the researcher with a detailed decision outcome. The manager indicated that the contaminated product was granted an international trading certificate 2 weeks after the application was made. The clients, on the other hand, were informed on the day that the decision made that they have the option to buy the contaminated cargo sent to them or receive a replacement from the open market. The manager indicated that about 70% of the affected clients agreed to buy the product, however, most negotiated the price of the shipments indicating that they were affected deeply by the problem. To minimise the risk of angering the clients, the company agreed to most price demands. The rest of the clients refused the shipments as they urgently needed the correct specifications of the product, which meant that the company had to pay the price of the open market to replace these shipments and were currently making up this cost by trying to sell the contaminated product collected from these clients.

Finally, the manager indicated that overall the decision taken this time turned out to be very successful and under the circumstances was the best decision available to the company.

4.5.6 Retrospective Analysis

The previous section discussed the analysis based on the decision taken by the company to the problem at hand. In section, individual participant reasons for their recommendation will be analysed and a comparison of their PSA during the process and retrospective ASA will be undertaken.

For this analysis, the participants were divided in two groups, Group 1 included the participants who recommended that the company's only choice was to accept responsibility for the problem and endure whatever loses it faced to safeguard its reputation and retain its customers. This was the recommendation which the company did not follow, and in

retrospect, turned out not to be the best decision. Group 2, on the other hand, included those participants who saw value in the contaminated product and recommended using this value when negotiating with the clients to solve the issue.

4.5.6.1 Group 1: Retrospective Analysis

This group included P1, P4, P6, P7 and P12, the interesting finding in this scenario is that the participants who recommended the decision that turned out to be the worst all had very high PSA levels at the end of the tasks. Differences in the levels at the beginning and middle parts of analysing the situations were the only parts that differed. For instance, P12 and P1 tackled the problem in the same way; however, P12 a high level of PSA throughout the task, as the participant indicated that he had been through a similar experience in the past, which is why they were so certain about their solution the problem. These assumptions affected the participants' comprehension of the problem and guided their perceptions throughout the task. P1, on the other hand, was younger and less experienced, therefore, his PSA was at a medium level as the participant thought that they understood the problem to a certain extent and wanted more information on how best to move forward in replacing the contaminated shipments for the client. However, as both participants failed to see value in the contaminated product, their focus was entirely on minimising the risks of losing the clients and replacing the shipments in the quickest and most effective way, therefore, their ASA was very low.

P4, P6 and P7 each had a very similar PSA levels at the beginning of the task, the difference again being in the timing of the increase in PSA levels. With P4, the time spent analysing the situation was the shortest as the participants only had to confirm their suspicions that the costs to replace the shipments was very high and once this fact was established, the participant decided that negotiating to minimise the losses that company was going to face was the only option. P6 and P7, on the other hand, investigated the most efficient and cost effective ways to replace these shipments, which meant that their PSA was enhanced at a later stage. Nevertheless, the ASA for all three participants was low as they also failed to see any value in the product and if the company followed their recommendations then it would have faced even greater financial loses. Figures 19

illustrates the different PSA levels of the participants in this group, on the other hand figure 20 illustrates the ASA levels of the these participants throughout the process

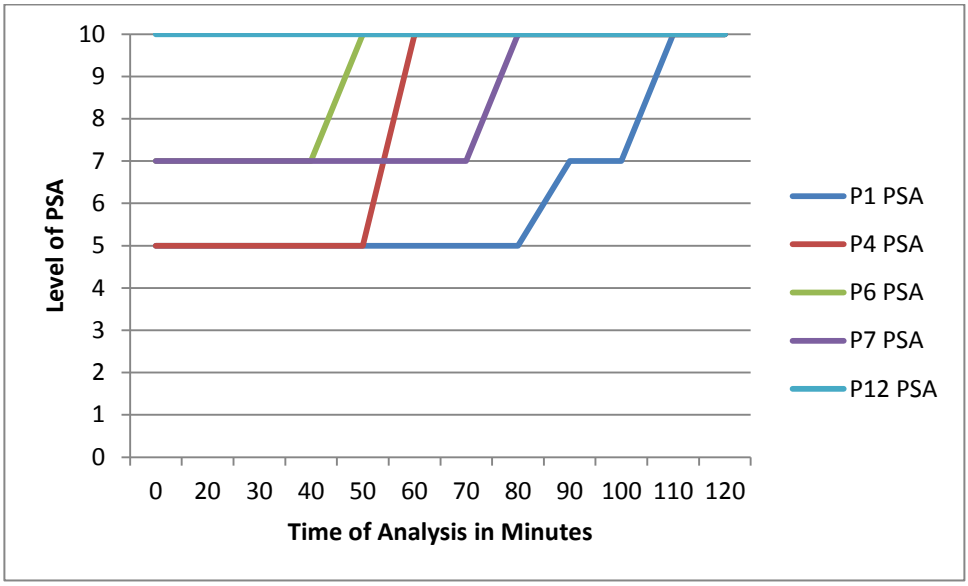


Figure 11 Scenario 2 Group 1 PSA Levels

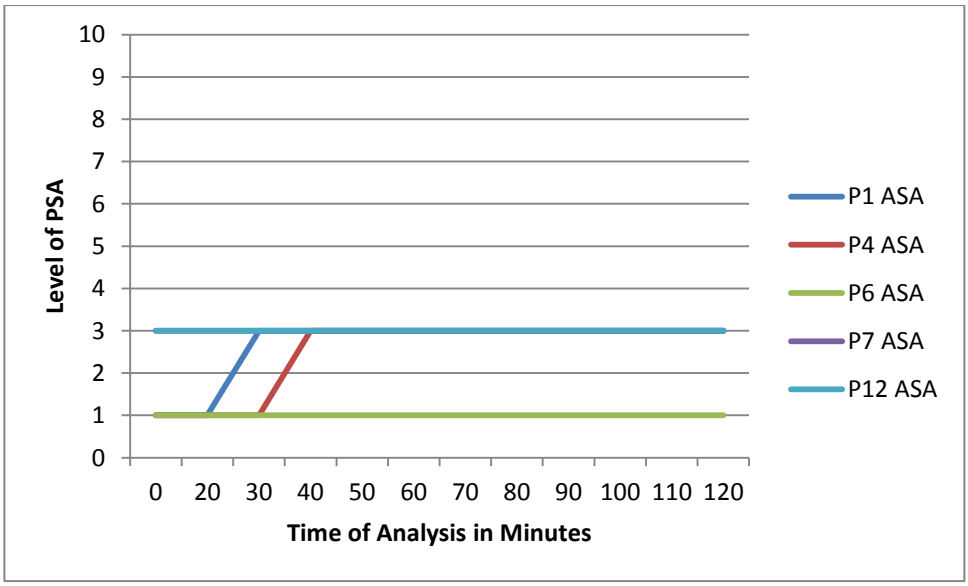


Figure 12 Scenario 2 Group 1 ASA Levels

4.5.6.2 *Group 2: Retrospective Analysis*

This group includes P2, P3, P5, P8, P9, P10 and P11, the interesting observation from this group is that P3, P5, P8 and P9 thought from the beginning of the task that there was value in the contaminated product. P8, having strongly linked this problem to a previous experience, looked to confirm their thoughts by investigating the contaminated product's data, which meant that their PSA level started off fairly high to very high. P5, on the other hand, was extremely confident from the beginning that the product held value, which correlated with a very high PSA throughout the task. P3 and P9 had PSA levels that slowly increased once they understood the value of the product and assessed the risk of losing the clients, with P3's PSA starting from a lower level as he was not as confident in the product's value. However, as none of these participants looked to investigate how and when the products would be replaced for the buyers if the contaminated product turned out not to hold value, and the fact that about 30% of the clients demanded the original product specification meant that their ASA was not as high as they thought.

P2, P10 and P11 had contrasting levels of PSA. P2 started off confidently indicating that there was no way out of this problem for the company apart from taking a huge loss and only investigating the product when the costs and the timeframe to replace the product were deem unexcitable to the buyer, which correlated to their PSA decreasing and led to them investigating the contaminated product. This eventually led to the P2's PSA levels increasing.

P10, on the other hand, started off with a very low PSA, as the participant was not sure how to proceed. However, this self-doubt led to P10 looking at all aspects of the information until they learnt of the value of the product. This led to P10's PSA and ASA levels to continually increase from the start of the process until the end, as the participants looked at all the information related to the problem at hand. Finally, P11 started confidently understanding the situation as they suspected that the contaminated product contained value, based on their experience as a chemical engineer. However, P11's PSA levels decreased slightly as they were unable to obtain a copy of the analysis of the contaminated

product until after the observation stage. Figure 21 illustrates the different PSA levels of the participants in this group, on the other hand figure 22 illustrates the ASA levels of the these participants throughout the process.

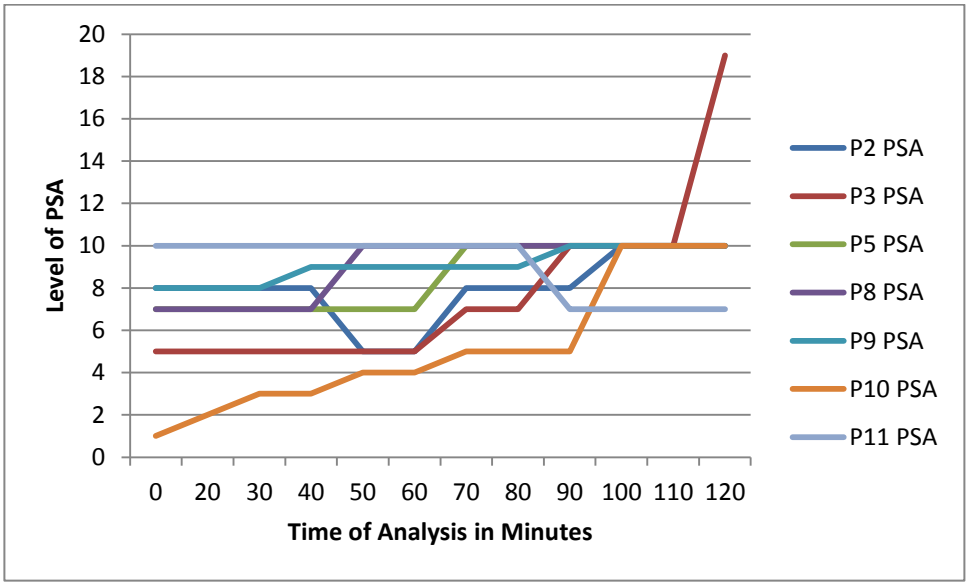


Figure 13 Scenario 2 Group 2 PSA Levels

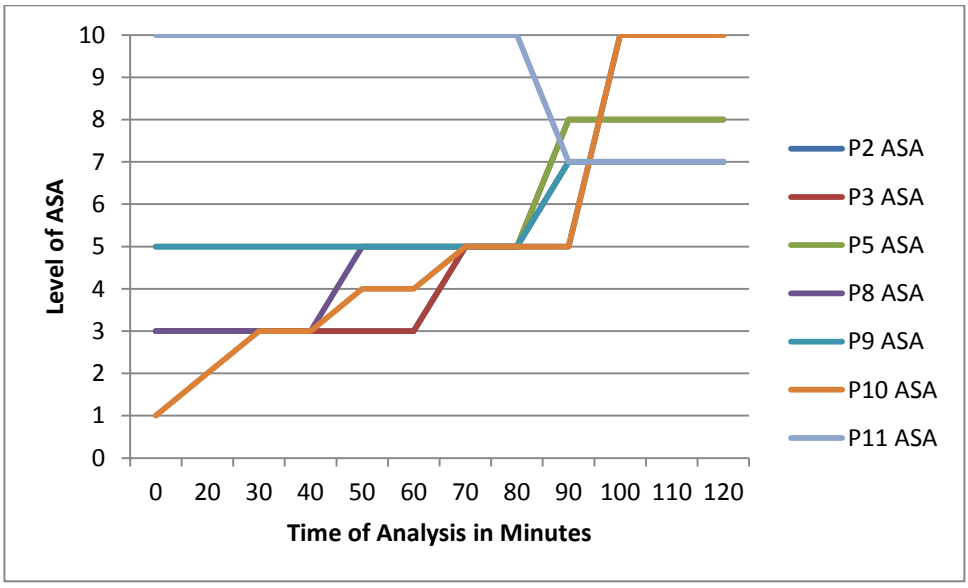


Figure 14 Scenario 2 Group 2 ASA Levels

4.6 Scenario 3

Scenario 3 first became apparent to the company's management when they received an alert from the networking department issuing a 'high levels of condensate gas storage warning'. The situation involved an oil field which the company owns 70% of in partnership with one of its partners. The partnership agreement indicated that the partner would be in charge of operating the field to produce the products. The production process would involve separating the condensate gas from the original product and the gas would then be sent directly through a networking pipe to the company's storage base, which is located near the port for easy access and sale. The partnership agreement also specified that the partner could produce whatever levels they deemed necessary; however, there was a mutual agreement indicating that both companies would look out for each other's interests throughout the agreement period.

Therefore, it came as a shock to the company that the partner increased production so dramatically, which in turn led to high levels of condensate being produced without any advanced warning. The management was faced with a tough decision, as the current deal was satisfactory for them and they did not want to damage their relationship with the partner unless these events severely damaged the company. The demand and price of condensate at the time was very low, which meant the company had to either pay extra for storage or burn the product, both of these options represented a loss that the company was keen to avoid.

4.6.1 Stage 2: Data Analysis

The senior manager called the analysts on duty and appraised them of the situation, requesting that they devise a solution to the problem at hand. The manager explained that their goal would be to find a solution to the problem that would ensure that the company avoided unnecessary costs rather than compromising the current agreement with the partner.

4.6.2 Stage 3: Data Analysis

The researcher began by gathering some general demographic information about each participant, including their age, level of experience in their current position and their professional background or area of expertise. The researcher gave a unique number to each participant in order to ensure their anonymity as agreed in the confidentiality agreement. Participants then confirmed the validity of the demographic data by signing the consent form presented to them. The following table (Table 7) represents a breakdown of the information gathered in this step.

Participant	Age	Experience	Area of expertise
S3P1	34	2 Years	Trading
S3P2	40	10 Years	Business
S3P3	52	17 Years	Marketing
S3P4	39	4 Years	Engineering
S3P5	53	15 Years	Marketing
S3P6	30	2 Years	Marketing
S3P7	55	16 Years	Engineering
S3P8	50	15 Years	Trading
S3P9	44	4 Years	Business
S3P10	29	3 Years	Business
S3P11	52	13 Years	Engineering
S3P12	51	11 Years	Trading

Table 6 Scenario 3 Participants' table

The following tables present a breakdown of each participant's decision-making process at three different stages during the observation. The first stage includes extracts from each participant's transcript, describing their initial thoughts on the problem and their initial actions in solving it. The second stage includes the outcome of the initial actions taken and any changes in the direction of solving the problem. The third stage represents the outcome of the second stage and the participants' overall thoughts on the problem. The tables also

include the BI tools at each stage of the process. These tables were constructed to aid in the development of the participant's cognitive maps and in highlighting the levels of PSA of each participant throughout the decision-making process. The full list of the individual cognitive maps can be found in the appendix

	P1	P2	P3	P4	P5	P6
Stage 1 perception	• *"When dealing with such a situation that might involve negotiating with a client it is always im-portant to always have all the facts."* • *"For this reason I want to first understand why the client increased production, it must mean that there is demand for their product, by knowing how much condensate we receive we would be able to calculate the equivalent of the original product production volumes and estimate the costs. This would enable us to have an idea of how much profit they make approximately which would put us in a better negotiating position"*	• *"I suspect that the partner has not been taken our interest into consideration whilst running produc-tion"* • *"Therefore, I want to look at some historical data, I want to review the production activity for the last 1 year, and review the price of the original product and the price of condensate for the same period"*	•• *"The problem with partnerships is that both sides always look for their benefits first and foremost, we all strive to maximise our profits as much as we can"* • *"Therefore, the direction to solve the problem for me is the same, I would first like to review the cur-rent production levels and the price of the original product for the last 3 years"* • *"Furthermore, I am going to conduct predictive price analysis to estimate what the price of both con-densate and the original product are going to be for the next 6 month"*	• *"My area of expertise unfortunately does not involve complicated partnership agreement."* • *"My main focus will be on the stoage issue, I want to review the timeframe we have to keep observ-ing the product into our storage unit and the current cost of storing it externally."*	• *"To me partnership always represents a risk, especially when production is with the partner rather than yourself."* • *"However, what is important now is to establish that it is fact that the partner did this intentionally as a reaction to a price increase to their product"*	• *"The partner definitely acted like this because the market was profitable at the time."* • *"What I would like to know is how profi was it, this could help us to determine wh negotiate for."*
PSA at stage 1	*Medium*	Medium	Medium	Low	Medium	Medium
BI Tools used at this stage	*ERP* *Simple finance*	ERP Simple finance	ERP Simple finance	ERP ERP multi-resource planning Simple finance	ERP Simple finance	ERP Simple finance
Stage 2 perception	• *"The first step showed that indeed the client is doing very well at the moment and that we can use this fact to our advantage as they would be reluctant to damaging the agreement at this point in time."* • *"The next step is to look at the levels of condensate we have and how much would are we expected to receive if the production continues at this high level."* • *"This will enable us to estimate the storage costs that we would have to pay once our own storage bases reach the levels where we cannot hold any in them."*	• *"The next step would be to review the levels of condensate produced and when will it reach critical storing levels and the cost of storing it externally. "*	• *"Now I would like to review the agreement we have with our client and conduct risk analysis of what are the chances of our client breaking the partnership over the issue."*	• *"Having looked at the storage costs and level, we deem to lose a lot."* • *"I want to now look at the current price of condensate to see if we can move it quickly and whether we have a chance to move it anytime soon."*	• *"The product price did increase for the last two weeks, which determines that the partner acted in bad faith and selfishly"* • *"What is important now is to determine if the price of both products will keep being the same or not, if both are estimated to pick up then we don't need to act, however if condensate doesn't then we should seriously consider the partnership's benefit t us. However, if we get lucky and only condensate is estimated to go up then we need to determine the risk of this being the case."*	• *"It looks to me that the partner indeed remarkably well during the period."* • *"I now want to look at how much condensate they have been pumping us a the cost and option of storing it."*
PSA at stage 2	High	Medium	Medium	Medium	Medium	High
BI tools used at this stage	ERP ERP multi-resource planning Simple finance	ERP ERP multi-resource planning Simple finance	ERP Risk management	Simple finance	Simple finance Risk management	ERP ERP multi-resource planning Simple finance
Stage 3 perception	• *"By conducting a +/- analysis we can compare the storage costs against the profits made by the part-ner which would allow us to understand how much of the costs the partner is likely to accept to not jeopardise the deal"* • *"Therefore, I would finally look at any historical precedent, which might give us a leverage and nego-tiate for the client to pay some of the storage costs."*	• *"Finally, after reviewing the production levels for the last 1 year and the market price changes for the same period for both products, I can see that there was a drop in production on several occasions where the original product price was low even though the price of condensate was high."* • *"Therefore, I would recommend negotiating with the partner to pay for all of our storage costs and I would expect them to comply to keep the partnership going."*	• *"Having estimated the price of the products for the next 6 months I can see that condensate pricing is going to pick up soon enough, however, the original product price is likely to drop. Since condensate is part of the original product, low demand of the original product means it will increase."* • *"Finally since the risk of the client abandoning the agreement is very low, I would only negotiate for the levels of production to stay high for the next 6 months since we stand to benefit soon enough"*	• *"There does not seem to be much we can do at the moment apart from calculating the costs and ne-gotiating with the partner to share some of them, whether they would accept or not unfortunately I am not sure."*	• *"I am very confident that condensate would increase for the next 6 months whereas, the original product is not estimated to do so well, however, as the partner acted in bad faith initially, I would recommend negotiating with the client to keep the levels of production the same for the next few month without condition, and I can see that the risk of such a move not working out is similarly low."*	• *"The cost of storing it is very high and e though the profits the partner made are I do not ex-pect them to pay for all of it"* • *"I would negotiating for the partner to the cost store the product but starting w high ceiling"*
PSA at stage 3	High	High	High	Medium	High	Medium
BI tools used at this stage	Simple finance CRM	ERP Simple finance CRM	CRM	Risk management CRM	Risk management CRM	Simple finance CRM

Table 7 Scenario 3 (P1 to P6)

	P7	P8	P9	P10	P11	P12
Stage 1 perception	• *"A high level of storage alert is a very serious stage to reach in terms of storage finances."* • *"Therefore, I first want to see what storing options we have and the cost of doing it."*	• *"It is important to investigate the situation fully and leave no rock unturned."* • *"It is clear that the partner acted selfishly here, their guilt is obvious by the fact that they never noti-fied us."* • *"What I want to do is to look at whether this has happened before and whether the roles were ever reversed and they took advantage of the situation by lowering production to reduce their own costs. Theo fore, I would look at the production and market price data for the last 6 months and keep the results in mind moving forward."*	• *"Business decisions in partnerships are tough, as we are all driven by the margins we can make and taking advantage of the opportunity"* • *"For this reason I want to establish how much the partner made by looking at the production volume and costs of the production process to get an approximate profit margin."*	• *"Having never had any experience in such a situation am going to air on the side of caution"* • *"The main goal here is to not damage the agreement in any way, therefore, my first move is to review the agreement and assess the risk of the partner leaving the agreement because of how we might re-act."*	• *"I wouldn't want to recommend ending the partnership; I understand that management has been keen to safeguard it no matter what."* • *"Therefore, I would try to solve the problem by minimising the costs this problem will create I will look at the cost of moving the condensate as quickly as possible, I think I can do this by looking at shipping costs to the closest condensate downstream companies"*	• *"We are governed by the levels of dema for our products and the price of it at tha moment in time."* • *"If demand for our product has been go this situation would not even be an issue* • *"Therefore, the key here is to confidentl estimate how condensate will fare in the future"*
PSA at stage 1	Low	Medium	Medium	Low	High	Medium
BI Tools used at this stage	ERP ERP multi-resource planning Simple finance	ERP CRM	ERP Simple finance	ERP Risk Management	Simple Finance	ERP Simple finance
Stage 2 perception	• *"The costs are going to definitely be high, especially as we don't have much time left before we run out of space internally"* • *"I know why the partner did this; there is only one explanation, which is a favourable profiting period for them."* • *"I would like to assess whether we can hold them responsible for the storage by looking at whether they ever lowered the production levels when the situation was reversed and the price of their prod-uct took a slump whereas the condensate was at a good level. Over the last 6 months."*	• *"Now I want to see how the price of the product for the buyer for the last 2 weeks have been to de-termine their profit levels"* • *"Furthermore, I also want to look at the projections for the prices for both products and assessing specially the risk of the condensate prices for the next 6 months"*	• *"Having established their approximate profit margin, I can now look at when the condensate levels will reach the point where we have t divert them to an external source and the cost of such an opera-tion"*	• *"The risk of the partner abandoning the situation is very low, they benefit quite handsomely from the deal and we should aim to use this to our advantage"* • *"I want to look at how the condensate market is predicted to reach in the next 6 months, if it is fa-vourable then we can gain to benefit as well"*	• *"Having established the shipping costs I want to compare them to the storage costs, time is of the es-sence, establishing when our internal storage levels will be maximise will determine the cost of the storage."*	• *"The demand is predicted to be high; I v like to assess the risk of this being the cas from a finan-cial point of view compared the storage costs we have to pay, this wil determine our next move."*
PSA at stage 2	Medium	Medium	medium	Medium	high	Medium
BI tools used at this stage SUM	ERP Simple finance	ERP Simple finance Risk management	ERP ERP multi resource planning Simple finance	ERP Simple finance	ERP ERP multi-resource planning CRM	ERP ERP multi-resource planning Risk management
Stage 3 perception	• *"Indeed, there were several occasions where the levels dropped when we were at a position to bene-fit."* • *"I would recommend presenting these facts to the partner and negotiating them paying for all the storage costs and compromising only a small cost in order to save the partnership"*	• *"The market is favourable for us for the next 6 month and the risk of it turning is very low, the projec-tions for the partner's product however are not favourable"* • *"Therefore, I would recommend that the production levels for the next 6 months to continue at the current high level and even though I expect the partner to not agree to this, I am sure that the fact that they acted in bad faith and this was not the first time this happened should leave them with no choice."*	• *"By using the margins and the cost data I can prepare a fair and good offer for the client that will not damage too much their profit margin and at the same time solve our storage cost problems and nego-tiate for the deal to go through."*	• *"The market looks to be turning favourable after a month, therefore, I would just predict the cost of storing the product externally for one month and then advise the buyer and negotiate that our posi-tion is that the production should stay at a high level for the next 6 months without any conditions"*	• *"Having established the costs of the shipping and the storage costs and analysed the situation further from a financial point of view, I think that the best solution is to find buyers quickly from our client list and pay for the shipping costs as they are more feasible than the storage costs"*	• *"The risk of the price not acting favourc low, for at least 6 months; at that point v can act dif-ferently."* • *"For this reason I would recommend th pay for the storage costs and negotiate f client to keep the levels high for a minim 6 months reviewable after 5 months"*
PSA at stage 3	High	High	High	high	High	High
BI tools used at this stage	ERP CRM	CRM	Simple finance CRM	Simple finance ERP multi-resource planning CRM	CRM Simple Finance	CRM

Table 8 Scenario 3 (P7 to P12)

4.6.3 Stage 4: Data Analysis

During this stage of data analysis, the researcher recorded the interactions between the participants and the senior manager who was ultimately responsible of making the decision. Each participant presented their recommendations and their justification for their decision. P1, P2, P4, P6, P7 and P9 all recommended that the company inform the partner that the increase was causing them storage issues and negotiate for the partner to pay some, if not all, of the storage costs. P1, P6 and P9 indicated that the analysis shows that the partner's profit margin was very high for this period and, in light of their actions, the company should share some of the storage costs. P2 and P7, on the other hand, indicated that when the condensate price was high compared to their product, the partner decreased production levels, and that knowing this would aid in their negotiations and should result in the partner paying the full storage costs.

P3, P5, P8, P10 and P12, on the other hand, advised the manager that their analysis showed that that condensate price and demand was expected to rise after one month and that the company should take advantage of the actions of the partner by demanding that the profits stay this high for at least the next 6 months. P8 confidently indicated that they had conducted a risk analysis of the price estimation and they were confident that the price should be the same. P8 also indicated that since the partner already acted selfishly to begin with, they would not be opposed to the company's production demands.

P11 indicated that their analysis showed that it was possible to avoid antagonising the partner and to preserve the agreement, which was essential for the success of this task, by selling the product on the open market and paying the shipping costs to the buyers which would increase its demands and work out cheaper than the storage costs.

The manager thanked the analysts for their work and indicated that, based on the information provided, the best decision to achieve the goal was to inform the partner of the problem that their increased of production had created, and since the data clearly showed that there was little risk of damaging the partnership agreement and the level of certainty of the price and demand of condensate turning in the company's favour, the company would demand that the production of the field to continue at a high level for the next 6 months.

Furthermore, to further minimise the risk of angering the partner, the company would not demand any payment from the partner for the storage costs for the period leading to the price and demand increases. Instead, the company will pay for external storage for this period and these costs will be eliminated with the price and demand shifts.

Transcripts of this session were sent back to each participant in order to check if the data was representative to their thoughts and activates at the time of the data collection and the decision analysis process.

4.6.4 Initial Post-Decision Data Analysis

4.6.4.1 Level of Reliance on BI Tools Analysis

The graph in Figure 23 represents the tools used by each participant during the observation stage.

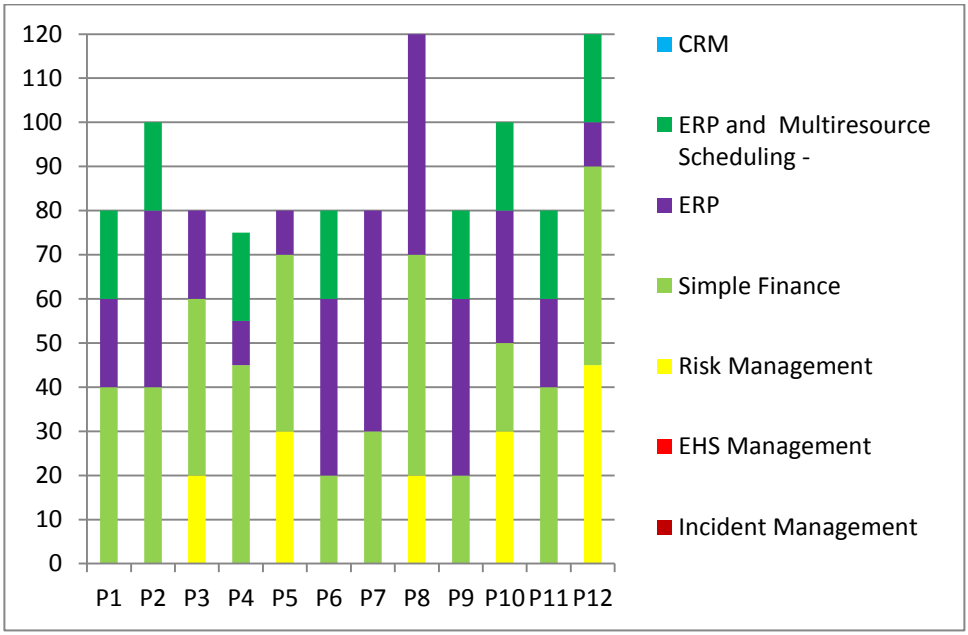


Figure 15 Stacked participant level of usage.

4.6.4.1.1 Level of Reliance Based on Decision Recommendations

As shown in Figure 23, none of the participants used all of the tools available to them at the time of conducting the analysis. At just four tools each, P10 and P12 used the most tools. However, all of the participants spent at least 80 minutes using the system. Therefore, the low number of tools used does not reflect upon the level of tool reliance; instead, it could mean that the tools that were not used were simply not useful for this particular scenario.

Those participants who recommended the decision that the company decided to take (i.e. to demand that the partner maintain high production levels for the next 6 months) each used the risk management tool to assess the risk of such a move. Participants who offered alternative recommendations did not use the risk management tool.

4.6.4.1.2 User Efficiency of the BI Tools

By looking at the concept shape styles of the cognitive maps generated for each participant, it was clear that P4, P5, P9, P11 and P12 each had user efficiency issues when trying to combine datasets using different BI tools. Interestingly, although the other participants did not face such issues, only P1 and P2 attempted such an action. Therefore, the lack of attempting to combine datasets using different tools could mask user efficiency problems amongst the other participants.

4.6.5 Decision Outcome

By staying in touch with the organisation, the researcher continued to monitor the situation closely. A few days after the decision was made, the manager indicated that the decision turned out to be beneficial for the company. The partner, once informed of the problems created by their actions, initially refused to maintain the high production levels for the period proposed. The partner indicated that their product market would not stay at its current levels for the entire period and instead offered to pay a share of the company's storage costs. However, the manager presented the partner with evidence that this was not been the first occasion in which the field's production volumes had been manipulated to the company's determent and that their partnership agreement would come under close scrutiny if the proposed demands were not met. The manager indicated that the analysts who

predicted that the risk of the partner terminating the agreement were non-existent turned out to be correct and the partner eventually complied with the company's demands. It was mutually agreed that the terms of the agreement needed to be amended so that this situation would not be repeated.

4.6.6 Retrospective Analysis

The previous section discussed the analysis based on the decision taken by the company to the problem at hand. This section explores individual participants' reasons for their recommendations and compares each participants' PSA during the process and their ASA in retrospect

For this analysis, participants were divided in three groups; Group 1 was comprised of participants who indicated that the company should demand that the partner pay for the cost of storage for as long as the production was high. Group 2 consists only of P11, who indicated that the company should sell the product on the open market by paying the shipping costs, which were considerably less than the storage costs. Group 3 includes those participants whose recommendations the company actually chose and what turned out to be the better option.

4.6.6.1 Group 1: Retrospective Analysis

Group 1 includes those participants (i.e. P1, P2, P4, P6, P7 and P9) who thought the best solution to the issue was to demand that the partner pay for the storage during the period. P4 showed, from the beginning of the task, a lack of experience and confidence when trying to analyse the problem. P4's only solution was to ask for the storage to be paid for by the partner, however, they remained unsure as to whether this was the right thing to do. P2 and P7 on the other hand, gave the same recommendation for the same reasons, with both participants looking at the level of production in the past to determine whether there were any changes in the levels when the situation was profitable to the company and, based on this evidence, decided that the partner should pay for the extra storage costs. The only difference was that P2 reached this conclusion first; therefore, P2's PSA increased at an earlier point. However, as neither participant examined how the market would react in the

future, they did not see the value in keeping the production level high; therefore, their ASA did not continue to increase in alignment with their PSA.

Finally, when looking at the rest of the participants in this group (i.e. P1, P6 and P9), each of these participants demanded that the partner pay for the storage costs based on their analysis of the client's profit margins during this period of increased production. This was the reason why their PSA levels increased more gradually as their suspicions regarding the reasons for the increased production were confirmed, however, as none of these participants looked to gain advantage of the situation, but only settle for the partner to take responsibility, there ASA levels never rose very high. Figure 24 illustrates the different PSA levels of the participants in this group, on the other hand figure 25 illustrates the ASA levels of the these participants throughout the process

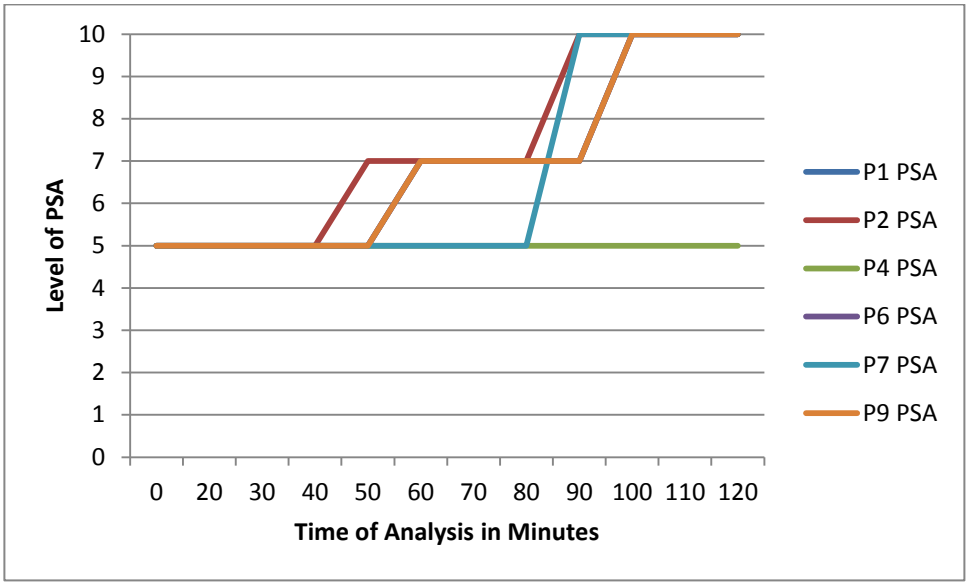


Figure 16 Scenario 3 Group 1 PSA Levels

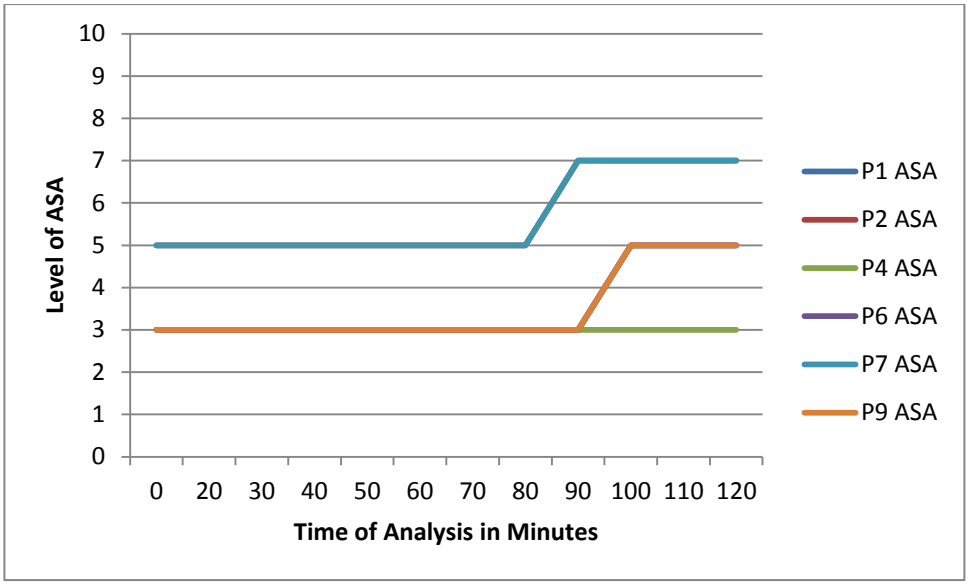


Figure 17 Scenario 3 Group 1 ASA Levels

4.6.6.2 Group 2: Retrospective Analysis

This group consists only of P11, who was the only participant who sought to solve the problem without confronting the partner at all. This was due to the participant being focused on achieving the goal of not compromising the partnership agreement to the point that it meant that they only sought to minimise the costs of the partner's actions by comparing the costs of storage and the cost of shipping the product to a willing buyer. Therefore, P11's PSA level started at a medium level and increased the longer the task continued, reaching its highest level once the client calculated the most effective option to minimise the costs. However, since the participant failed to look at the situation as an opportunity to take advantage of the problem in the long-term, or at least eliminate the storage costs, their ASA level was very low throughout the process. Figure 26 illustrates P11's PSA and ASA levels.

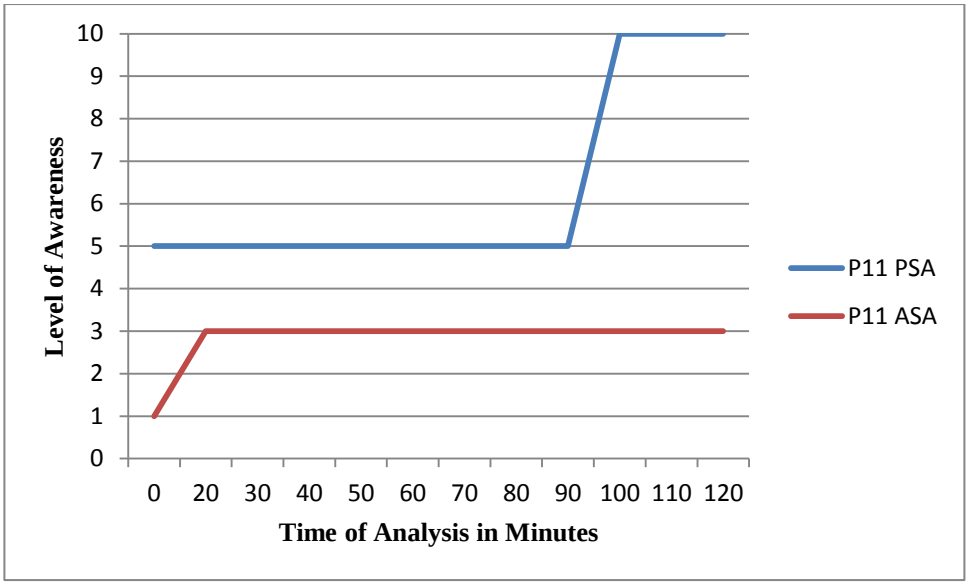


Figure 18 Line graph illustrating PSA vs. ASA for P11

4.6.6.3 Group 3: Retrospective Analysis

The final group includes those participants who recommended that the company should demand that the production increase continue for the next 6 months, as the demand and price were predicted to increase during this period. This decision turned out to be the better of the three options in this situation and the one that management eventually took. These participants included P3, P5, P8, P10 and P12.

Starting with P3 and P10, both participants recommended the same course of action and based their decision on the same reasoning, which was that the risk of the client abandoning the problem was very low and that the market would turn favourable in the next few months. However, neither of the participants assessed the risk of this prediction or the storage costs to determine if the risk was worth taking or not. Therefore, although their recommendation turned out to be the better decision, the fact that they did not look at all of the data meant that their ASA levels were lower than their PSA levels. The noted difference is the order of the actions the participants took meant that P3's ASA level was higher than P10's at an earlier point.

The next sets of participants in this group were P5 and P12. Both participants recommended the better decision, but for different reasons. Whilst both participants started with medium PSA levels, P12's PSA increased at an earlier point as, from the beginning of the task, they focused on analysing the market for the condensate and looking at what, when and if it would turn favourable, comparing that to the storage costs. P5, on the other hand, focused on looking at why the situation occurred, although they already suspected the reasons. Therefore, P5's PSA levels only increased once they focused on when the problem would turn favourable to the company. However, both participants ASA levels were not as high as their PSA levels as they did not focus on whether this was an isolated problem or if the partner had in fact manipulated production previously when it suited them.

Finally, P8's PSA and ASA levels were closely aligned throughout the decision-making process. P8's SA started at a medium level while they focussed on understanding all aspects of the problem at hand. As more information became apparent, their PSA and ASA levels continued to increase. This would indicate that the decision recommended by the participant and their reasons for making their recommendation were both correct and sound. Figure 27 illustrates the different PSA levels of the participants in this group, on the other hand figure 28 illustrates the ASA levels of the these participants throughout the process

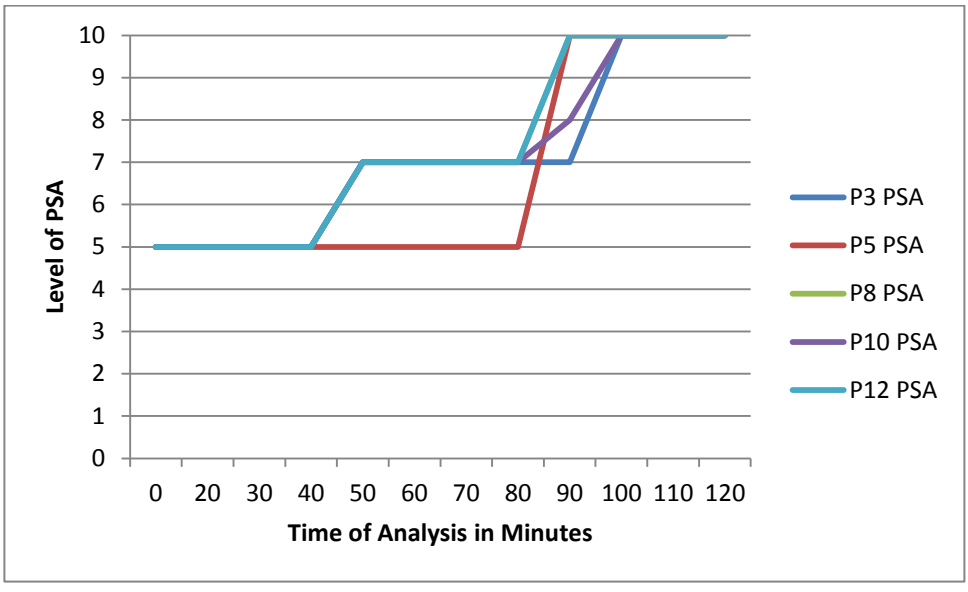


Figure 19 Scenario 3 Group 3 PSA Levels

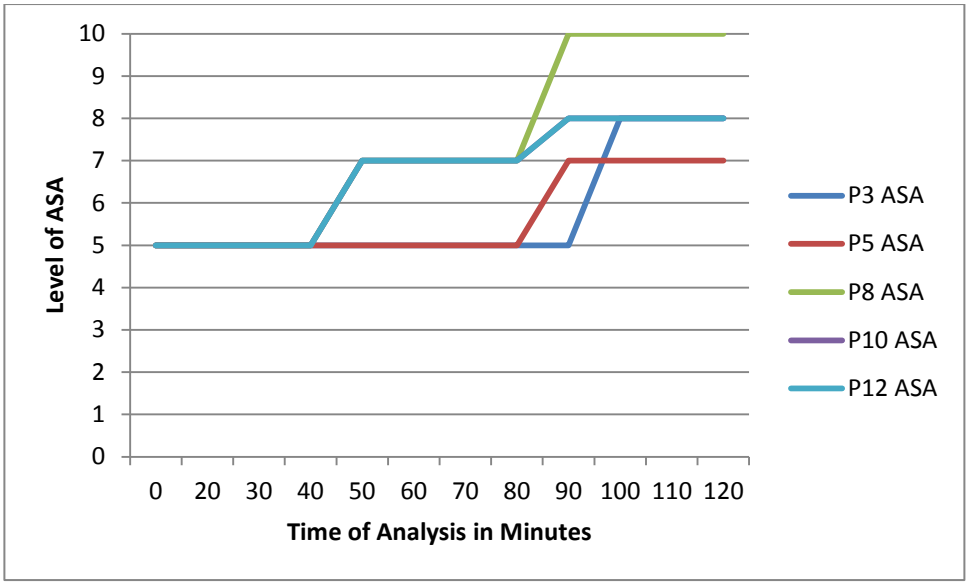


Figure 20 Scenario 3 Group 3 ASA Levels

4.7 Summary

The analysis of the scenarios in the upstream sector of the industry outline naturalistic decisions the company faced, which were mostly the result of problems in the production operations that are out of the control of the company. The first two scenarios were a result of a storage tank compromise, the solution for which was initially misjudged (i.e. Scenario 1), which resulted in the company subsequently trying to minimise financial loses (i.e. Scenario 2). The third scenario, on the other hand, involved a partnership agreement which, at the time, provided the company with unexpected costs that needed to be minimised as the agreement served the company's long-term interests. Furthermore, there was a level of reliance on BI in the industry; however, this reliance was guided by individual analysts' previous experiences and background knowledge. Moreover, where decision-makers relied entirely on these experiences for NDM using BI, they could easily fall victim to a narrow mindset, thus resulting in them making poor decisions.

CHAPTER 5
DOWNSTREAM SECTOR DATA ANALYSIS

5.1 Overview

This chapter presents the data collected from Company B and the analysis stages described in the research strategy. The chapter includes three downstream scenarios where the company had to make naturalistic decisions. Each scenario's data and analysis is presented consecutively. The chapter is structured as follows: an introduction to the site where the research took place, an overview of the company's BI system and its capabilities as described by the BI manager of the company (Data Collection Stage 1), an introduction to each of the selected scenarios or problems observed that meet the characteristics of naturalistic decisions, data analysis from the observation stage (Data Collection Stage 2), the focus group which led to a decision taken (Data Collection Stage3), an analysis of the level of reliance on the BI tools by each participant, the decision outcome, and finally a retrospective analysis of each participant based on their decision recommendations and decision outcome.

5.2 Company B Site

Data collection took place in the company's head office in Europe. Unlike Company A, the analysts in Company B work standard business hours and the management office is staffed by one senior manager and a group of 14 analysts (i.e. decision-makers) with varying levels of experiences in the role and areas of experience. Only 12 of the analysts took part in this study for consistency reasons.

5.2.1 Stage 1: Research Analysis

The first stage of the data analysis is intended to investigate the BI capabilities of the organisation. However, the researcher was informed by the senior manager that since Company A owned Company B, both organisations shared the exact same BI capabilities. Furthermore, the BI management was located in Company A, whilst company B had wireless access to all the data through the system.

5.3 Scenario 4

Scenario 4 involved a pipe being compromise in one of the underground networks in the downstream operations of the company. The network pipeline in question begins at the company's local refinery and feeds the storage base located in a city centre. This storage feeds the company's gas stations, with 60% of all gas stations in the area being owned by the company which enables them to leverage their strategic advantage of having a pipe networking system in place, which means lower transportation costs. The remaining stations are owned by the company's main rival, who has a similar but less efficient networking system.

The networking advantage in this current situation served to be the company's weakness; with the local authority, the public and the media unlikely to forgive the company if it fails to provide end-user gasoline and diesel to the local community and the businesses that rely on the products for their everyday activities. This problem meant that the company was at risk of losing an edge to its rival competitor, as in the event that the market demand is not satisfied during this compromise period, it will be difficult for the company to win back its customer base after the situation is resolved.

5.3.1 Stage 2: Data Analysis

The senior manager called upon the team of analysts and explained the situation to them. The director indicated that the company needed to solve the problem as quickly as possible, before their reserve levels run low. The manager indicated that the goal was to satisfy the local market and to not lose any of the company's market shares to its competitor.

5.3.2 Stage 3: Data Analysis

The researcher began by gathering some general demographic information from each participant. The information the researcher was interested in involved the participants' age, level of experience in their current position and the professional background or area of expertise. The researcher gave a unique number to each participant in order to ensure anonymity as agreed in the confidentiality agreement, which was then confirmed by having the participant sign the consent form presented to them. Participants' demographic data is summarised in Table 10.

Participant	Age	Experience	Area of expertise
S4P1	27	1 Years	Trading
S4P2	54	14 Years	Business
S4P3	53	10 Years	Engineering
S4P4	37	4 Years	Engineering
S4P5	48	12 Years	Trading
S4P6	41	3 Years	Business
S4P7	61	17 Years	Trading
S4P8	39	5 Years	Engineering
S4P9	54	11 Years	Business
S4P10	40	9 Years	Engineering
S4P11	55	15 Years	Business
S4P12	53	13 Years	Marketing

Table 9 Scenario 4 Participants'table

The following tables present a breakdown of each participant's decision-making process at three different stages during the observation. The first stage includes extracts from each participant's transcript, describing their initial thoughts on the problem and their initial actions in solving it. The second stage includes the outcome of the initial actions taken and any changes in the direction of solving the problem. The third stage represents the outcome of the second stage and the participants' overall thoughts on the problem as described by the participants themselves. These tables were used to help develop the cognitive maps

used to code, visually structure and present each individual's decision making process. The full list of the maps can be found in the appendix

	P1	P2	P3	P4	P5	P6
Stage 1 perception	• *"I have never come across a networking situation in the past. Therefore I think it is important to understand the effect this is going to have on our market"* • *"First I want to see how much are we are producing and evaluate our current reserve levels and when they are going to end, this will give me an idea of the timeframe that we are working with."* • *"I also want to understand the compromise solution plan and look at our best options to get the network up and running again."*	• *"We can never be sure of what could happen and when to a network pipe, these things are underground and even though we do spend a lot of money and attention on maintaining them, things do breakdown every once and a while"* • *"To sort out the issue, we need to first understand our position in the market compared to our competitors and our sales volumes over a period of 6 months."* • *"We also need to look at when our current reserves will end in order to establish how long we have to act."*	• "Looks at effects on compromise and thinks that limiting production for environmental risks is important and adding shipping costs and by doing so there is a good excuse to increase price as local authority and public pressure will understand, looks at the end for cost of repair or replace" • "What we need to establish is how we have been doing recently compared to our main competitor in the market." • "By establishing this fact and by looking at when our reserve levels will end we can then look at what the next step will be"	• "I understand the effects of a network compromise, theorefre, form experience I know that the main issue here is to understand when this problem will become urgent by looking at the levels of reserve we have in our storage and looking at the timeframe and cost for delivering the product through a different route"	• "We obviously need to satisfy the market, however, we should not appear weak doing so, we know that our main competitor can't afford to match our low price; therefore, we should assess the possibility of matching theirs." • "The risk that concerns me the most is that of the local authority and the pressure through the media that they might put to damage us."	• "From a business point of view I am mostly concerned with knowing when will our network run as normal again. Therefore I want to look at the cost of fixing or replacing the compromised pipe and the quickest option."
PSA at stage 1	*Low*	Medium	Medium	Medium	Medium	Medium
BI Tools used at this stage	*ERP multi-resource planning* *Incident management* *Simple finance*	ERP ERP multi-resource and planning	ERP	ERP multi-resource planning Simple finance	Risk management Incident management	Incident management ERP multi-resource planning Simple finance
Stage 2 perception	• "We were producing at a very good rate which meant that our reserve levels at the storage rates are high, however, the timeframe to fix or even replace the pipe compromise still represents a longer period of time." • "The only thing I can think of is either shipping the product from the refinery to the local market through different means, which I would think is going to be costly or buying it from the open market from one of our partners and satisfying the demand that way."	• "The reserve levels are at a good level; however it is not projected for it to stay long as we are eating away at it to satisfy the market." • "We need to now look at ways to urgently satisfy the market and assess the ways and the costs of doing so are going to be." • "Whilst establishing these costs we already established that our competitors have been pricing their products at a higher rate, we need to now asses of increasing our price match theirs, we have to worry about the local and the media pressure as we are known to always be lower and the financial risks of doing this in the long term that might result in customers leaving us."	• "We need to analyse the situation further by establishing the costs of delivering the product to the stations by road or buying them from the open market and assessing the risks of increasing our price to align with our competitor, these risks are tricky to assess as they include the reaction of the public, our customers and our competitor who might decide to lower their prices."	• "Having looked at the cost of sending our products to the stations by road and the time we have to start doing so, I know want to look at our position compared to our competitor." • "It is commonly known that we have a lower price than, however, I want to look at how we are doing sales wise for the last few months and assess the risks of increasing our price to match theirs."	• "The risk is there, however I have a couple of ideas to try to eliminate it or at least minimise it, however, I want to turn my attention to the time we have left for our reserve to end the options we have to satisfy the market and their costs."	• "Having established the cost and time repair the compromise which in either case will surprisingly take a considerable amount of time" • "I now want to turn my attention to the plan to satisfy the market demand, which is represented by buying from the open market or by shipping by road. "
PSA at stage 2	Low	Medium	Medium	Medium	Medium	Medium
BI tools used at this stage	ERP multi-source planning Simple finance	Simple finance Risk management Incident management	ERP multi-resource planning Simple finance Risk management	Risk analysis Incident analysis	ERP multi-resource planning Simple finance	ERP multi-resource planning Simple finance
Stage 3 perception	• "The timeframe to fix or replace the compromise are equally long, therefore, it comes down to picking which other way to satisfy the market." • "After analysing the situation from a financial point of view I think that it is better to negotiate and by from the open market, the prices are ok at the moment and we can use our relationships within the industry to get a fair and good price."	• "The costs of shipping the products using alternative options or buying it from the local market are high due to the distance from the refinery and the market price." • "We might face some risk from the local authority and bad publicity for increasing the product, however, this gives us a good opportunity to align ourselves with our competitor price wise, and I don't think that the risk of losing our customers to them is existent as the price will be the same." • "Therefore, after conducting a financial analysis, we can solve the problem by buying the product from the open market as it would long term work out cheaper than shipping our production for the whole distance	• "It would be difficult for our competitor to lower their prices as even though they have a network similar to ours, their costs are much higher which is why they always had a higher market price." • "The costs of shipping the products are very high due to the distance, however, the market price is tempting and we might get a good deal through our contacts." • "I would recommend buying the products from the open market and shutting down our production to save costs until the compromise is overcome which will reduce the risk of public pressure. Finally increasing our price to match our competitor to minimise our costs as well."	• "The issues here is that we cannot predict how our competitor will react to our price change, they might lower their prices just to increase their market share and use the bad publicity we are likely to get against us" • "Having looked at the situation closely, I feel that the best option is to pay for extra shipping to deliver the product by road whilst the compromised is being repaired, match our client's price for a period of 6 months, and introduce a rewards scheme in order to keep our customers loyal which would last for 6 months after which the price will return back to normal."	• "We can either ship the products from the refinery directly or buy from the open market. The best option for me is to ship by road as even though it will cost less it means that we can keep the refinery going." • "I have also calculated a rewards scheme to be introduced to our customers which might entice them to stick with us and Minimise the risk of the local pressure." • "Finally the best option is to increase the price to match our competitors for a period at least until our compromise is fixed."	• "Having analysed the situation financially I think that our only option is to fix the compromise and for the time being satisfy the market by shipping from the refinery by road as it is still slightly cheaper. And endure whatever loses we have to until we are back to the normal networking standard."
PSA at stage 3	Medium	High	High	High	High	High
BI tools used at this stage	Simple finance	Simple finance	Simple finance	Simple finance	Simple finance	Simple Finance

Table 10 Scenario 4 (P1 to P6)

	P7	P8	P9	P10	P11	P12
Stage 1 perception	• *"I have been many situations like this in the past, however, I always say that each situation is different and it is better to establish a full understanding of the situation than working on assumptions"* • *"My first action Is to look at our position and sales volume for the last few months compared to our main competitor in order to understand what we can achieve in the market"* • *"I also want to look when the incident is going to start affecting us which is when the reserve levels will run down and our options in our options and costs to satisfy the market internally or externally"*	• *"I am not sure how to proceed, I feel like first I need is to establish our reserve levels and when they are expected to end and how and for how much can we satisfy the market when it happens."*	• *"I have been through a similar issue, what is important is to understand our market position versus our competitor, I know for a fact that our prices are lower than theirs, however, it is important to understand if we can increase ours to match theirs or not since we have spent a lot of time advertising that our prices are the lowest, we will face a local and financial risks by making such a move."*	• *"I have no clue about how to solve the problem in all honesty"* • *"All I can think of is to learn what happened, and minimise the loses as much as possible, therefore, I will look at the compromise, when it will affect the reserve and where can we deliver the product from in that timeframe and the costs of this action."*	• *"There was an incident in the past similar to this one, which is why I want to be cautions and not repeat what happened before, we might solve it by increasing our price for a period of time at least."* • *"But what we need at the moment is to look at our health, at how much are we selling and at what price compared to our competitors."* • *"We also need to establish the time we are working with, if we have time, we can figure it out a more rational solution, which is why we need to establish our costs, we need to look at how and from where can we get the product during the compromise and also how can we make sure to retain our customers and keep our reputation intact."*	• *"The only way to satisfy the market is to spend, and is to spend means extra costs and at the moment extra costs with our price simply equals a loss"* • *"Our only hope is to increase our prices for the period of the compromise, which I would suspect will take a few months to repair. Therefore, a detailed risk analysis of such a move needs to take place, the risks could come from our competitors reacting to our price, local pressure, or financially losing some of our customer pace"*
PSA at stage 1	Medium	Low	Medium	Low	High	medium
BI Tools used at this stage	ERP Incident management ERP multi-resource planning Simple finance	ERP multi-resource planning Simple finance	ERP Risk management Incident management	Incident management ERP ERP multi-resource planning Simple finance	Incident management ERP ERP multi-resource planning Simple finance	Risk management Incident management
Stage 2 perception	• *"Our market position is healthy with prices lower than our competitor"* • *"We urgently need a plan to satisfy the market as the reserve levels are running low, however the costs are very high."* • *"The only way we might overcome the situation is to look at increasing our price to match our competitor to make up these costs, however, I first have to assess the risk of taking such a move which include competitor lowering their price after we increase ours, customer loss and local and media pressure damaging our reputation."*	• *"The reserve will run out soon and the open market represents a lot of issues as companies will take advantage out of our predicament, therefore, the best option is to ship our product by road which will also be costly but we can overcome the costs by increasing our price marginally, however, we first have to assess the financial, local and competitor risk of making this move."*	• *"Our market position is good, what worries me is the level of local risk that we might face if we decide to increase our price, however, this will depend on how long we have to make a decision based on the reserve levels we have and the cost of whether to ship the options directly by road meanwhile or by buying it off the open market."*	• *"We don't have a lot of time on our hands and the cost are damaging, as the market price means we will be at a loss and so are the road delivery costs."* • *"I have to look at our market position, our sales volume recently and our competitor's pricing and asses the risks of matching their price, I would think that they might act on this move and lower those and the community will not take well to our increase as well which could damage us in the long term."*	• *"Our costs are high but in any case necessary, Our safeguarding costs on the other hand are ok, what we have to do now is to establish the risk of minimising them by increasing our production, the risk that I am concerned of Is our competitors reducing their prices which from experience is very damaging."*	• *"The risk is there, however, we need to establish before deciding to take it or not the actual costs,"* • *"I am going to review the reserve levels and when they are expected to finish, as this is the maximum time we have to satisfy the market."* • *"I also need to look at the ways to satisfy the market internally or externally and their costs"* • *"Other costs I have in mind are rewards costs to retain our customer base and advertising costs to gain public sympathy"* • *"All these costs need to be analysed and weighted against the risks in order to make a confident decision"*
PSA at stage 2	Medium	Low	medium	Low	High	Medium
BI tools used at this stage	Risk management Incident management	Risk management	ERP multi-resource planning Simple finance	ERP Risk management Incident management	Risk management	Incident management ERP ERP multi-resource planning Simple finance
Stage 3 perception	• *"The risk of our competitor lowering their price is not relevant in my opinion, however the media pressure we might fact could ruin us"* • *"Therefore, I would recommend to first introduce a rewards scheme to justify the increase, this scheme will not cost much in the long term, furthermore, I would recommend that we advertise the fact that we have a compromise issue through the media which would also gain us sympathy for the price increase."* • *"Finally I would recommend shipping from our refinery through land and increasing our price to match our competitors."*	• *"The risk that is worrying is the local authority and media risk, therefore, my solution is to advertise our problem, introduce a rewards program that might also save our reputation and increase the price only for the period that our network is compromised."*	• *"We have no option but to endure high levels of loses during the repair period"* • *"We can also gain public support by advertising our problem so that it justifies the increase"*	• *"The only risk that might affect us is the local pressure as our competitors will struggle to lower their prices"* • *"I finally understand what needs to be done; I think we should increase our price to match theirs, whilst gaining public sympathy by advertising our problems and also introducing a rewards scheme that was discussed a few months ago as the time is opportune."*	• *"I believe that the risk is not as high as I had expected, however, just to be cautions I believe and would recommend increasing our price for only the period the compromise is still taking affect at"*	• *"Having conducted the analysis I am sure that we can increase our prices to solve the issue until the compromise is resolved, however, I don't think we should make a decision now on keeping them high, I believe we can make this decision when the time comes"*
PSA at stage 3	High	High	Medium	High	High	High
BI tools used at this stage	Simple finance	Simple finance	Simple finance	Simple finacne	Simple finance	Simple finance

Table 11 Scenario 4 (P7 to P12)

5.3.3 Stage 4: Data Analysis

During this stage of data analysis, the researcher recorded the interactions between the participants and the senior manager who was ultimately responsible of making the decision. Each participant presented their recommendations and a justification for their decision. P1, P2, P6 and P9 recommended that the company satisfies the market, but presented different ideas on how to do so. P1 thought the best option was to avoid the logistics of shipping the products byway of alternative methods and buying the products from the open market instead. This idea was supported by P9, who indicated that halting production and buying the product from the open market, at least until the network was up and running again, would save on production costs for the period. P2, however, indicated that halting production was not a viable option as some costs would continue anyway, and therefore recommended shipping by road.

On the other hand, P3, P4, P5, P7, P8, P10, P11 and P12 all thought that, under the circumstances, the company should increase its prices and offered varying opinions concerning the delivery of the product to the stations. P4, P5, P8 and P11 all agree that this was the right choice, but only whilst the compromise was still a problem. These participants indicated that there were various risks that might result in a loss of the market share to the company's main competitor. P3 and P6, however, indicated that these risks were not relevant as the company would only be matching the competitor's prices and the competitor cannot afford to lower their prices any further. P7 and P10 indicated that by introducing a loyalty scheme for customers that would not, in the long-term, cost the company much and by advertising the current predicament the company was going through, these risks could be completely eliminated. P12 agreed with this suggest, however, the situation could be revised again after 6 months.

The manager thanked the analysts for their work and indicated that the information provided was very useful. The manager indicated that, under the circumstances, slowing or halting production was not an option as some of the costs would continue regardless. Acknowledging that the company had recently been deliberating whether to increase its prices to match its main competitor, the problem seemed to present an ideal opportunity.

Consequently, the decision was that the company would pay for shipping by road until the repairs to the compromise were complete and would increase the prices for that period. Moreover, to limit the risks associated with the decision, the company would advertise their reasons for increasing their prices and would introduce the proposed customer reward scheme. Finally, the risk of maintaining a high price once the compromise was repaired would be revisited at that time.

Transcripts of this session were sent back to each participant in order to check if the data was representative to their thoughts and activates at the time of the data collection and the decision analysis process.

5.3.4 Initial Post-Decision Data Analysis

5.3.4.1 Level of Reliance on BI Tools Analysis

Figure 29 highlights the tools used by each participant during the observation stage.

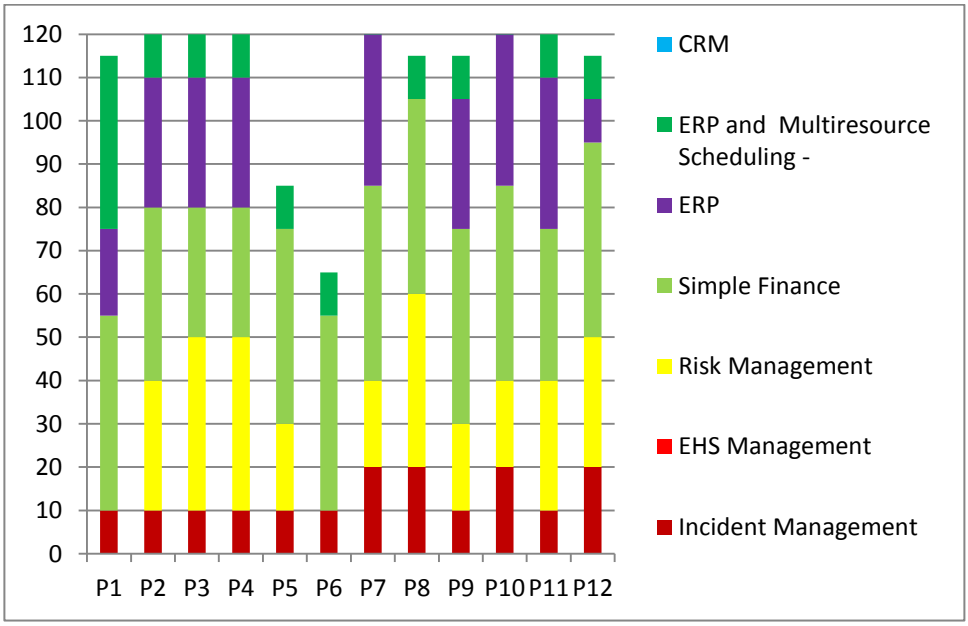


Figure 21 Stacked participant level of usage

5.3.4.2 Level of Reliance Based on Decision Recommendations

As shown in Figure 29, none of the participants used all of the tools available to them at the time of conducting the analysis. The tools not used were the CRM and EHS management tool, their absence being explained by the nature of the scenario or problem at hand. The graph also shows a high level of reliance on the tools. P1, P2, P6 and P9, who recommended that the company satisfies the market in other ways, all spent over 110 minutes using the BI system. P6, however, spent the least time of all participants in the study (65 minutes). The other difference being that P2 and P9 considered the risks of increasing the price to save some of the costs, whereas P1 and P6 never considered such actions.

When analysing the participants who thought that the best option was to increase the price, but only whilst the compromise was still active (i.e. P4, P5, P8 and P11), P5 spent the least time using the system out of these participants and the second lowest out of all the participants in this study.

Finally, when looking at the participants who recommended that the company increase its prices to match the competitors, all spent a considerable amount of time using the system.

5.3.4.3 User Efficiency of the BI Tools

By looking at the concept shape styles of the cognitive maps generated for each participant, it was found that most of the participants had user efficiency issues when trying to combine data sets using different BI tools. P3 and P4 were, however, the exception and these participants did not suffer from any user efficiency issues.

5.3.5 Decision Outcome

By keeping in contact with the organisation, the researcher continued to monitor the decision closely, the researcher was eventually contacted by senior manager 5 months after the date upon which the decision was taken. The senior manager provided the researcher with a detailed outcome of the decision. The manager indicated that during the initial period following the decision, the company went through a difficult public relations (PR)

moment, as competitors and the local community took the price increase as a greedy move that was unfair since the company was in a unique cost saving position. The company initially spent a lot of time and effort in disclosing the details of the compromise to gain a degree of public sympathy. At the same time, the company initiated its rewards scheme programme. Over the first 3 months, the company's sales volumes decrease slightly as some customers were influenced by the greedy perception being portrayed in the media. However, sales started returning to normal after this period, and the loyalty scheme had a big influence, with the company teaming up with a highly respected international rewards company and the rewards proved to be very attractive. Therefore, the manager concluded that the company was very satisfied with the overall results of the decision and, after deliberation, decided to keep the prices high for the foreseeable future.

5.3.6 Retrospective Analysis

The previous section discussed the analysis based on the decision taken by the company in response to the problem at hand. In this section, individual participants' reasons for their recommendation will be reviewed and comparisons made between participants' PSA during the process and their retrospective ASA.

For this analysis, the participants were divided in 4 groups. Group 1 included those participants who recommended that the company ship the product by a different means. Group 2 includes those participants who decided to increase the prices to match their competitors whilst the compromise was still affecting the delivery of the product. The third group included those participants who recommended that the company increase its prices permanently to match their competitors. The final group included those participants who advised an increase in price, but for the decision to be revised after the compromise was repaired and networking operations had returned to normal.

5.3.6.1 Group 1: Retrospective Analysis

This group includes those participants who thought that the company should deliver the products using a different method and bear the costs for this period. Starting with P1 and P6, who were the least experienced out of the analysts in this group, the participants' lack

of experience and familiarity with the problem meant that their PSA level started from a low point. P1's PSA levels gradually increased as the participant looked to further understand the problem by examining more data. P6's PSA increased at a later stage. However, both participants only looked at ways to satisfy the market and minimise the costs of doing so; as such, their ASA levels never increased due to the direction they took, which was a product of their lack of experience and familiarity with the problem, which in turn explains their recommendations.

P2 and P9, on the other hand, recommended the same decision but for different decisions for the same reasons, although both participants used the same tools and investigated almost the same sets of data during the decision-making process. After starting from a low level of PSA, P2 recommended that the company maintain its current prices and ship products by road. P2 advised not to increase prices as the risk of doing so was too high. P9 decided similarly, but their solution to the issue was to halt production to save on production costs, and instead to buy the products from the open market, which in the long-term turned out to be the cheaper option. Therefore, both participants PSA levels increased in a similar way, however, their ASA levels were lower as both participants thought the risk of the increase was too high when in retrospect it turned out to be a better solution to the problem. It is interesting to find that both participants ASA levels were identical, as P2 was aware that the company could not halt production as some of the costs will continue and P9 understood that advertising the problem would turn the publics' opinion in the company's favour. Figure 30 illustrates the different PSA levels of the participants in this group, on the other hand figure 31 illustrates the ASA levels of the these participants throughout the process.

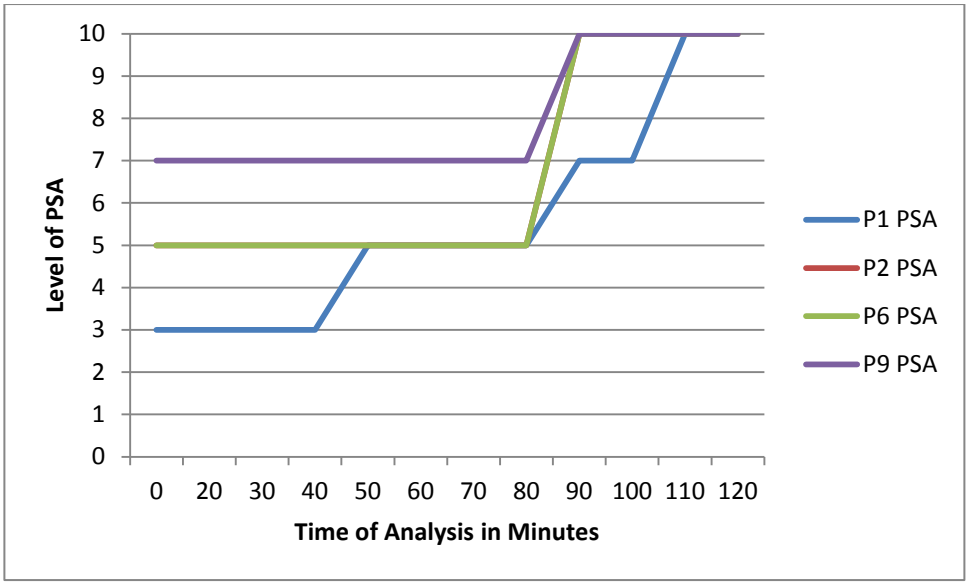


Figure 22 Scenario 4 Group 1 PSA Levels

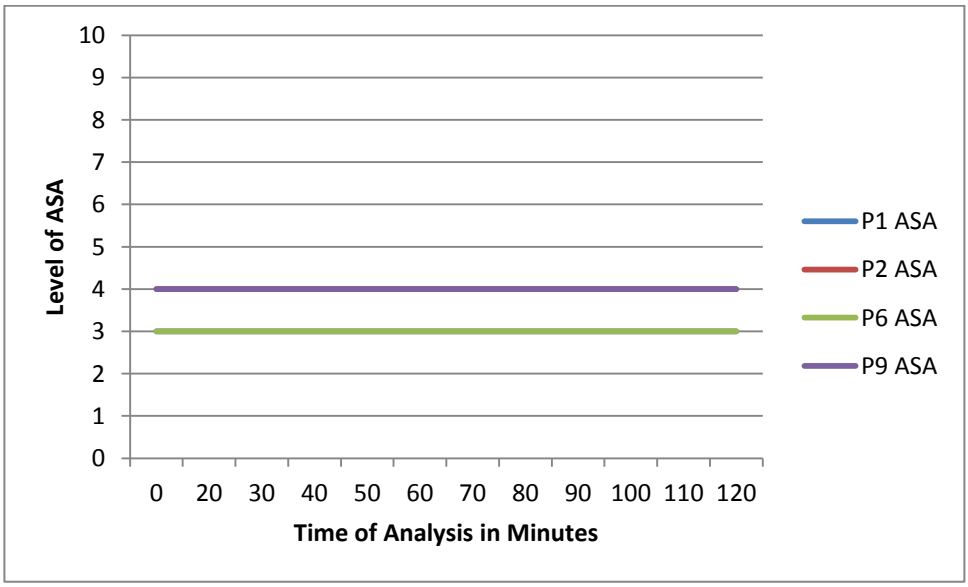


Figure 23 Scenario 4 Group 1 ASA Levels

5.3.6.2 Group 2: Retrospective Analysis

This group includes the participants who decided to increase the product price for the end-user to match their competitors, but only whilst the compromise was still adding to the costs. The participants in this group include P4, P5 P8 and P11. P4's PSA levels started out

moderately as the participant understood compromise and its affects. P4's PSA increased after examining the costs and effects of the compromises until their PSA reached its highest levels after the risk assessment stage, which the participant deemed to be high. This led P4 to the decision to increase the price only whilst the compromise was still affecting transportation. The participants ASA levels, however, did not increase due to the fact that although the participant attended to the risks involved, they failed to look at all the ways to minimise it.

P5 and P8, on the other hand, gave the same recommendations, with the difference being that P5 thought that the only risk relevant was the local risk from the media because of increasing the prices. On the other hand, P8 thought that there was a risk of the competition decreasing their prices and the potential loss of customers. However, both participants ASA levels were lower, as although they recommended introducing the rewards programme to minimise the risk of customer loss, they did not look at ways to minimise other risks and deemed increasing prices permanently to be too risky.

P11 had encountered a similar experience to the present scenario in the past. Their PSA level started reasonably high, however, this previous experience affected their perception of the situation, which meant that their ASA levels did not increase in relation to their PSA levels. P11 focused on the risks that were important in their previous experience and did not think that keeping the price high in the long-term would be the right choice. Figure 32 illustrates the different PSA levels of the participants in this group, on the other hand figure 33 illustrates the ASA levels of the these participants throughout the process

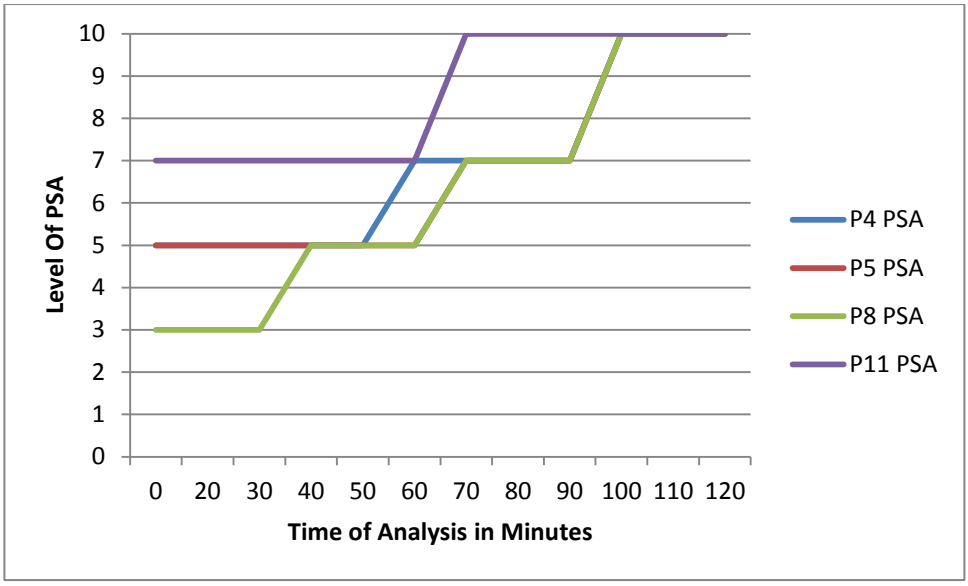


Figure 24 Scenario 4 Group 2 PSA Levels

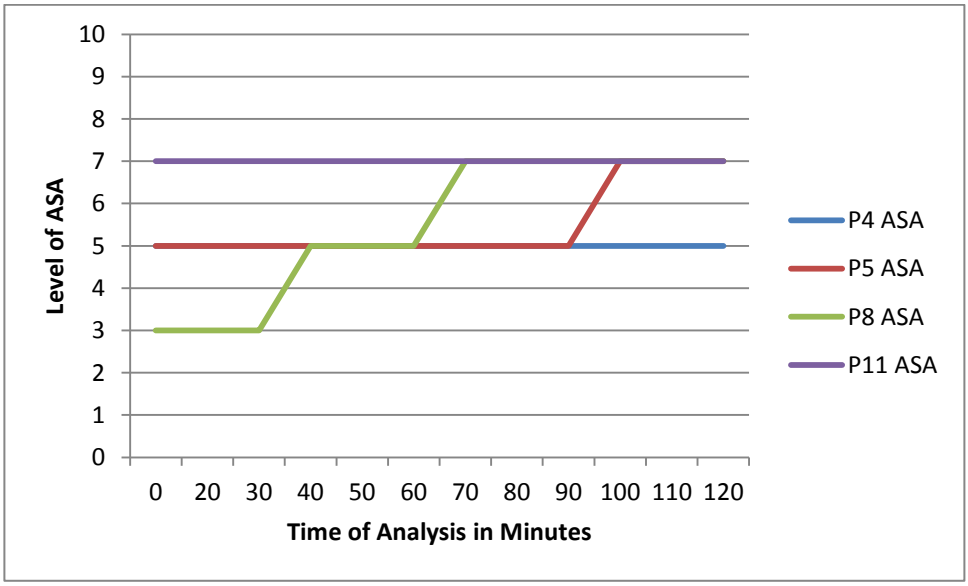


Figure 25 Scenario 4 Group 2 ASA Levels

5.3.6.3 Group 3: Retrospective Analysis

The participants in this group (i.e. P3, P7 and P10) all recommended that the price be permanently increased to match the company's main competitor. All three participants conducted the same tasks to reach their recommended decision except for P3, who did not deem the risks of the price increase to be realistic and did not consider introducing the rewards programme or advertising the problem to gain public sympathy. As such, P3's

ASA levels did not increase as high as their PSA levels. The other glaring difference between these participants is that P10's PSA started at a lower level as P10 had never encountered a similar situation in the past; P10's age and experience were significantly less than the other two participants. Nevertheless, P7 and P10's PSA and ASA levels were aligned throughout the task to reach a high level. Although the company's initial decision was to reconsider their decision on whether to keep the price increase permanently or not after 6 months, P7 and P10 thought from the start that the decision should be permanent. Figure 34 illustrates the different PSA levels of the participants in this group, on the other hand figure 35 illustrates the ASA levels of the these participants throughout the process

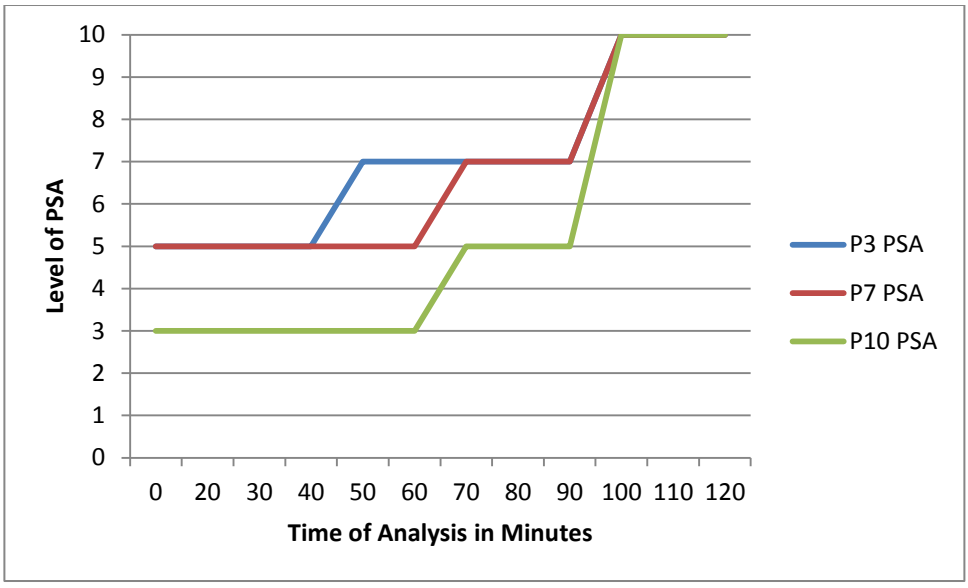


Figure 26 Scenario 4 Group 3 PSA Levels

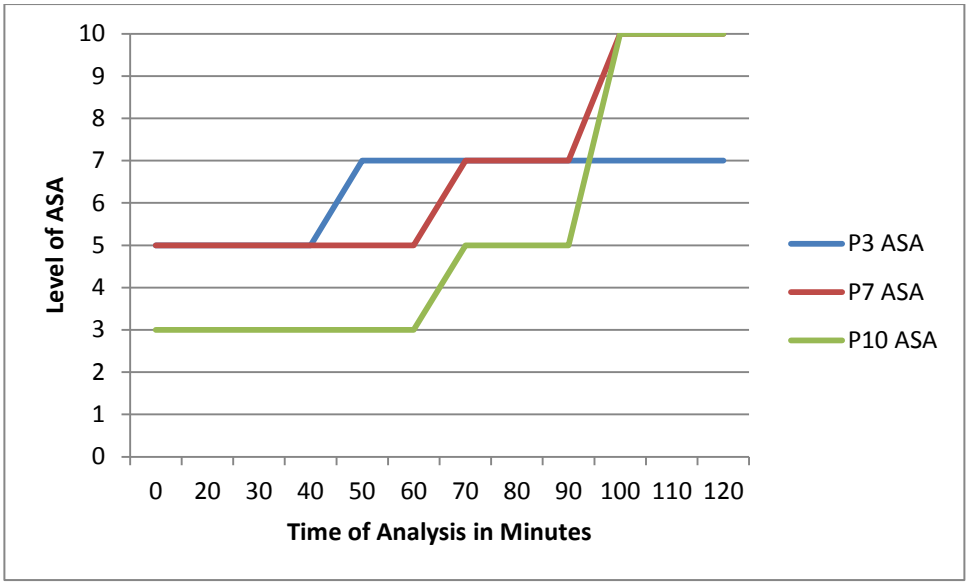


Figure 27 Scenario 4 Group 3 ASA Levels

5.3.6.4 Group 4: Retrospective Analysis

The final group includes only P12, who looked at the situation in the same way as the participants in Group 3 did; however, P12 indicated that the company should revise the situation once the compromise was fully repaired, which the company agreed to do. Consequently, P12's PSA and ASA levels were aligned throughout the process. The line graph in Figure 61 illustrates the P12's PSA and ASA levels.

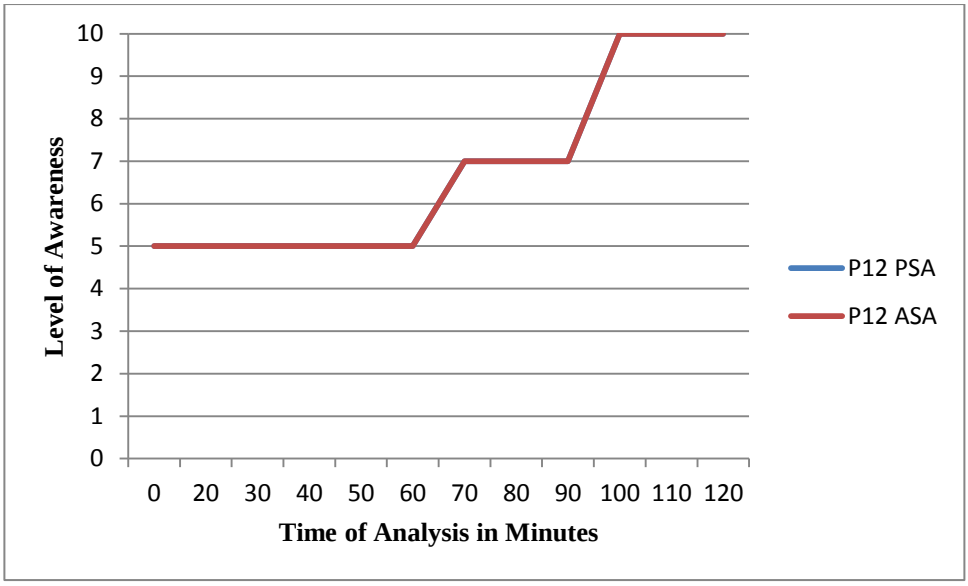


Figure 28 Line graph illustrating PSA vs. ASA for P12

5.4 Scenario 5

Scenario 5 was a result of a downstream wholesale marketing decision aimed to generating greater income. The company's downstream operation in one of its markets was going through a period of low volume sales and very low profit margins due to the current market demand and price. The company's refinery was established to produce large volumes of products for both the retail and wholesale markets; these levels, however, could not be reduced due to the size and the operational set up of the refinery, which meant that no costs could be saved from such a reduction. Furthermore, the company's retail prices were governed by the local authorities, which meant that the only price the company could manipulate was the price of its wholesale products. The company needed to find a way to move the products the refinery produced despite the low levels of demand as it could not afford to store the products due to continuous production which would lead exaggerated storage costs and might even lead to unsold products being burnt.

5.4.1 Stage 2: Data Analysis

The senior manager appraised the analysts on duty of the problem, explaining that the company needed to act as soon as possible as senior management was not happy with the situation, and if the problem were to continue then the company might have no option but to burn its produce to minimise costs. Burning product is an option that O&G company's try to avoid as best as they can. The manager indicated that the analysts needed to see what could be done to increase the profit margin, rather than to continue the company's current average sales in order to avoid burning the products, which would in itself constitute an income loss strategy.

5.4.2 Stage 3: Data Analysis

The participants in this scenario are the same participants who took part in Scenarios 4, therefore, the information gathered at this stage had already been obtained (see Table 10).

Again, the researcher observed each analyst separately under the same conditions as established in the research strategy. The following tables present a breakdown of the participant's decision-making process at three different stages, the tools used at each stage, their PSA at each stage and finally the decision outcome.

The following tables present a breakdown of each participant's decision-making process at three different stages during the observation. The first stage includes extracts from each participant's transcript, describing their initial thoughts on the problem and their initial actions in solving it. The second stage includes the outcome of the initial actions taken and any changes in the direction of solving the problem. The third stage represents the outcome of the second stage and the participants' overall thoughts on the problem as described by the participants themselves. The tables also include the BI tools at each stage of the process. These tables were constructed to aid in the development of the participants' cognitive maps and to highlight the PSA levels for each participant throughout the decision-making process. The full list of the maps can be found in the appendix

	P1	P2	P3	P4	P5	P6
Stage 1 perception	• *"I spent the majority of my career so far working as a trader."* • *"Therefore, maximising profits during a bad demand and price period exactly fits my skill set."* • *"The first thing we need to decide is will the market change favourably in the future?."* • *"If it is I wonder if there is a way we can hold off on the sales at the moment on the products that are not under contracts until he market booms again, this might be possible if we have the right profit space or not"*	• *"As a business expert, I always look at a lack of real profit margins as not only a market slump but also as a costs issue"* • *"We might be able to manage to optimise the production process by looking at saving the networking, equipment rent and staff costs"*	• *"From my experience, I like to keep an open mind, I believe that a combination of things can be looked at to achieve maximum profit."* • *"I want to first look at optimising costs across the whole production process, there might be areas of improvements there"*	• *"I am not sure about the optimisation levels of the production process, we might be able to increase the profits if we reduce some of the unnecessary costs the incur"*	• *"As a trader, we learn very early that it's important to understand the market"* • *"Our prediction of the way the market might react in the future should determine what we need to do, therefore, a market overview and price and demand predictions are the first step forward"*	• *"In this industry, saving half a cent adds up to significant profits"* • *"We need to look at the production process; we surly can reduce the costs there which will solve the whole issue"*
PSA at stage 1	*Low*	Low	High	Medium	Medium	High
BI Tools used at this stage	*ERP* *ERP multi-resource planning* *Simple finance*	ERP Simple finance ERP and multi-resource	ERP Simple finance ERP multi-resource and planning	ERP ERP multi-resource planning Simple finance	ERP	ERP Simple finance ERP multisource
Stage 2 perception	• *"The market is favourable, however, the costs of storing at the moment are very high as we have to store externally rather than from our own."* • *"The only thing left to try is to try to hedge the product to be sold for a future agreed price where we and the buyer gain to profit."* • *"This involves a high level of financial risk as the price might not react as predicted, these risks need to be taken into consideration when calculating the hedging price."*	• *"It turns out that currently the production process is highly optimise and there isn't really any costs to be saved from the process."* • *"The only thing left to do is to look at the way market might react in the future, if it react well then we might be able to assess the risks of hedging the product from for a future date with a fixed price or to not react at all."*	• *"As the production process is optimised to the maximum level, we need to look at how the market is predicted to react, this might give us potential options to look at such as whether we can hold off on the product and store it to a future date, but this might turn out to be costly"* • *"Another option might be to look at hedging the product for a future date; however, before conducting this strategy we need to assess the risks of the prices increasing as expected and the no delivery issues that might occur from the local political situation."*	• *"The production process maximises as much profit s possible at the moment"* • *"The only thing I think of is to look at the market and see if we can store the product until a time where it might go up."*	• *"The market is strongly predicted to improve in the near future and that gives us at least a security caution to lean back on"* • *"The next step would be to look at a potential hedging strategy where we sell the product at a future date with a set price"* • *"We need to asses the financial, competitor and local risks before we move forward with such a strategy"*	• *"Surprisingly the process is currently operating at a maximum optimisation levels, therefore this route is blocked"* • *"The only thing I can think of which might save our problem is to predict whether the market is predicted to pick up in the future or not."*
PSA at stage 2	High	Medium	Medium	Medium	Medium	Medium
BI tools used at this stage	Simple finance Risk assessment Local authority risk	ERP Risk Finance Incident management	ERP ERP multi-resource planning Simple finance Risk assessment Incident management	ERP ERP multi-resource planning Simple finance	Simple finance Risk management Incident management	ERP
Stage 3 perception	• *"There is a level of risk to be considered, however it does not seem to me to be significant"* • *"This seems to be the best solution to the problem"* • *"It may not be ideal but I think we can find potential buyers and we can negotiate a favourable price."*	• *"The risks of the product not reacting favourably are literally non-existent, however, the risk of hedging the product are very risky from a local authority point of few, as the current political climate is not quite enough to guarantee on time delivery."* • *"The financial costs for such a risk are very high"* • *"Therefore the best option is to wait until the market picks up as predicted."*	• *"The market is predicted very strongly to pick up in the near future, however, the costs of storing the product are too high"* • *"The financial risk of hedging the products are not very high and profits of conducting this are enticing, the only risk that seems to be more realistic is of something wrong occurring locally which might risk the process of delivering the product."* • *"From experience the risk is always there but it hardly ever becomes reality and I believe that hedging is the best strategy to achieve the goal and I am confident of negotiating a good deal with a potential buyer."*	• *"There doesn't seem to be much point in storing the product as the costs are too high"* • *"Since the market is projected to increase eventually, I think that the best way forward is to do nothing at the moment and be satisfied with the profits we have now and the future is brighter"*	• *"The risks of such a strategy for me out way the benefits, if an incident occurs locally then financially we will take a big hit and we risk our competitors gaining an advantage on us in the market by poaching our customers"* • *"I believe as we are secure in the knowledge that the market will definitely improve, we don't need to react to the issue."*	• *"The market is predicted to pick in the near future"* • *"I believe that our current margins even though low, are ok to live with and since the market is strongly expected to improve, we don't have to do anything as our profits will soon increase"*
PSA at stage 3	High	High	High	High	High	High
BI tools used at this stage	CRM Simple finance	Simple finance	CRM Simple finance	Simple finance	Simple finance	Simple finance

Table 12 Scenario 5 (P1 to P6)

	P7	P8	P9	P10	P11	P12
Stage 1 perception	• *"My Experience is likely to help me with this problem, however, I need more information"* • *"Everything needs to be taken into consideration, starting with our production process; we need to figure out if it's efficient or if we are wasting money unnecessarily"*	• *"It's easy I determine whether or not we can save products from our production process, however, I think that the answer should be in the market."* • *"If we can see how it might react we can determine how strongly we should now react ourselves. Therefore an analysis of the market should be undertaken."*	• *"I have been through many situations like this in the past."* • *"The way forward is to always look at the market and how it will react and how we can capitalised on it as best as we can."*	• *"To maximise profit normal equals reducing costs"* • *"Form my experiencing in production I think that some costs can be minimise, therefore I think the way forward is to analyse these costs as best as possible."*	• *"The whole situation needs to be analysed rigorously, before this it's hard to determine the best course of action"* • *"The first step is to determine the market, how it will react and when."*	• *"I try to keep myself aware of how the company is operating most of the time and I have recently looked at our production process and I know for a fact that even for the current lay off program we have the storage costs are very high,"* • *"I think we should evaluate the market and react to how it is predicted to react"*
PSA at stage 1	Low	Medium	High	High	High	Medium
BI Tools used at this stage	ERP Simple finance ERP multi-resource planning	ERP	ERP	ERP ERP multi-resource and planning Simple finance	ERP	ERP
Stage 2 perception	• "As our production is running to the maximum level in terms of efficiency we can now turn to the market" • "We need to conduct a full market analysis in order to establish what is going to happen, when and how likely is it going to be as we estimated." • "If this information is favourable we can then look at a hedging strategy that we don't normally conduct assess the risks of conducting such a strategy."	• "The market is predicted to act well, therefore now we should look at trying to minimise costs as much as possible and then decide our next action and asses the financial risk of the market reacting as predicted."	• "I think the market is looking good, but a big part of our job is to maximise our potential income as best as we can, therefore, I think we need to now think outside the box." • "We should calculate the costs and risks of hedging the products for a future sale date which might would achieve our goal."	• "The production is surprisingly very efficient, in this case, it's a matter of the market, I think we should assess the market and determine if this price slump will continue for long."	• *"As the market is reacting well, we need to assess the risks of a hedging strategy, by seeking the product at a fixed price in a future date which might increase our potential."* • *"I know for a fact that this is the only way forward as I recently looked out storage costs and they are very high."*	• *"Our analysis shows that the market will turn and recover which gives us an edge in deciding our next move"* • *"I would like to analyse the potential of a hedging strategy and determine whether or not it's feasible and assess the local risks associated with the delivery of the product."*
PSA at stage 2	Medium	Medium	High	Medium	Medium	High
BI tools used at this stage	ERP Risk management Simple finance Incident management	ERP ERP Multi-resource and planning Simple Finance Risk assessment	Simple finance Risk management	ERP	Risk management Simple finance	Simple finance Risk management
Stage 3 perception	• *"The market will turn favourably"* • *"The risk that worries me is the local risk, even though I have to admit that I don't think it is very likely, I do think that it's costs could be catastrophic if it does happen"* • *"As the market is favourable I think we should air on the side of caution."*	• *"There is no extra cost cutting options left for is."* • *"The market is going to pick up and therefore the best options is to not to react to the current issue as things will turn soon as we are expected to make a healthy profit."*	• *"The main risk that might affect us is the local situation, however i believe for experience that it will never materialise"* • *"We can calculate a good price for the hedging strategy and find potential buyers as it stands"*	• *"It is predicted that That market will recover soon enough, therefore I would recommend that we calculate the we do nothing based on this strong prediction"*	• *"The best action would be to hedge the product,"* • *"There is a level of risk but it's worth taking"* • *"We can find a buyer and calculate a good offer"* • *"We can also look at our costs during production process and see how and where we reduce these which might give us a further profitable edge"*	• *"Financially I believe we would gain a lot from the strategy."* • *"We might face a local risk of anything politically goes wrong, however, with our current operation we haven't had any problems"* • *"I think we should act and find a potential buyer and negotiate a good deal"*
PSA at stage 3	High	High	High	High	High	High
BI tools used at this stage	Simple finance		Simple finance CRM	Simple finance	ERP ERP multi- resource and planning simple finance	Simple finance CRM

Table 13 Scenario 5 (P7 to P12)

5.4.3 Stage 4: Data Analysis

During this stage of data analysis, the researcher recorded the interactions between the participants and the senior manager who was ultimately responsible of making the decision. Each participant presented their recommendations and a justification for their decision. P2, P4, P5, P6, P7, P8 and P10 all agreed that the company should do nothing and that the market was simply going through a price slump. However, the company had no option but to wait. P2, P5 and P7 all indicated that they looked at the option of hedging the products to be sold at a future date. However, all indicated that the local situation in the country where the refinery was meant that such a decision carried a high level of risk, as products not delivered on time in accordance with the hedging agreement could result in the company having to pay over the odds from one of its competitors to make up the shipment or face legal action from the buyers.

P1, P3, P9, P11 and P12, on the other hand, all recommended that the company hedge its products for a future date, as by doing so the company would be able to set the price with an agreement from a buyer for a future date. This means that the company can manipulate the market and production in a way as to increase its profit margins.

Furthermore, P9 indicated having some local risk concerns that the other participants did not. However, P9 indicated that these risks had been in play for a long time, but have never materialised in the past and were unlikely to do so in this particular situation, thus suggesting that it was a risk worth taking.

The manager thanked the participants for their analysis and, after looking at the problem more closely, under the current market demand, indicated that the company needed to act to increase its sale volume and profit margin and that, with the information available, in order not to lose some of its production, the best option seemed to be to find a buyer for a future date and to hedge the product for the wholesale market at a convenient market price date. The strategy, therefore, would be to sell the product immediately, but with a future date price agreed with the clients, which will increase the company's current financial position and allow it to continue its production and cover storage costs.

5.4.4 Initial Post-Decision Data Analysis

5.4.4.1 Level of Reliance on BI Tools Analysis

Figure 37 highlights the tools used by each participant during the observation stage.

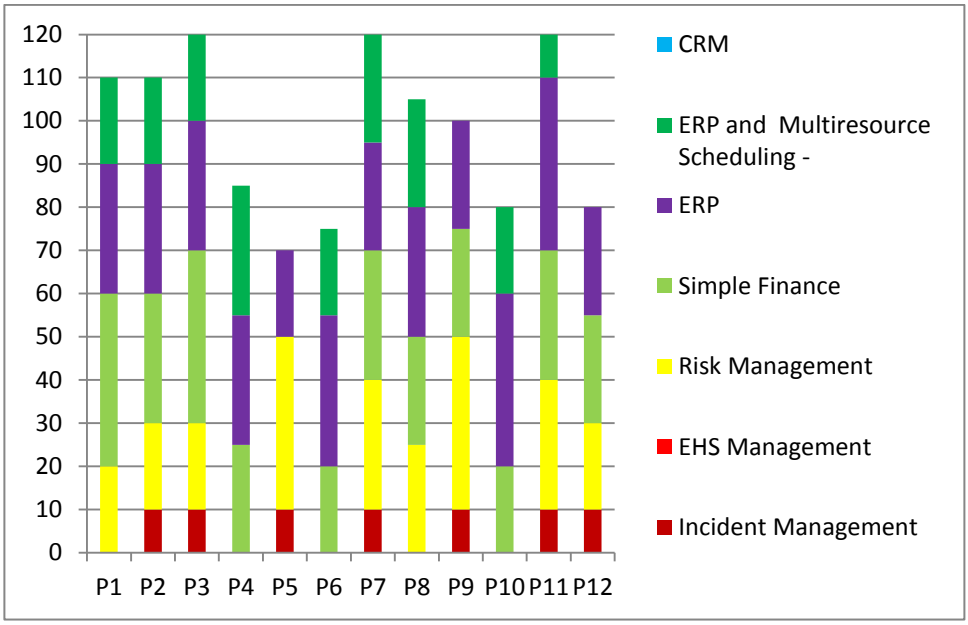


Figure 29 Stacked levels of reliance on BI graph

5.4.4.1.1 Level of Reliance Based on Decision Recommendations

As seen in Figure 37, none of the participants used all of the tools available to them at the time of conducting the analysis. With most participants, this can be explained by the nature of the scenario as there were no health or safety considerations inherent to the scenario, and although some of the analysts recommended hedging the product, none of them used the system as the basis of their recommendation as it was they felt there were always buyers in the market in a hedging scenario and that the search for one would commence once the strategy was chosen.

Figure 60 also shows that the participants who recommended that the company should not react to the demand slump showed a lower level of reliance on the system than the participants who recommended that the company hedge the products for a future price sale,

specifically P4, P5, P6 and P10. Only P2 and P8 showed a normal level of reliance. Furthermore, P12 was the only one of the participants who recommended that the company should adopt the hedging strategy to spend less than 100 minutes using the system.

5.4.4.1.2 User Efficiency of the BI Tools

Since the same participants who analysed this scenario are the participants who analysed Scenario 4, it was interesting to observe for any changes in the level of user efficiency in each participant. The individual cognitive maps generated show that P3, P4, P6, P8 and P10 did not manifest any user efficacy issues, with the rest of the participants showing issues when combining data using different BI tools. It is important to remember, however, that out of the participants that did not show any efficiency problem, P3 was the only participant who attempted to analyse data using different BI tools. Moreover, since the participants who took part in this scenario are the same participants who took part in Scenario 4, it would be safe to assume that the some of the participant's efficiency issues were not detected due them not attempting any complicated analysis that involved using multiple systems simultaneously.

5.4.5 Decision Outcome

The researcher kept in touch with the company in order to follow-up on the decision; a week after the date of the hedging agreement, the manager contacted the researcher with a decision outcome. The manager indicated that the situation faced by the company with the price slump was tricky as this slump had been on-going for some time. Moreover, with high production levels, the company needed to consider ways of increasing its margin from its wholesale stock since the retail stock could not be manipulated. Therefore, although the political situation in the country hosting the refinery was very tricky, it was a risk worth taking since the risks tended never to materialise. However, the manager indicated that when the laycan dates for the hedged shipments arrived, an attack by militants on the collection port meant that the buyer's vessel captain could not approach the port. This situation meant that unless the product was delivered within the three laycan dates as established in the agreement, the company would have to deliver the product from the open market. At that time, the market price was US$5 over the price of the shipments sold,

which meant that the company faced financial disaster. Initially, the company waited 24 hours to see if the situation would calm down and the security issues resolved, however, this waiting period meant that the prices increased by a further $2. The manager indicated that it was only by luck that the militants left the port on the third date of the laycan period after the local authorities managed to push them out, thus enabling the vessels to approach the port safely.

The manager indicated that, in hindsight, the company should not have hedged the products. It should have simply maintained operations as normal and burned whatever products it could not store as the loss of such an action would have been a lot less than having to burn the products and buy from the open market. Finally, the manager indicated that the local risk was hard to predict in this environment, and were it not for luck, it was only a matter of hours that this risk could have significantly damaged the company financially.

5.4.6 Retrospective Analysis

The previous section discussed the analysis based on the decision taken by the company in response to the problem at hand. In this section, individual participants' reasons for their recommendation will be reviewed and comparisons made between participants' PSA during the process and their retrospective ASA.

For this analysis, the participants were divided in 2 groups. Group 1 included those participants who recommended that the company do nothing and wait for the market to improve, which in hindsight the manager indicated the company should have done. Group 2, on the other hand, included those participants who recommended the hedging strategy, which luckily worked, but which the manager indicated in hindsight that the company should not have adopted.

5.4.6.1 Group 1: Retrospective Analysis

This group includes P2, P4, P5, P6, P7, P8 and P10. When looking at these participants, it is interesting to see that P4, P6, P8 and P10 never considered the hedging option as a strategy, which indicates that they were not fully aware of the situation which affected their

ASA levels. Furthermore, P8 was the only participant who considered the risk of the prices actually turning favourably or not before making his recommendation, which meant that his ASA level did increased marginally in comparison to the other participants. Nevertheless, all three participants recommend what was ultimately the better decision, although their ASA levels were not particularly high.

This group also included P2, P5 and P7, with these participants having evaluated the possibility of hedging the product, and after assessing the risks of doing so, deciding against it. The only difference in this group is that P2 did not evaluate the risk of such a strategy leading to losing an edge on the competitors in the market which affected their final ASA levels in comparison to their PSA level. Furthermore, P2 and P7's PSA levels at the beginning of the task were low, as they analysed different cost reduction options in order to optimise the production process, which had no actual bearing on the problem. P5, on the other hand, spent the shortest amount of time of all the participants using the tools available whilst looking to analyse the data relevant to the problem and making what in hindsight turned out to be the correct decision. Nevertheless, all three participants PSA and ASA levels were aligned throughout the task. Figure 38 illustrates the different PSA levels of the participants in this group, on the other hand figure 39 illustrates the ASA levels of the these participants throughout the process

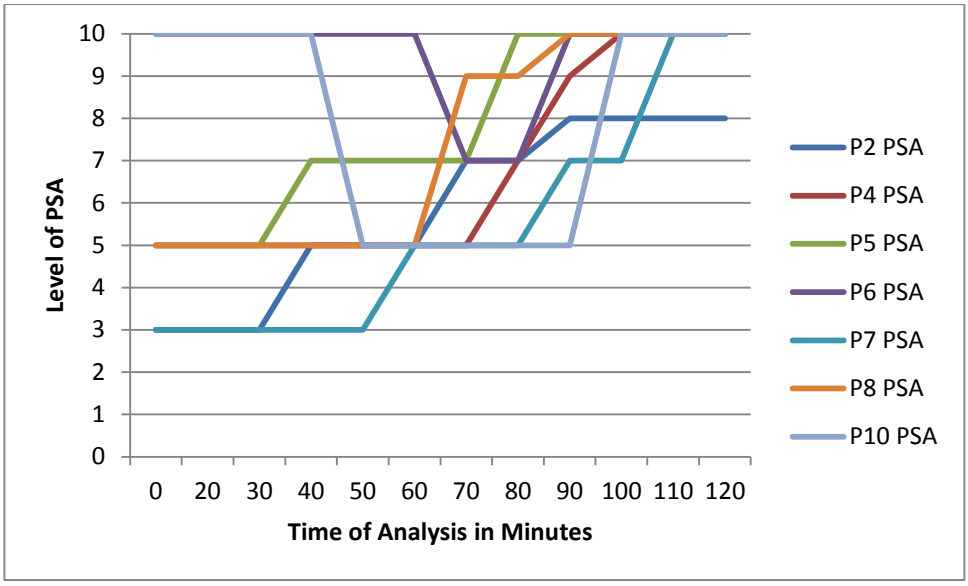


Figure 30 Scenario 5 Group 1 PSA Levels

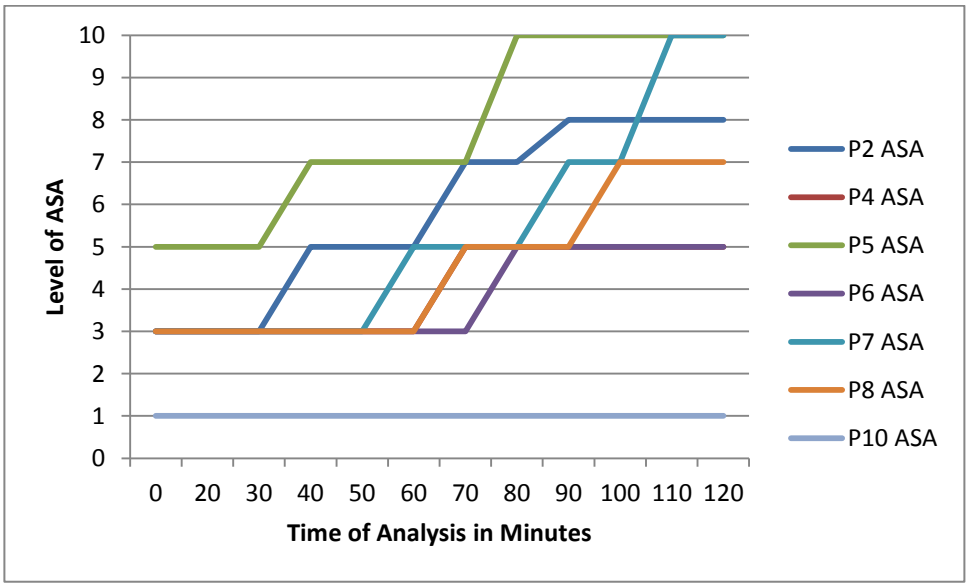


Figure 31 Scenario 5 Group 1 ASA Levels

5.4.6.2 Group 2: Retrospective Analysis

This group includes P1, P3, P9, P11 and P12. Starting with P1, P3 and P11, all three participants looked at cost reduction options to try to optimise production as they thought that such a strategy could help the problem. However, in hindsight, this option was irrelevant in solving the problem because the refinery generally operates at a high cost–saving level, which meant that the participants started with a low ASA levels. Furthermore,

P11 only looked at the financial risk of hedging the product and failed to assess the risk that, in hindsight, could have damaged the company heavily which was the local risk. P3 on the other hand, also failed to consider the competitor risk of the hedging strategy going wrong. Nevertheless, all three participants' ASA levels were low, with all three underestimating the risk of such a strategy.

This group also included P9 and P12. Both participants showed high ASA levels at the onset of the task as they understood that the company needed to understand when the product demand would turn favourable and also looked at the hedging strategy option and assessed its risks. P12, however, ignored the risks of losing the clients if the strategy failed or the risk of the competition taking advantage of the situation, which meant that their ASA levels were lower than P9 during the same period. Nevertheless, as both participants realised that the local situation represented a real risk, but failed to be cautious when doing so, their ASA levels suffered as a consequence during the decision-making stage. Figure 40illustrates the different PSA levels of the participants in this group, on the other hand figure 41 illustrates the ASA levels of the these participants throughout the process

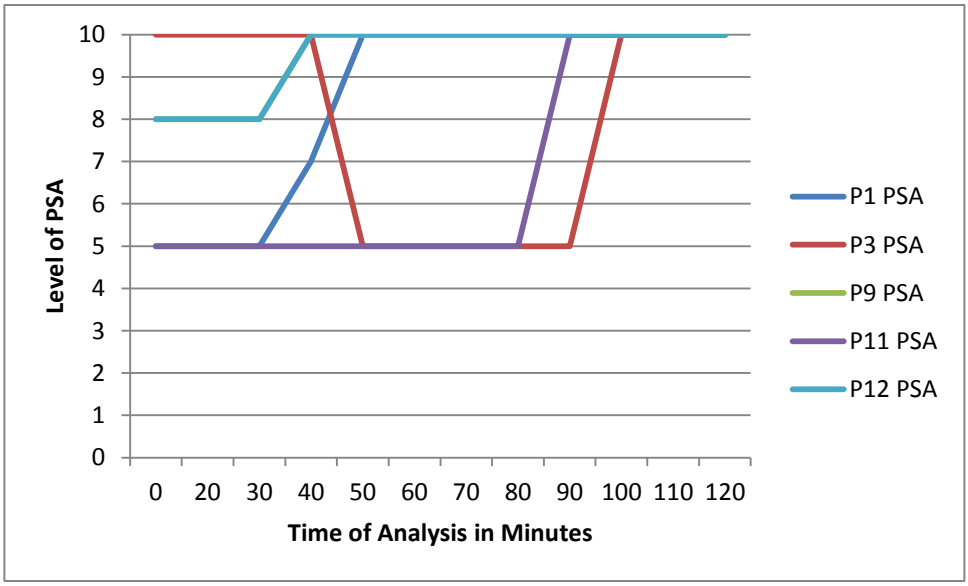


Figure 32 Scenario 5 Group 2 PSA Levels

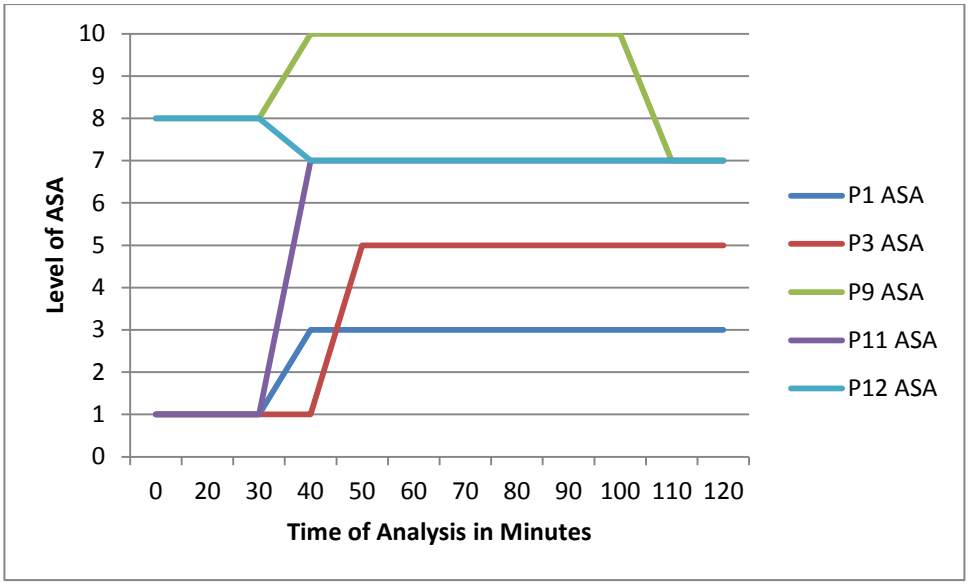


Figure 33 Scenario 5 Group 2 ASA Levels

5.5 Scenario 6

Scenario 6 involves an underperforming refinery owned by the company that had been profitable for many years, but that was now a producing a product for which there was a cheaper substitute that was preferred on the market. For years, the refinery had been doing very well, employing hundreds of people from the local community and made a positive impression on both the public and within the industry. However, the cost of refining and the price of the original product no longer matched the level of market demand. The company was hopeful that the demand for the substitute would eventually drop and that it would not need to make a decision on the future of the refinery.

5.5.1 Stage 2: Data Analysis

The manager on duty called the analysts and asked them to recommendation possible solutions to the problem. The goal of the task was to find a solution that would minimise the losses of the refinery and its problems rather than having to continue with the losses of running it. The manager indicated that a decision needed to be recommended as soon as possible as it was to be presented to the stakeholders during their annual meeting.

Moreover, these losses were draining away the company's resources and revenues from other operations and the uncertainty surrounding the future of the refinery continued to put pressure on the company by competitors who are waiting to take advantage of the situation.

5.5.2 Stage 3: Data Analysis

As the participants during this scenario were the same participants who took part in Scenarios 4 and 5, their demographic information has already been obtained and presented in Table 10..

The researcher observed each analyst separately under the same conditions as established in the research strategy. The following tables present a breakdown of the participant's decision-making process at three different stages, the tools used at each stage, their PSA at each stage and finally the decision outcome.

The following tables present a breakdown of each participant's decision-making process at three different stages during the observation. The first stage includes extracts from each participant's transcript, describing their initial thoughts on the problem and their initial actions in solving it. The second stage includes the outcome of the initial actions taken and any changes in the direction of solving the problem. The third stage represents the outcome of the second stage and the participants' overall thoughts on the problem as described by the participants themselves. The tables also include the BI tools at each stage of the process. These tables were constructed to aid in the development of the participants' cognitive maps and to highlight the PSA levels for each participant throughout the decision-making process. The full list of the maps can be found in the appendix

	P1	P2	P3	P4	P5	P6
Stage 1 perception	• *"Even though I have never faced a similar situation, the goal of the task dictates the direction of the decision process"* • *"The problem is merely financial which can be investigating simply by prediction whether or not the product demand will ever pick up again with the price also increasing to a profitable level"*	• *"This situation is very straightforward, the driving force for any business is to gain profits and avoid losses as much as possible"* • *"Therefore, we need to see if and when our product will ever recover and then make a decision based on that"*	• *"As an engineer, I appreciate the value of better and more sufficient products"* • *"The new product is here to stay so there is no point trying to determine if the old one will ever recover because it won't"* • *"The way forward is to determine the long term price of the product and its level of demand"*	• *"From experience I know that there are a lot of costs that can be saved from production"* • *"If we can optimise the process further by looking at reduction costs for materials or maybe staffing we might be able to save the refinery"* • *"The only thing to be done now is to look at whether or not there is any hope for the product and if it will ever recover price and demand wise."*	• *"The situation doesn't look promising"* • *"Maybe saving costs could help us in this situation, its better to reduce staff than for all to be turned away from their livelihood and maybe the market has better equipment rates than our current partners"*	• *"I strongly suspect that our product no longer holds any value compared to the substitute but we need to be sure of this before we move forward, therefore, I would conduct simple predictive analysis to determine if and when and to what level the product price and demand will ever recover"*
PSA at stage 1	*Medium*	Medium	High	Medium	Medium	High
BI Tools used at this stage	*ERP*	ERP	ERP	ERP Simple finance ERP multi-resource planning	ERP ERP multi-resource planning Simple finance	ERP
Stage 2 perception	• *"The market clearly predicts that the product is out-dated which unfortunately means an exist scenario needs to be seriously taken into consideration"* • *"To close down the refinery we need to first evaluate the media and local authority risks that we are most definitely going to face due to the jobs that will be lost and how we can handle them, we also need to consider the financial penalties and worker's packages we have to pay along with the equipment and waste costs that are inevitable at this situation"*	• *"The product will never recover; the substitute is cheaper and more efficient to produce"* • *"We now need to consider closing down the refinery; we need to look at the financial cost of doing so and asses the risks of losing our good reputation locally as a result of the jobs loss"*	• *"The product is expected to keep up well and is much cheaper to produce with a good profit margin"* • *"I think that if we can determine whether the costs of refurbishing the refinery to produce the new product and recruit experience staff to run it and train our current staff are favourable, we might be able to solve the problem"*	• *"There is no way to produce the product at any cheaper rate and the demand of it is expected to keep going down"* • *"The only thing left to do is to look at the equipment, staff training and recruiting costs of refurbishing the field to produce the new product and the potential of the product."*	• *"Unfortunately there is no costs saving strategy available, we just need to look at the price of the product and how it is predicted to act and whether there will be any shift in demand"*	• *"Since it is established that we have to move forward with a different plan, I would look at the costs of closing down the refinery and the associated risks of carrying out this strategy from a media and local authority point of view. Keeping in mind that the refinery land is owned by the company and is a very crucial asset."*
PSA at stage 2	High	High	Medium	Medium	Medium	High
BI tools used at this stage	Simple finance Risk management	Simple finance Risk management	Simple finance	ERP Simple finance	ERP	Simple finance Risk management
Stage 3 perception	• *"After consider the above I would recommend shutting down the refinery as even though we will take an immediate financial hit, we can't continue with the refinery operational as it is in any case"*	• *"The only way forward is to close down the refinery, when compared to loses we are going through now, this is a stronger but quicker hit which might make us recover"* • *"The value of the land also gives us an opportunity to minimise the risk by using its sale value to compensate the workers of a higher rate or transform some of to a local entertainment yard for the community"*	• *"I think the new product has potential and the timeframe for completing the process is reasonable and we might be able to turn the situation and in the long run use our client base to gain a share in this new product market. "*	• *"The new product is expected to dominate the market, however when comparing the costs of refurbishing the refinery against the costs of it closing down, it seems to be a very costly situation for me as the refinery land could generate significant income."* • *"I would recommend closing it down and taking whatever short-term losses rather than keeping it as it is. "*	• *"The only solution is to shut down the refinery"* • *"There are some costs we have to get through from penalties occurring from the shutdown and the workers compensation packages we have to pay out, additionally its mandatory to dispose of the equipment and materialism in a proper way which is expensive, however the cost of the land is going to be a bonus, and we would eventually reach these costs if we continue the running of it"*	• *"The risk of closing the own the refinery could be damaging to our reputation and is very costly"* • *"When establishing on the other hand the value of the new product in the future and cost of refurbishing our land to start producing it, it seems to be a better fit to me"* • *"We might have to invest heavily but we would be able to save the jobs of the workers and eventually turn profitable again. "*
PSA at stage 3	High	High	High	High	High	High
BI tools used at this stage	Simple finance	Simple finance	Simple finance ERP multi-resource and planning	Simple finance	Simple finance	ERP Simple finance

Table 14 Scenario 6 (P1 to P7)

	P7	P8	P9	P10	P11	P12
Stage 1 perception	• *"Having spent many years in the company and knowing a lot of the workers, I am going to exhaust all the options available to keep the refinery going, however, I am pessimistic at the moment about the chances of doing this. "* • *"Let's look first at first trying to reduce costs by looking at if we can lower the cost of the materials and maybe reduce the size of the staff currently employed or their salaries."* • *"We should also see what the future holds for the product, by analysing how its price and demand levels are likely to look in the future."*	• *"Too many people's jobs would be lost if we can not fix this situation."* • *"I was an engineer at the field not so long ago"* • *"I think we might be able to fix the situation if we cut down on some costs, we might be able to let some workers go to save the many, or find cheaper materials from the market to run the production process, if we can do that, this at least could help the process."*	• *"The refinery has been having problems for a while"* • *"I knew when the new product came into play that we can no longer continue the way we were"* • *"We have to simple look at whether or not we should refurbish our refinery to produce the new product and take a piece out of the market"* • *"We have to first predict at the potential of the product and if its demand will be sustainable or not and compare that to the different costs of carrying out such an operation"*	• *"Closing down the refinery is not something I am even going to contemplate"* • *"We need to do all we can to keep it going at it is"* • *"We need to try to cut down the costs in order to make it more profitable, we might have to let some of our staff go to reduce the issue and review the market to get cheaper materials in."*	• *"The only way forward is to see what we can do to save production costs"* • *"Staff reductions and getting cheaper materials for the production might minimise our loses but I am not sure if it is the real solution"* • *"We have to review the market for the new product and the pricing of it and see if any levels of cost reductions can match the price of the product"*	• *"With any product, the most important fact to establish is whether we can see any future for it or not, if we can establish this fact then we would be able to act more confidently"* • *"That is why, I want to perform predictive analysis on the old product, and see if it has any future, if it has then we can wait, if not the we need to look at the new product and see if we have the resources to take a chunk out of its market"*
PSA at stage 1	Low	Low	Medium	High	Medium	Medium
BI Tools used at this stage	ERP ERP multi-resource planning Simple finance	ERP ERP multi-resource planning Simple finance	ERP Simple finance	ERP ERP multi-resource planning Simple finance	ERP Simple finance ERP multi-resource planning	ERP ERP multi-resource planning Simple finance
Stage 2 perception	• *"There aren't any real reductions that can be applied for the product and it's future is also bleak, therefore, we do very much need to look at acting as soon as we can to reduce the loses as they will continue"* • *"We might be able to looking at refurbishing the refinery to be able to produce the new product"* • *"We have to first look at the potential of the product to understand its future value,."* • *"We also have to estimate the timeframe of carrying out this strategy and the financial costs that would include hiring experienced staff to run and train our current staff and new equipment need to be brought in as well"*	• *"The production costs are being squeezed to the lowest possible value."* • *"The situation now totally depends on whether the demand for our product will ever recover compared to that of the new one."* • *"If it is then we can endure the losses for a while, if the new product is here to stay, then we might look at joining its market."*	• *"The new product has good potential, however, what's worrying is the costs, it is a long term project, for the operation to be optimised at a high level, we need experienced staff to train our current ones as well as new equipment."* • *"I need to look at closing down the field and the costs and risk associated with such a decision before I can really reach a final decision"*	• *"Nothing can be saved looking the production; we have to look at if the product will ever hold any market value in the future and if not, at the overall costs of refurbishing the refinery to produce the new one."*	• *"As suspected, there are no reductions to be had and if there was, it really doesn't offer us a solution to the issue as the new product is priced very low."* • *"We have to now make a tough decision,"* • *"We have to look at the costs of turning our field to produce the new product, which involves new equipment, staff, and training for the current staff, this I suspect will take time"* • *"Our other option is to shut down the refinery, which would leave us with our land as an asset. But involves the risk of aggravating the public and whether we can ride that storm or not I am not sure, other costs involve paying staffing compensations for their contract terminations and disposing of the materials and the equipment safely."*	• *"Unfortunately, we have been outdone by the new product; it has completely rendered our product, expensive and therefore useless. "* • *"The cost of producing it though are also very high, finding experienced staff to produce it who are now probably a commodity within the industry is going to be tough and expensive. Training our new time and getting new equipment in are similarly challenging. "* • *"Therefore, I would like to look at the costs of closing down the refinery and what costs and risks are associated with such a decision"*
PSA at stage 2	Medium	Medium	Medium	Medium	Medium	Medium
BI tools used at this stage	ERP ERP multi-resource planning Simple finance	ERP Simple finance	Simple finance Risk management	ERP ERP multi-resource planning Simple finance	Simple finance	Simple finance Risk management ERP multi-resource planning
Stage 3 perception	• *"The cost of producing the new product is very high and involves a long project; I am not sure if it is a project worth undertaken"* • *"When comparing these costs to the costs of closing down the refinery which would include responsibly clearing the equipment, the worker's compensation and penalties, the project seems even more challenging and financially damaging."* • *"The only considerations that are making me hesitate are the risk we take in damaging our reputation through aggravating the local environment and the media stick we would get. "* • *"As much as I would like to keep the refinery open however, I don't think that keeping it is financially visible and the right option"*	• *"The old product is not predicted to recover and the new one is predicted to dominate the market"* • *"The situation can be resolved by updating the refinery to produce the new product, we do have to take a big financial hit initially and the timeframe to completing the process means we won't turn profitable for a while, but it is the best option I can see at the moment"*	• *"The cost of refurbishing the field when compared to that of closing it down is much higher"* • *"There is a risk of losing our reputation within the local industry which would give us bad publicity; however, we can use the land or part of it for charitable purposes and to cover some of the worker's compensation packages"* • *"I believe the best decision from a business standpoint is to close down the refinery."*	• *"The old product is not predicted to ever return to its former demand and price levels, however, the new one is predicted to keep going for a sustained period of time."* • *"The cost of refurbishing the refinery are high and the time to do is reasonably long, however, it represents the best possible option to keep the refinery going for the foreseeable future."*	• *"The decision is tough, I am not sure which way to lean, but my judgment tells me that the risks and costs of closing the refinery are safer than undertaken a long and unsafe project of entering a new market with a product we are unfamiliar with "*	• *"The costs of closing down the refinery are much lower than that of refurbishing it, the issue however is that we have to face a little bit of a public storm due to the jobs lost and the local business benefiting from our existence."* • *"Regardless, I do believe that we have no option but to close down the refinery and turn our resources to the markets we are doing well at to continue growing within them "*
PSA at stage 3	Medium	High	High	High	Medium	High
BI tools used at this stage	Simple finance Risk management	Simple finance	Simple finance	Simple finance	Simple finance	Simple finance

Table 15 Scenario 6 (P7 to P12)

5.5.3 Stage 4: Data Analysis

During this stage of data analysis, the researcher recorded the interactions between the participants and the senior manager who was ultimately responsible of making the decision. Each participant presented their recommendations and a justification for their decision. P3, P6, P8 and P10 all indicated that the best solution was to refurbish the refinery so that it could be used to produce a new, more popular product. These participants provided costs and timeframes for the process to start. P6 argued that having looked at the option of closing down the refinery, the risk of adverse media coverage meant that refurbishing the refinery would be the best option and would carry the added benefit of preserving the worker's jobs. The rest of the participants argued that closing the refinery was the only feasible and sound option; P2 and P4 indicated that the land was a valuable asset and part of it could be developed and donated to the local community to limit the risks of closing down the refinery. Furthermore, P7, P11 and P12 indicated that they had investigated the option of refurbishing the refinery, however, the costs and the timeframe of the project meant that they reluctantly concluded that the company should begin the process of closing down the refinery.

The manager thanked the participants for their work and indicated that a decision like this was out of his hands and that it would be subject to a discussion amongst the shareholders during their annual meeting in a few days.

Transcripts of this session were sent back to each participant in order to check if the data was representative to their thoughts and activates at the time of the data collection and the decision analysis process.

The researcher was permitted to attend and silently observe the shareholders meeting whilst the refinery situation was under discussion. The manager presented a short presentation of the findings of the analysts and their recommendations. After a short discussion, the decision was put to a vote and the shareholders unanimously decided to shut down the refinery within a year and begin a PR campaign justifying their decision and turn part of the refinery into a local community playground.

5.5.4 *Initial Post-Decision Data Analysis*

5.5.4.1 *Level of Reliance on BI Tools Analysis*

Figure 42 represents the tools used by each participant during the observation stage

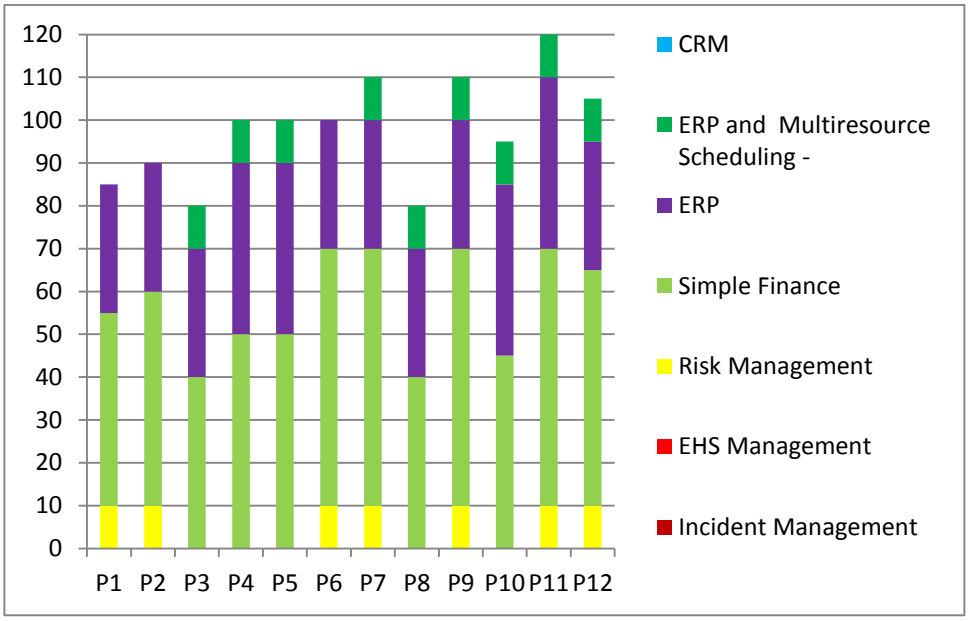


Figure 34 Stacked levels of reliance on BI graph

5.5.4.1.1 *Level of Reliance Based on Decision Recommendations*

As shown in Figure 42, none of the participants used all of the tools available to them at the time of conducting the analysis, with most participants only using three to four tools at most. However, this low level of reliance on the CRM, EHS and Incident management tools can be attributed to the nature of the scenario. When looking at the level of reliance on the tools based on the recommendations given by the participants, it is apparent that the participants who thought that the refinery should be refurbished to produce the new products had used only three systems to arrive at their conclusions. P6 was the exception, and spent 10 minutes using the risk management tool. Furthermore, these participants spent less time using the tools on average, with P3 and P8 using the least amount of time out of all the participants. On the other hand, most of the participants who recommended that the refinery be closed used at least four tools to arrive at their recommendation. P4 and P5 were

the exception; having not used the risk management tools because they thought that there was no other option and did not contemplate any of the risks being a factor.

5.5.4.1.2 User Efficiency of the BI Tools

Since the same participants who analysed this scenario also analysed Scenarios 4 and 5, it was interesting to observe for any changes in the level of user. The individual cognitive maps show that only P3, P4, P8 and P10 had no user efficiency issues, with the remaining participants having difficulties when analysing different datasets using multiple BI tools simultaneity. However, while not showing any efficiency problems, P4 was the only participant who attempted to carry out such an action; therefore, it would be safe to assume that the since the other participants who took part in this scenario also took part in Scenarios 4 and 5, that some of these participants lack of efficiency problems might not have been detected simplicity because of the way I which they used the systems.

5.5.5 Decision Outcome

By keeping in contact with the organisation, the researcher continued to monitor the decision closely. The researcher was eventually contacted by the senior manager 9 months after the date that the decision had been taken. The senior manager provided the researcher with a detailed decision outcome. The manager indicated that after the company announced the closure of the refinery, the company has unfortunately continued to a massive media and PR backlash. Furthermore, workers and local business are protesting outside the refinery daily in response to the decision. The company has spent a lot of time, money and effort on a PR campaign to explain their reasons for the closure, offered the workers generous redundancy packages and developed of part of the land on which the refinery is based for the benefit of the local community. The manager indicated that so far, from a financial point of view, the decision so far is turning out to be the correct decision; however, the true extent of the outcomes of the decision is unlikely to be known for some time.

5.5.6 Retrospective Analysis

The previous section discussed the analysis based on the decision taken by the company in response to the problem at hand. In this section, individual participants' reasons for their recommendation will be reviewed and comparisons made between participants' PSA during the process and their retrospective ASA.

For this analysis, the participants were divided in two groups. Group 1 included the participants who recommended that the company refurbish the refinery to produce the new product. Group 2 includes the participants who recommended that the company shut down the refinery.

5.5.6.1 Group 1: Retrospective Analysis

This group includes P3, P6, P8 and P10. Starting with P3, the participant's engineering background meant that they understood the value of the new product in the market from an early point and that the product the refinery currently produced could not compete with it. Therefore, P3's PSA and ASA levels at the start of the analysis were both equally aligned; however, the participant focused entirely on analysing a plan to refurbish the refinery and never considered that closing down the refinery could be an option. Consequently, P3's ASA levels took a dip whilst they thought that the problem could and should be solved by saving the refinery. P6, on the other hand, had strong suspicions that the product that the refinery was producing had no value and that its very existences should be reconsidered. Therefore, P6's PSA and ASA levels were also aligned at the beginning of the task until the participant decided to investigate the possibility of refurbishing it and weighting up the costs and risks of closing it down. This led to the participant to decide that the risk of closing down the refinery outweighed the costs of refurbishing it, which in hindsight meant that his ASA dropped even though he used the system correctly

P8 and P10 were both from an engineering background, with their area of expertise affecting their perception of the problem from the beginning of the task. These participants thought that it was possible to reduce the operating costs of the refinery, thus enabling it to remain open. Notwithstanding, they also understood that there was a cap on the level of

reduction possible, as the new product's value meant that no further cost reductions could ever affect the situation. Therefore, P8 and P10's ASA levels started from a low point. Furthermore, once they established that no cost reductions could be achieved, the participants focused on doing all they could to try and save the refinery, which meant that they did not consider the option of closing it down, which in turn meant that their ASA levels continued to be low throughout the task. Figure 43 illustrates the different PSA levels of the participants in this group, on the other hand figure 44 illustrates the ASA levels of the these participants throughout the process

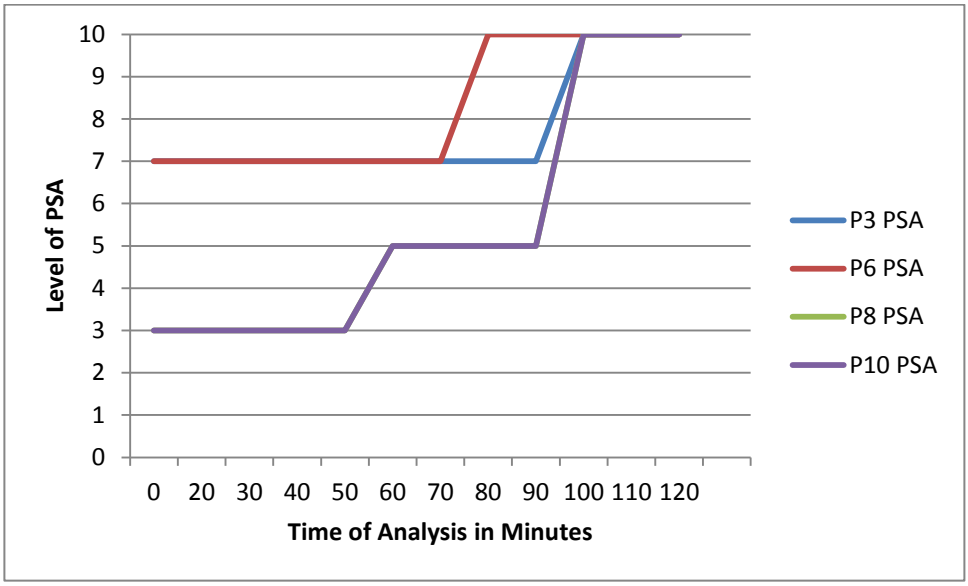


Figure 35 Scenario 6 Group 1 PSA Levels

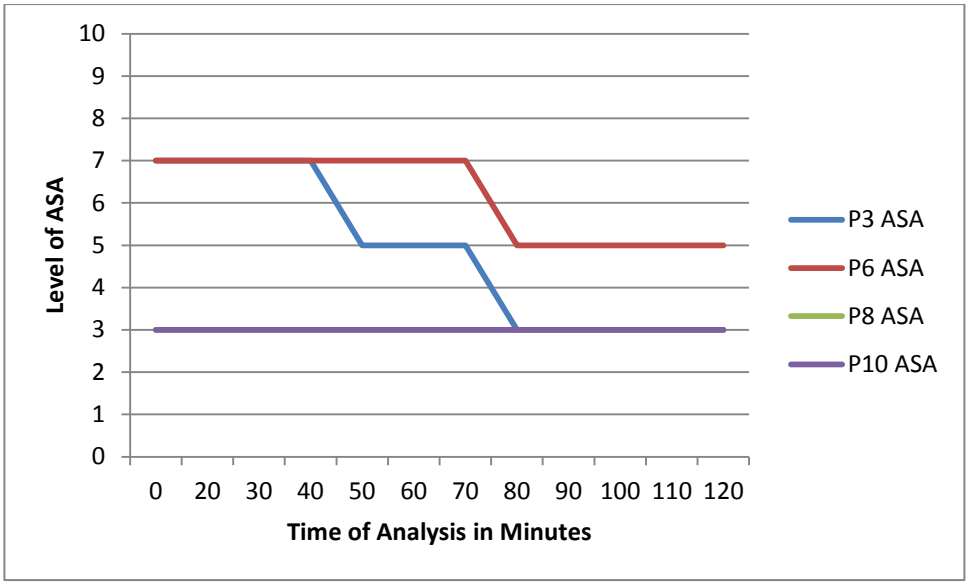


Figure 36 Scenario 6 Group 1 ASA Levels

5.5.6.2 Group 2: Retrospective Analysis

This group included those participants who decided that shutting down the refinery was the only option left available to the company. Starting with P1, P2 and P5, these participants never considered refurbishing the refinery as an option. The glaring difference between these participants is the way that their levels of experience and perceptions of the problem influenced their decisions. P1, for instance, who was the least experienced of all the participants, started with moderate PSA and ASA levels. However, the participant's lack of experience meant that they looked only at the market for the product that the refinery produces and then analysed the option of closing down the refinery without taking into account the value of the land or the risks of such a move. P2, on the other hand, looked at both of these factors when making a decision; whilst P5 looked at the land costs, but did not consider the risk of such a move, and instead looked at cost saving options to lower the value. Nevertheless, none of these participants' ASA levels ever reached a high level as none of them were aware of the relevant data to the problem at hand and were therefore more lucky than right with their recommendations.

P4, P7, P9, P11 and P12 are the final participants in this group. These participants investigated both options: to refurbish the refinery and shutting it down. P4 looked was unaware that no matter how much of a cost reduction the refinery could make, the product it produces could never be a match for the new product on the market. Consequently, P4's ASA levels were lower than their PSA levels. Furthermore, although the participant eventually arrived at a recommendation that turned out to be the right option, the participant failed to assess the risk of shutting down the refinery or looking at the feasibility and timescale of refurbishing the refinery, which meant that whilst their PSA increased, their ASA level took a dip.

P7, P9, P11 and P12 all had fairly consistently aligned PSA and ASA levels throughout the process. P11 started the process with low ASA and PSA levels, trying to look at ways to reduce the costs of production to compete with the new product. P11's PSA and ASA levels gradually increased when they looked at market value of the new product and investigated both refurbishing and shutting down the refinery options. However, despite recommending the better option in the end, the participant's PSA and ASA levels never reached their highest levels because they were reluctant to accept this option and lack certainty. Similarly, P7 went through the same analysis stages but only looked at the market value of the new product after establishing that the current product the refinery produced has little to market value. The participant did, however, recommend with a higher level of certainty that the best option for the company was to shut down production, which meant that their PSA and ASA levels eventually reached a high level.

Finally, P9 and P12 both conducted the same tasks whilst analysing the problem at hand, with the only difference being that P12 was not aware that the currently produced product held no market value, thus leaving them to analyse the market value of the product before analysing the market value of the new product. P9, on the other hand, already knew that the current product held no market value, so instead looked directly at the new product value in the market, which meant that their PSA and ASA levels were higher at the start of the analysis. Nevertheless, both participants' PSA and ASA levels were aligned throughout the process and both eventually recommended the right decision based on their analysis. Figure 85 and 86 illustrate P9 and P12's PSA and ASA levels. Figure 45 illustrates the different

PSA levels of the participants in this group, on the other hand figure 46 illustrates the ASA levels of the these participants throughout the process.

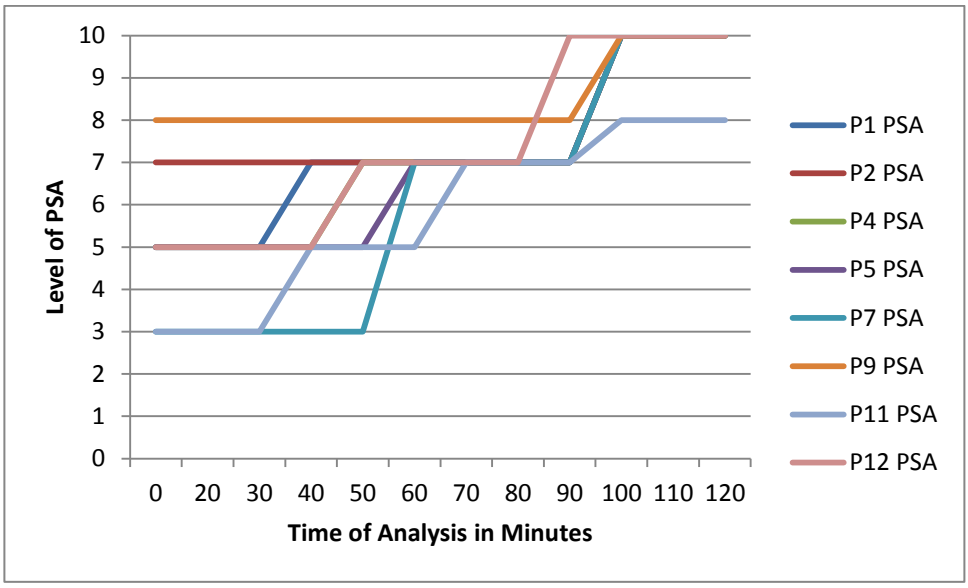


Figure 37 Scenario 6 Group 2 PSA Levels

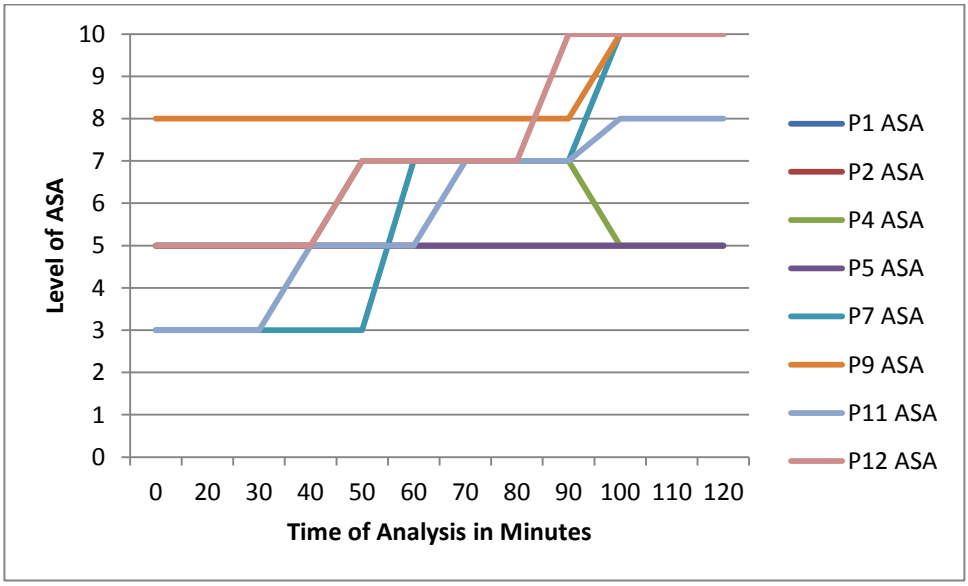


Figure 38 Scenario 6 Group 2 ASA Levels

5.6 Summary

The analysis of the industry downstream sector scenarios highlights several naturalistic decisions faced by the company, which were a result of problems occurring in the transportation of oil (Scenario 4), proactive decisions to improve sales volume due to high production volumes (Scenario 5), and competition for a new product that threatened the existence of a refinery (Scenario 6). This analysis revealed a level of reliance on BI tools in the industry, with this reliance being guided by individual experience and background knowledge. Human emotion also plays a major role in influencing the reliance on decision-making tools and outcomes. The analysis further shows that when decision-makers rely entirely on these experiences and emotions when making naturalistic decision using BI, they are likely to fall victim to a narrow mind-set, which in turn results in them making bad decisions.

CHAPTER 6

FINDINGS

6.1 Overview

This chapter is presented in the form of a discussion and aims to present the findings of the study and their implications for literature, theory and practice. Section 6.2 of this chapter discusses the theoretical findings of the study that include: a representation of the BI tools used by decision makers in the O&G industry, the nature and frequency of the naturalistic decisions faced in the industry and the level of reliance on BI when faced with these decisions. Furthermore, how the DMSC model was used in tracing the flow of the decision-making process is considered, in order to understand the underlying individual reasons of what influenced the participants' decision making process. Section 6.3 discusses the role played by cognitive mapping in the structuring and analysis of the collected data at the beginning of the analysis. Similarly, the role of the SA measuring technique, developed to measure individual participants' PSA and ASA levels at different stages of the process in real-time, is compared to the measurements discussed in the literature, and how the fusion of these techniques enhanced the analytical approach of this study is considered. Section 6.4, presents the idiocentric process of individual decision makers. Section 6.5 evaluates the research methods and techniques used for the conduct of this study. Finally, a summary of the results and recommendations is presented and its implications on the field are highlighted

6.2 Theoretical Findings

6.2.1 Business intelligence

The first theoretical gap highlighted in the literature review and table 1 is the lack of empirical evidence illustrating how business intelligence really is utilised in real world settings. This investigation illustrates that the end user business intelligence tools adopted in the two companies operating in the two streams of the O&G industry are a set of sophisticated processing and analysis tools that developed overtime and continue to develop to uphold and improve the companies' market position, maximise their operational processes and improve their decision making. The tools which the individual participants were

observed using in the study can be used independently based on the information sought by the participants or integrated for the conduct of high level analysis between separate sets of data. These tools include:

- The ERP tool, which the findings illustrate is used to investigate information within the company's internal operations. Analysts could utilise this system to examine historical sales of transaction information, the level of production for any given period of time, price changes for any given period of time, live production data from any of the company's fields and the changes to the price of every product the company produces.

- The Incident Management tool, which is utilised to deal with operational incidents that might face the company at any time; these incidents include: shortage of staff, a compromise in production, adverse weather conditions, local political unrest or a compromise in transportation.

- The Risk Management tool is utilized to assess any risks that could affect the companies, these risks include financial, competitors and local pressures.

- The Multi Resource and Planning tool is utilized when the companies need to organise their resources on an ad hoc basis. The findings show the tools are necessary in the planning of product transportation routes, staff management and the planning or management of any maintenance work required.

- The Simple Finance tool is probably, along with the risk management tool, the most flexible tool out of the tools that make up the system. It is used to calculate and predict any financial investigations conducted by the decision makers. These calculations include maintenance works, sales calculations, predictive loses, price shifts or financial risks. The data analysed using this tool can be combined with other sets of data from other tools for matrix analysis.

- The Environmental, and Health and Safety Management Tool is used by the decision makers to assess and predict the severity of any environmental or health and safety risks that might occur if an operational incident takes place. The system provides the decision makers with guidelines for what to do if or when such incidents occur based on reports generated after an incident assessment is conducted. These guidelines are

in place to protect the safety of the personnel working in the oil fields, the environment and the public.

- The CRM tool is used to access details of all the clients associated with the organisation (past and present) with the ability to contact the customers directly through email using the company's email server which is integrated into the system. Furthermore, a shortcut to the ERP system is provided in the system in case the clients' transaction history data is needed.

6.2.2 Nature of NDM in the O&G Industry

The research shows that naturalistic decisions exist in both sectors of the industry, which is one of the gaps highlighted in table 1. The research also shows the high volume of frequency of these decisions (Six in six months of observation) and the sub decisions that they develop as a consequence of their occurrences. However, these decisions are limited to 'crisis decisions'. Furthermore, the level of complexity of these decisions in both sectors depends on the nature of the situation:

- Decisions faced that are due to compromises or leaks represent complex situations and a high level of varied risk that could prolong the issue. The nature of these problems means that the data necessary for decision-making is often not available within the timeframe of the decision.

- Decisions of a trading or marketing nature often contain unknown issues, such as political or war risks that cannot be assessed accurately, and outcomes of decisions of this nature tend to represent either missed opportunities if these risk do not materialise or great financial losses if they do.

- Other strategic decisions, such as the closing down of operational refineries, represent naturalistic problems in that the financial aspects of such decisions tend to be difficult to pin down due to the short- and long-term implications of such decisions. Furthermore, the role of human emotion and loyalty plays a significant part in such decisions.

6.2.2 Role of the DMSC

The flow of each participant's decision making aspect was traced using the DMSC in order to pinpoint at which stage the participant during the process perceived the situation correctly or wrongly and the underlying reason behind either case.

- **Narrow Minded Thinking Approach**

The analysis showed that 16 of the 69 individual observations conducted (22.8%), assumed that a situation is identical to a previous problem faced, and therefore, did not look at all of the facts and data available to them. Four of these participants fell victim to a narrow-minded way of thinking which meant that the participants' perceptions of the problem were not accurate, which in turn made subsequent stages in the decision-making process irrelevant, as the data they were comprehending was not relevant to the problem and projections were not representative of the goal at hand. To avoid such problems, participants should use caution when a situation and problem seems familiar to them; this way they can avoid falling victim to a narrow-minded way of thinking and their PSA will be aligned with their ASA. The following table 17 lists these participants:

Participants	DMSC Lens	Decision Outcome
S1P7	Perception (Oval 4)	Unfavourable
S1P11	Perception (Oval 4)	Unfavourable
S2P12	Perception (Oval 4)	Unfavourable
S5P11	Perception (Oval 4)	Unfavourable

Table 17 Participants having Perception Issues due to Narrow Minded Approach

Although some of the participants did recommend the decisions using this narrow minded approach and did arrive at the correct decision and their PSA levels were high, their ASA levels were in fact usually lower, as the focus on previous experience meant that they ignored data that could have highlighted differences in the situation. As such, some participants arrived luckily at the correct decision, as they based their decisions on incorrect assumptions and comprehension of the data; the following table 18 lists these participants:

Participants	DMSC Lens	Decision Outcome
S2P3	Comprehension (Oval 5)	Favourable
S2P9	Comprehension (Oval 5)	Favourable
S3P5	Comprehension (Oval 5)	Favourable
S3P12	Comprehension (Oval 5)	Favourable

S4P11	Comprehension (Oval 5)	Favourable
S5P2	Comprehension (Oval 5)	Favourable
S5P4	Comprehension (Oval 5)	Favourable
S5P8	Comprehension (Oval 5)	Favourable
S5P10	Comprehension (Oval 5)	Favourable
S6P2	Comprehension (Oval 5)	Favourable
S6P4	Comprehension (Oval 5)	Favourable
S6P5	Comprehension (Oval 5)	Favourable

Table 18 Participants having Comprehension Issues due to a Narrow Minded Approach

Assuming that the situation was identical to a previous situation without examining all relevant data could have damaged the participants' comprehension of the problem and meant that the participants' ASA never matched their PSA levels. Therefore, a certain level of self-doubt and uncertainty can enhance an individual's SA.

- **Lack of knowledge of Decisions Faced**

The data shows that when participants have never encountered a situation similar to the one faced, they tended to look at the problem through the lens of their own areas of expertise. These participants will have perception issues if the situation is not relevant to their area of expertise, or comprehension issues if it is not totally relevant, as this would lead to them not considering data that could be vital in the decision outcome even if the decision recommended is in retrospect correct. This lack of knowledge occurred with 24 out of the 69 participants who took part in the study (34.2%) The following table 19 illustrates these participants:

Participant	DMSC Lens	Decision outcome
S1P1	Perception (Oval 4)	Unfavourable
S1P3	Perception (Oval 4)	Unfavourable
S1P6	Perception (Oval 4)	Unfavourable
S1P10	Perception (Oval 4)	Unfavourable
S2P1	Perception (Oval 4)	Unfavourable
S2P4	Perception (Oval 4)	Unfavourable
S2P5	Comprehension (Oval 5)	Favourable
S2P6	Perception (Oval 4)	Unfavourable
S2P7	Perception (Oval 4)	Unfavourable
S3P1	Perception (Oval 4)	Unfavourable
S3P2	Perception (Oval 4)	Unfavourable
S3P4	Perception (Oval 4)	Unfavourable

S3P6	Perception (Oval 4)	Unfavourable
S3P7	Perception (Oval 4)	Unfavourable
S3P9	Perception (Oval 4)	Unfavourable
S4P1	Perception (Oval 4)	Unfavourable
S4P4	Comprehension (Oval 5)	Favourable
S4P5	Comprehension (Oval 5)	Favourable
S4P6	Perception (Oval 4)	Unfavourable
S4P8	Comprehension (Oval 5)	Favourable
S5P1	Perception (Oval 4)	Unfavourable
S5P3	Perception (Oval 4)	Unfavourable
S5P6	Comprehension (Oval 5)	Favourable
S6P1	Comprehension (Oval 5)	Favourable

Table 19 Participants Reliant on Expertise which led to Perception and Comprehension issues.

On the other hand, some participants with similarly low SA levels at the beginning of the tasks developed a sense of curiosity which drove them to want to develop a deeper understanding of the problem. These participants used the system correctly and requested information outside their area of expertise, which not only enhanced their understanding of the situation, but enhanced their PSA levels too. When tracing these participants using the DMSC model, the model is operational at its ideal mode. These individuals are listed in the following table 20:

Participant	DMSC Lens	Decision Outcome
S1P4	Perception Developed due to Curiosity	Favourable
S1P8	Perception Developed due to Curiosity	Favourable
S1P12	Perception Developed due to Curiosity	Favourable
S2P2	Perception Developed due to Curiosity	Favourable
S2P10	Perception Developed due to Curiosity	Favourable
S3P8	Perception Developed due to Curiosity	Favourable
S4P7	Perception Developed due to Curiosity	Favourable
S4P10	Perception Developed due to Curiosity	Favourable
S412	Perception Developed due to Curiosity	Favourable
S6P9	Perception Developed due to Curiosity	Favourable
S6P12	Perception Developed due to Curiosity	Favourable

Table 20 Healthy Curiosity Develops Participant Perception of Unfamiliar Decisions

This means that a lack of experience or knowledge pertaining to a certain problem can be remedied simply by examining all aspects of the problem, even if the problem is inherently naturalistic. Therefore, the BI tool can provide valuable insights if the data is utilised correctly.

- **Uncertainty due to lack of Complete Information**

Furthermore, tracking each individual participant's decision-making process showed that due to the naturalistic nature of some of the decisions faced, some data was missing from the system or was not yet available when the decision-maker needed it. These participants perceived and comprehended the situation correctly and requested all the relevant data, but a crucial piece of information was not yet available in the system, which meant that the participant made their decision without all of the data available, which affected their comprehension of the situation at the final stage of the decision-making process. These Participants included S1P2, S2P11, S3P11 and finally S6P11.

- **Use of Traditional Approaches rather than NDM Approaches**

Furthermore, the DMSC helped track how in some instances participants used conventional decision making approaches rather than rely on their intuition when making decisions, even though they had the right levels of experience and expertise. Examples of these are S4P2 and S4P9, who used the Programme approach as they took great care in ensuring that they chose the best course of action that minimised the uncertainty of the situation by not taking any risks but rather ensuring that they followed the conventional guidelines set by the company (Huber, 1981).

Similarly, participants S6P3, S6P8 and S6P10 used the individual difference perspective approach of decision making as these participants' emotions and background played a major role in deciding their best course of action.

- **Advantages of Decisions Loops**

Furthermore, the modified DMSC adopted in this study identified loops from the three human ovals occurring for two reasons:

1. At the perception stage, the decision-maker examines a single set of data for each decision action and once this data has been comprehended, makes a decision to go back and either:
    a. if the data was useful, the decision-maker moves forward to the next decision analysis action; or
    b. if the data was not useful, the decision-maker moves back to purse a different course of action.

2. The decision-maker keeps going back to re-do things as a result of system efficiency issues.

Finally, loops are not a cause for concern if the decision-maker eventually reaches the right decision and their ASA at the end of the task is at its highest point.

6.3 Impact of Analytical Techniques

6.3.1 Role of Cognitive Mapping

The cognitive mapping technique adopted in this study played an important role in the structuring, theming and understanding of the flow of decision-making at an early stage in the data analysis. The individual concepts map aided the researcher in visibly understanding the order of each participants' decision-making process. The colour coding of concepts helped highlight the BI tool used for each task within the decision-making process and the styling of the concepts helped visibly highlight individual user/system efficiency issues when conducting the task. All of the cognitive maps can be found in the Appendix chapter.

6.3.2 SA Measuring Technique

The SA measuring technique developed for this study successfully measured participants' PSA levels throughout each of the tasks. The measurement of the PSA levels is a more straightforward approach, as it only takes into account how individuals perceive their level of awareness during the decision making process. Furthermore, when participants were presented with their individual measuring scores and evidence (i.e. data collected) upon which the measurement was based, all of the participants' scores were confirmed by the participants themselves and deemed to be accurate in their estimation. This high level of agreement amongst the participants was expected, as they had all submitted reports during the decision-making stage with recommendations on how to solve the problem and provided detailed justifications for these recommendations to the senior manager, who in all likelihood would confirm the data collected by the researcher. However, the measurement of the ASA levels was a lot more complicated as the factors, tools used and emotions considered by each individual decision makers were compared to the ground truth (i.e. decision outcome and relevant data), and cross-referenced against other individual data. In most cases for example, when participants recommended the same decisions, the difference in the degree of confidence between the participants during the process was the reason for the difference in ASA levels. Furthermore, in other instances where the participants recommended the same

decisions with the same level of certainty, the difference in the time the participants reached the decision or the difference in the number of relevant factors considered was the reason for the difference in their ASA levels.

When compared to the SAGT technique, the technique developed for this study had the following advantages:

- could be applied in the field, in real-time;
- used the same queries for all users when measuring PSA and ASA levels;
- accounted for human influences, such as emotions and bias; and
- all data was recorded and gathered live, so it does not rely on the memory of the participant to be judged retrospectively.

The main advantage of the measurement technique is that it does not rely on simulation or a high level of expertise on the part of the researcher. Although the queries by which the measurement is conducted are standardised, the main disadvantage of the technique is that it requires a level of judgement by the researcher to identify the PSA and ASA levels involved, which means that these levels are not 100% scientifically accurate. However, presenting each PSA scale backed up by the relevant summary data to the relevant participant upon measurement ensures a higher level of validity in the application of the technique.

6.3.3 Fusion of Techniques

The fusion of the techniques and methods used in this study resulted in the crystallisation of the situation at hand. The coding schema adopted helped guide the analysis process in identifying the key concepts used in drawing out the individual summary tables and cognitive maps, which in turn aided the researcher in understanding the actions the participants took when facing each naturalistic decision. This initial step resulted in the researcher being able to measure the PSA levels of each participant. Once the decision outcomes were revealed, the SA measuring technique was then able to assess the PSA levels of each participant in retrospect and measure their ASA levels by comparing their PSA levels against the ground truth and themselves. Finally, by tracing the flow of each decision made using the DMSC, the researcher was able to pinpoint at which stage during the process a participant perceived the situation correctly or wrongly, and the underlying reason behind either case. The above-summarised findings and the combination of these approaches helped in filling the gaps highlighted in the literature

6.4 Idiosyncrasy of individual decision makers

Results from Chapters 4 and 5 suggest that there is indeed a level of reliance on BI in the O&G industry when an organisation is faced with naturalistic decisions. This level of reliance is, however, dictated by the level of experience and knowledge of the individual decision-maker. In both sectors of the industry, all participants used the BI system in order to arrive at their recommended conclusions.

Participants with low levels of experience and knowledge of the situation tended to take a course of action that could either see their knowledge of the situation increase and lead to better decisions, or decrease and lead to them recommending the worse decision, and in turn, being less reliant on the system. In most situations where participants lack prior knowledge or experience of the problem at hand, they tend to use the Incremental model (DeVault, 2011). This meant that these participants tend to make the less controversial decision due to high stakes and the pressure of the situation, combined with their lack of experience, meant that the participants did not think of exploring recommendations that might work against the goals set by the manager. Others use the program approach by making the least risky decision, whilst others were influenced by their personal emotions and biases when making the decisions (i.e. the difference perspective approach).

However, other participants decided to investigate the situation more thoroughly once they assumed that the choices they were left with did not meet the goals set. This was also guided by the participants' thirst for extra information on how the situation might turn out. In doing so, the participant's attitude to the situation was more exploratory, trying to solve the problem at hand rather than sticking to the established goals.

Participants with a high level of experience tended to tackle situations by relying on their areas of expertise and skills, and do not have the same issues with confidence that those who lack this experience have. These participants tended to either:

A. Rely heavily on their areas of expertise when making a decision. These participants focused entirely on looking at the situation from a narrow point of view to meet the decision goals; or

B. Get stuck on a certain point or do not deem the results of their analysis to be sufficient for the established goals and thus explore the situation through different viewpoints. In so doing, they hope to understand the situation better and enhance their SA.

Participants who had faced similar situations and made similar decisions in the past tended to either:

A. Rely entirely on their experiences in analysing the situation by navigating only the data deemed relevant to the problem, which might confirm their initial perceptions of the situation; or
B. Stay open-minded and conservative in their analysis. They not only navigate the data that might confirm that what their experience tells them, but also test the validity of their perceptions by examining all the relevant data that might affect such a decision.

The following figure 47 illustrates the idiocentric process of NDM in the oil and gas industry:

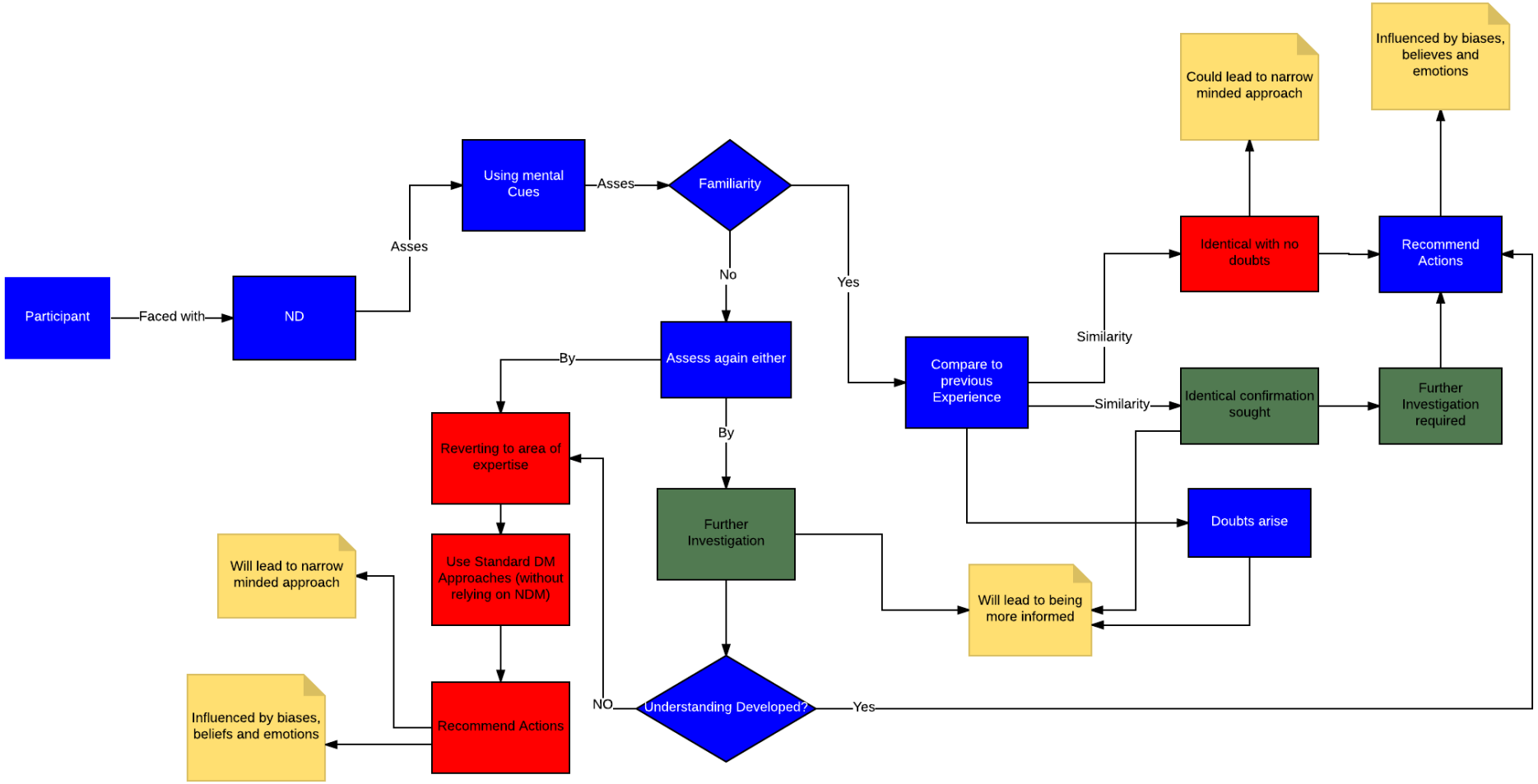


Figure 47 A summary of The Idiocentric Process of NDM in The O&G Industry

6.5 Evaluation of the Study's Research Methods and Findings

When evaluating the methods and techniques adopted in this study, the researcher refers to the seven principles for conduct and evaluation of interpretive field researcher studies proposed by Klein and Meyers (1999). The authors derived these principles from classical philosophical findings that contributed heavily to the study of interpretivism. The authors indicated that the application of these principles would help researchers to defend their work by appealing to principles that are firmly grounded in at least one major direction of interpretive philosophy. Therefore, the researcher will use these principles as a reference point to evaluate the research acquisition and analysis methods used in this study.

1. The Fundamental Principle of the Hermeneutic Circle

The authors indicated that the most fundamental principle when evaluating interpretive research is that of the hermeneutic circle. This principle is foundational to all interpretive work of a hermeneutic nature and is in effect a meta-principle upon which the rest of the proposed principles expand. The idea of the hermeneutic circle suggests that the researcher would be able to understand a complex problem from preconceptions about the meanings of its parts and their interrelationships.

For this study, the research data acquisition methods were broken down into individual stages to satisfy the aim of the study, which was to understand the role of BI in the oil and gas industry when dealing with naturalistic decisions. Each stage of the data acquisition process helped in the general understanding of this aim. For instance:

- The first stage, which was in the form of a semi structured interview with the BI manager of the companies, helped understand the structure and understanding of the BI capabilities of the organisation; the analysis of this stage led to the researcher gaining a grounded understanding of the systems used in the (individual observational) third stage of the research.

- The second stage, which was in the form of a group observation, helped the researcher gain a clear understanding of the problem at an early stage, rather than having to interfere excessively with the individual analysis by each participant during the third stage.

- The third stage of the process helped in establishing whether the participants understood the full capabilities of the BI system and to what extent did they rely on it. It also allowed the researcher to understand how each individual decision maker uniquely analysed the situation and came to recommend the decisions they did.

- The fourth stage helped in understanding what the final decision was that was taken by the company and then in understanding which participants recommended what decisions and why.

- The final stage helped in the understanding of the outcome of the decision and gave the researcher the retrospective view of the whole decision in order to work the analysis backwards to crystallise the aim of the study.

The combination of these parts helped complete the picture of the role of the business intelligence in the oil and gas industry when dealing with naturalistic decisions.

2. The Principle of Contextualization

The second principle is the principle of contextualization. The authors indicated that this principle requires critical reflection and elaboration into the context in which the situations under investigation emerged to give the readers a lens into how these situations emerged. The researcher tried to ensure richness in the reporting of the data acquisition and analysis process as it occurred. Furthermore, the researcher tried to ensure that the circumstances that led to each scenario emerging were fully reported; giving the reader a solid base of understanding the situations, the reasons for these situations occurring and how they continued to develop during the decision making process after decisions were made, and finally the levels of success of these decisions, as highlighted in chapters 4 and 5.

3. The Principle of Interaction Between the Researchers and the Subjects

This principle requires the researcher to evaluate to what extent the interaction between the researcher and the study subject helped in the acquisition and construction of the data. During the third stage of data collection (individual observation) the researcher tried to ensure a healthy level of interaction between the participants and the researcher occurred without compromising the flow of the analysis observed. This interaction led to the researcher finding insights into the data that would have otherwise stayed uncovered such as the unique feelings or struggles of the participants when facing the naturalistic decisions.

4. The Principle of Abstraction and Generalization

This principle requires the idiographic details revealed by the data interpretation to be theoretical, general concepts that describe the nature of human understanding and social action. In order to interpret the data collected through this study, the researcher used multiple data analysis models and techniques. Cognitive mapping was used in order to understand graphically what each individual DM did and how. The SA measurement technique adopted helped in understanding the reason behind every action each DM did and understanding whether, in retrospect, it was favourable or not, Finally, the DMSC helped the researcher to understand at what stage of the DM process the Perception, Comprehension, Projection, increased or decreased and the role of BI in this.

Furthermore, the insight into the role of BI in the O&G industry generated from this study is substantial. The details of the tools used for the analysis and how they interact, provide a solid basis of understanding for how companies use the system, not only in naturalistic decision making but also in rational decision making. Furthermore, the research gave an insight into the level of complexity of the naturalistic decisions that organisations in the industry face. Finally, the most evident insight is providing an understanding into the shortcomings of BI in the industry that were highlighted by the findings. The system is in part very powerful and useful; however, without proper guidance and knowledge sharing, it is not utilized to its full potential.

5. The Principle of Dialogical Reasoning

Due to the lack of the maturity of the research in business intelligence application in the O&G industry, there were no preconceived ideas about the potential findings. Therefore, the design of the researcher was constructed as a ‘study in the wild’ with preconceived areas of interest rather than findings.

6. The Principle of Multiple Interpretations

This principle requires the researcher to be sensitive to possible differences in interpretations among the participants as are typically expressed in multiple narratives or stories of the same sequence of events under study. The researcher tried to ensure, through interacting with each participant, a full understanding of their thoughts and actions is gained when dealing with the decisions at hand. The individualised cognitive maps and SA levels measured through the participant observations helped establish sensitivity to any contradictions of views or

different interpretations between the participants, whilst the tracing of each participant's DM process using the DMSC highlighted the reasons for the occurrence of these different interpretations and how they affected each participant's SA levels.

7. The Principle of Suspicion

This principle requires researchers to be sensitive to possible systematic biases in the actions of the participants under observation when dealing with the decisions faced. The research methods designed in this study were limited in their impact in identifying participants' biases towards the decisions faced. There were different partnering companies and clients involved in the scenarios investigated with direct communications being conducted between some of the participants and these partners/clients throughout the decision making process; however, there was no possible way for the researcher to establish whether any of the participants had biases or vested interests in any of the decisions observed.

6.6 Implications and Recommendations for Practice

The complicated nature of the O&G industry means that naturalistic decisions will occur regardless of whether their causes are of a management, engineering or trading nature. As such, O&G organisations will have to rely on analysts with different backgrounds and experiences in order to have a complete understanding of these problems. The issue with this approach, however, is that most analysts tend to focus on the consequences of the problem from the perspective of their own area of expertise, often ignoring information drawn from other domains, thus leading to recommendations which turn out to be based on a narrow understanding of the issue at hand.

By summarizing the findings previously discussed in this chapter, it becomes immediately clear that there is a major flaw in the way BI is utilised in the industry when dealing with naturalistic decisions. The system does play a role when dealing with naturalistic decisions; however, this role is limited by the actions of the system's users. Evidence shows that even when the tools have the information needed to solve the decisions faced, there is a high degree of probability that these answers will remain hidden from the decision makers' attentions due to their perception of the problem faced being skewed by either: their lack of experience when dealing with the problem at hand or mistakenly confusing the problem with a previous similar experience. Furthermore, as the knowledge and background experiences of

the DM vary, unless the decisions making process is done collectively with a higher degree of knowledge management, then this issue would continue to persist.

Therefore, based on these findings, the researcher proposes a naturalistic knowledge management system that would serve as a complimentary tool to the BI system already in place. It is important to emphasise that this system is not aimed at serving as a replacement to the BI tools already in place, but rather to guide the decision maker's application of the system during the decision making process.

The system can be built by using a combination of data acquisition techniques that will draw out the unique naturalistic experiences that have faced the decision makers in the company. Analysis techniques will then be utilised to break down the major factors that played a role in these experiences separately. For instance, if the immediate factors that should have been considered when making the decisions were immediately clear to the participants in scenario 1 from the beginning of the analysis process (the environmental and financial risks that occurred due to the contamination of the product from the tank compromise), then all of the participants would have been able to perceive the situation correctly from the start of the process. The data collected from each participant would then be analysed and integrated for a complete picture of the factors that influence a particular topic. The following figure illustrates the methodology of the system:

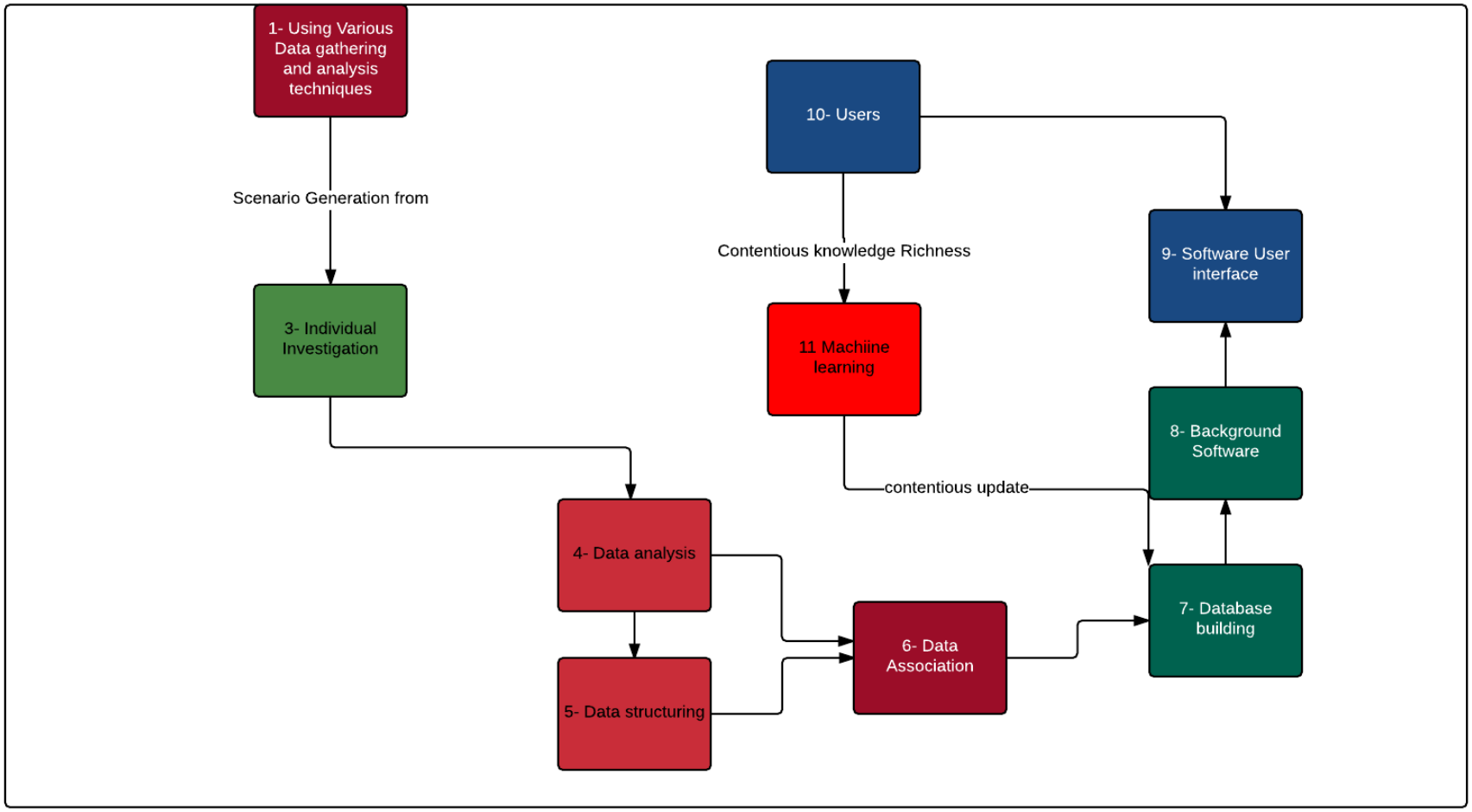


Figure 48 The methodology of the Recommended Naturalistic Knowledge Management System.

The system would work using query based search functionality not dissimilar to popular search engines, with the participants able to use keywords related to the problem they face to search for the important factors/concepts that should be considered to solve this problem. The results of this search would:

a) Be displayed from the most important to the least based on the experiences analysed during the data collection and analysis stages (based on how relevant it was in similarly previous experiences).

b) By clicking on each concept the participant can understand why this concept is likely to affect the decision they face.

c) The concepts would be colour coded to point the analyst to the right BI tool(s) to be used for the analysis of this concept; this would provide the analyst with a road map to the data sought.

d) In case of further information needed on any concept, the system would indicate the details of the analysts who most related the said concept to the problem subject.

e) The participant would have to mark the concepts that they thought relevant to the problem and cross out the ones that they did not with justification for both instances needed.

f) The decision recommendation would have to be made electronically so each concept would have to be considered for the recommendation option to be submitted (this would ensure that all participants were well informed when making a decision)

g) The manager would be able to electronically review the concepts relating to the decision faced and quickly distinguish any contradictions in the decisions recommended and the reasons for them occurring.

h) The decision and related concepts can then be ranked once the decision outcome is established and the information would be automatically saved in the system.

Figure 49 illustrates the advantages of such a system being in place.

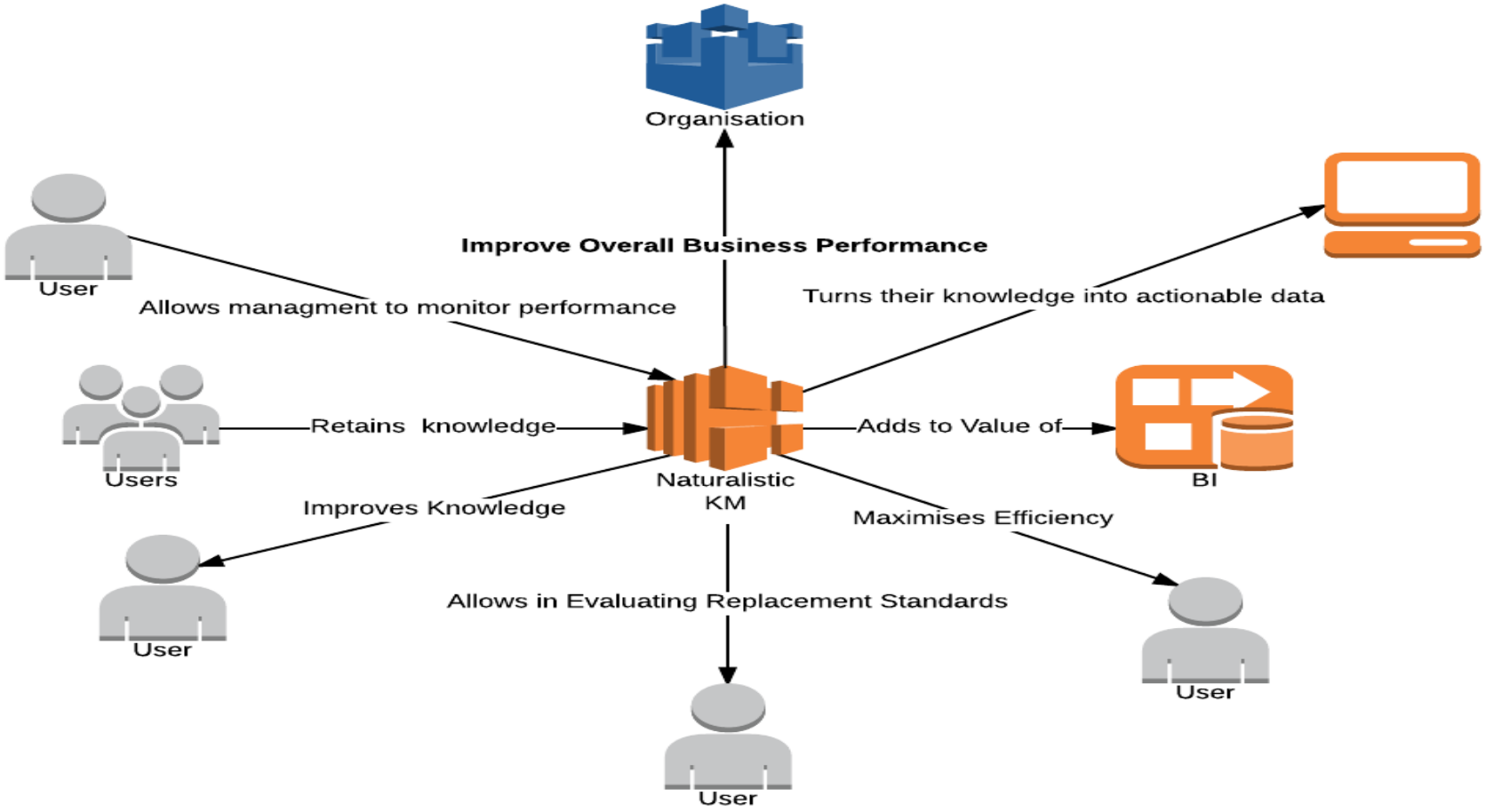


Figure 49 The Advantages of the Recommended Naturalistic Knowledge Management System

CHAPTER 7

CONCLUSIONS

7.1 Overview

The first part of this chapter presents a reflective summary of the findings where answers to the research questions are presented. The second section presents the study's contribution to the literature and the following section lists the study's contribution to practice in the inductee. The next two sections of the chapter list the limitations of the study and future directions for academic research as revealed by the study. The last section presents a summary of the key points discussed in the chapter.

7.2 Summary of Findings

This study aimed to investigate the role of BI in NDM in the O&G industry. The study helped in the understanding of the different business intelligence tools used by decision makers in the industry through live observation of how these tools were operationalised by individual decision makers. Furthermore, the research identified different naturalistic decisions that decision-makers face in the different streams of the industry, with each decision varying in its level of complexity and cause. These decisions that answer the question include:

1. Naturalistic decisions that are due to compromises or leaks, which represent complex situations and a carry a high level of varied risk that could prolong the solution. The nature of these problems means that the data necessary is often not available within the timeframe needed for a decision.

2. Naturalistic decisions of a trading or marketing nature. These represent unknown wild cards, such as the risk of political unrest or war, which often cannot be

accurately assessed and the outcomes of decisions of this nature tend to either represent missed opportunities if these risk do not materialise or significant financial losses if they do.

3. Other strategic decisions, such as the shutting down of operational refineries, which represent naturalistic problems in that the financial aspects of such decisions tend to be difficult to identify due to their short- and long-term implications. Furthermore, the role of human emotion and loyalty plays a significant role in such decisions.

In addition, the study was able to identify how individuals in the industry dealt with naturalistic decisions; the findings are listed as follows:

1. Most novice decision-makers who do not have experience with making a similar naturalistic decision in the past tend to focus on the elements of the decision that represent their own areas of experience. In most situations, the decision-maker falls into a narrow-minded way of thinking and their level of SA stagnates as the process progresses, regardless of whether they are confident of what they are doing or not, and they also tend use the Incremental decision making model (DeVault, 2011). In these situations, the participants tend to recommend the least bold or controversial decision due to their lack of confidence, which results from their lack of experience. However, there is evidence to suggest that novice decision-makers develop a level of curiosity in relation to different knowledge domains outside their own areas of experience and expertise.

2. Most experienced decision-makers, who have also not experienced a similar naturalistic decision in the past, also tend to focus on the elements of the decision that represent their own areas of experience. In most situations, the decision-maker falls victim to the same narrow mind-set and their level of SA stagnates as the process progresses, regardless of whether they are confident of what they are doing or not. However, these decision-makers tend to not worry about recommending controversial decisions as their higher levels of experience means that they are more accustomed to making decisions under pressure.

3. Some decision makers use decision making approaches other than the NDM approaches describes in the literature. The findings show that some decision makers attempt to use the naturalistic decisions as a way of highlighting an advantage to be gained from the problem at hand (i.e. the garbage can approach) (Turpin and Marais, 2004).

4. Some decision makers take great care in ensuring they follow the conventional guidelines set by their organisations rather than take any risks when faced with the naturalistic decision at hand (i.e. the programme approach) (Huber, 1981).

5. Some decisions makers background and emotions played a major role in choosing a particular course of action when faced with a naturalistic decision making process. (i.e. the individual difference perspective approach) (Turpin and Marais, 2004).

6. Finally, decision-makers who have had similar experiences in the past tend to, in most cases, rely entirely on these past experiences in the decision-making process. By doing so, the decision-makers run the risk of perceiving the situation as being identical to their previous experience, and in most cases, this leads to a failure to perceive all the data affecting the decision process or to the assumption that the situation is identical to their previous experience. In such cases, the decision-maker either gets lucky and the situation does turn out to be identical, or unlucky and the situation turns out to be different, which affects the decision-makers' comprehension of the situation and decision outcome. Decision-makers should exercise caution when faced with situations similar to ones previously encountered and establish all of the facts involved before arriving at a decision.

The main aim of the study is to investigate the level of reliance on BI in the O&G industry when decision-makers are faced with naturalistic decisions. The study suggests that there is a high level of reliance on BI in the O&G industry. However, this level of reliance is guided by individual decision-maker's experience and background knowledge. Ostensibly, decision-makers who rely entirely on these experiences when making decisions using BI are likely to fall victim to a narrow mindset, retarding their way of thinking. Therefore, a

certain level of self-doubt and uncertainty can enhance an individual's SA, as identical previous experiences and a high level of SA both demand testing by the decision-maker throughout the decision-making process to avoid confirmation biases and falsely perceived SA.

Furthermore, in the literature Leon (2008, p81) concluded that 'timely and good quality information is like having a crystal ball that can give an indication of what is going to happen in the future', the author indicated that BI allowed companies to excel at identifying where their profit advantage lies and how best to capitalise on this advantage what's the best course to take. However, when faced with naturalistic, this can only be the case when the system's capabilities are combined with an individual's highly achieved PSA level and a degree of caution when data is incomplete could further minimise the uncertainty that characterises the industry and NDM.

However, the findings show that a high degree of minimisation of these uncertainties is difficult to achieve with the current status quo, as most decision makers are guided in their interaction with the system by the aforementioned factors. Therefore, the way the analysis is conducted is ill structured and skewed towards specific sets of data through the unique cognitive lens of each individual decision maker. This point is illustrated in figure 50. The relevant data to the decision goal should be central in the decision making process, with all relevant data/factors that are relevant to the decision easily obtained without the heavy reliance on individual cognitive processes. However, as the figure shows, the problem or decision faced is not at the centre of the factors, but rather skewed towards a specific factor deemed important by an individual decision maker. Thus, the researcher believes that by implementing the recommended naturalistic knowledge management system, companies can ensure that the combined historical knowledge of the whole organisation can enable the relevant factors that could affect a particular decision to be apparent to the decision makers, with the decision goal staying central throughout the process.

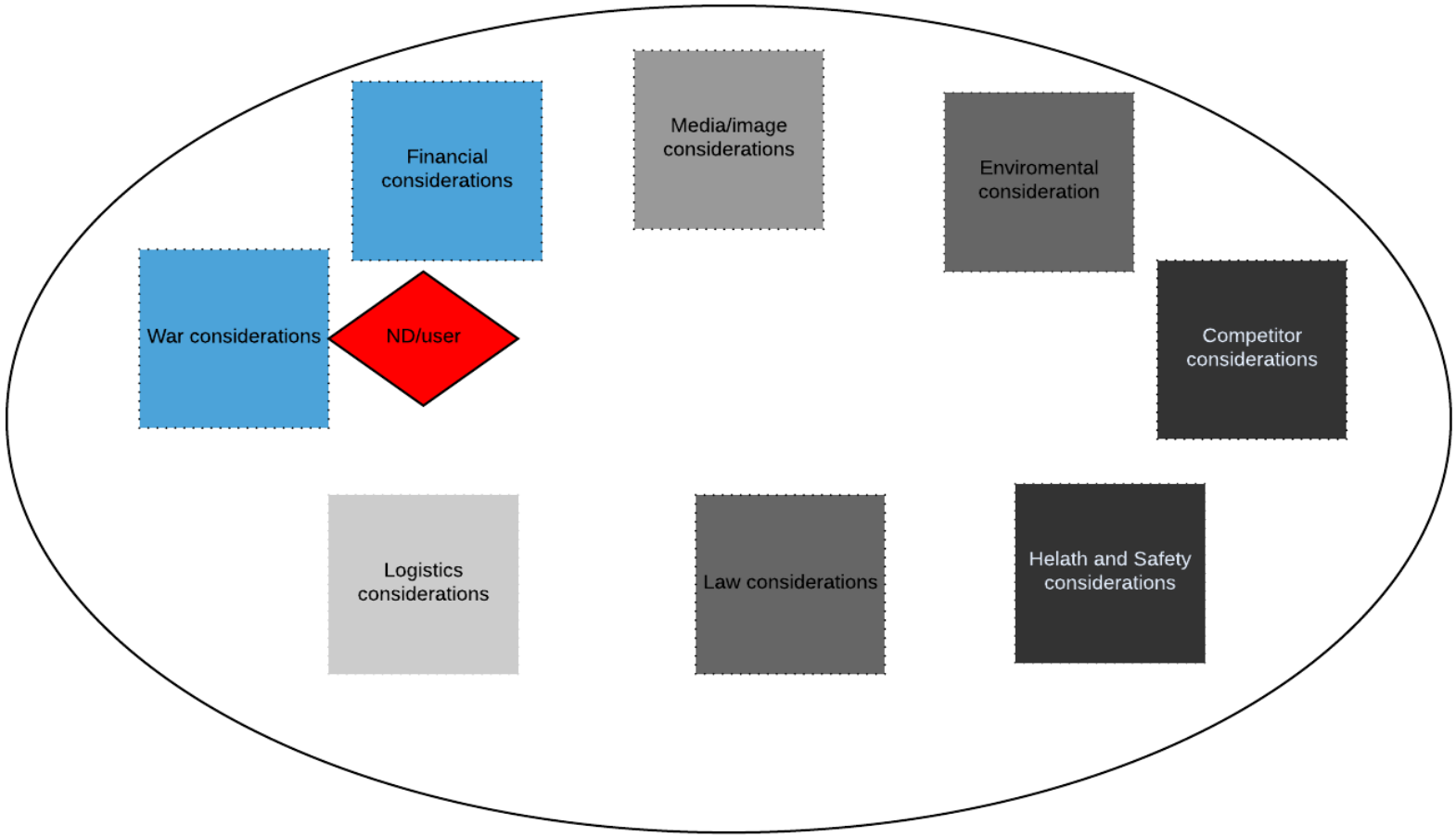


Figure 50 Decision Goal Skewed Based on Individual DM's Unique Cognitive Lenses

7.3 Contribution of the Research

This study has a number of theoretical implications and offers several practical contributions for practice. Firstly, the researcher's use of a modification of DMSC to trace and analyse the flow of the decision process, with BI representing the technological component of the model, contributes to research in the NDM field, especially as research adopting the model had only been previously applied in the military domain. The model proved successful in analysing the individual participant's decision process and managed to highlight at which oval/stage of the decision process participants faced difficulties, which represented the underlying reason in their unique decision making processes

Secondly, the study also offers several important contributions in the field of NDM in the O&G industry, highlighting the different types of decisions in the industry and if, when and how BI can aid decision-makers in making these decisions. The research is especially important since there is a paucity of research available in this field. Moreover, this study helps to explain the practical NDM process used in the industry by analysing data from the decision-makers who took part in this study. The diversity of these individuals, in terms of their experiences and areas of expertise, has helped in establishing what influences decision-makers' actions when faced with naturalistic decisions and how their SA levels might be enhanced:

- in cases where there is a level of experience and familiarity with the naturalistic decision being faced—perceive and test these experiences correctly.
- in the absence of familiarity with the naturalistic decision being faced—develop curiosity to understand and investigate all elements relevant to the decision, rather than only the elements that match the decision-maker's area of expertise.

Furthermore, the research also helps to illustrate the shortcomings of business intelligence when dealing with naturalistic decisions, as the findings show how the BI system's capabilities were not utilised to their full potential, due to the heavy reliance on individual cognitive processors in the navigation of the system. Finally, the research recommends a

solution to overcome these shortcomings which represent an interesting area of research for future development.

7.1 Limitations

The lack of a tested real-time measuring technique for SA meant that the measuring technique applied in his study to measure participant's PSA was, at best, experimental. The technique used in the present study relied heavily on subjective judgements by the researcher to pinpoint participants' PSA and ASA levels. Consequently, these levels are unlikely to be 100% scientifically accurate. However, the researcher attempted to control this limitation by providing each participant with a copy of their relevant SA measurement scores and a justification for those scores to be assessed by the participant in order to enhance the scores validity. Furthermore, the scores of all participants were submitted for review to the senior manager in each scenario for further validation.

Another limitation of the study lies in the fact that both companies that took part in the research were owned by the same group; therefore, they shared the same BI capabilities, which led to less variety in the analysis. Had the organisations used different BI systems then the capabilities of the different systems could also be further analysed in order to understand if some BI systems aid the NDM process more than others.

Furthermore, The complexity of the scenarios meant that constructing group maps proved to be a difficult process to achieve, this strategy would have added greater clarity to the findings, however, the unique decision making process each participant took and the different elements that played a part in the process (i.e. BI tools, user efficiency, order of tools, the number of participants and their areas of expertise) meant that this strategy was not undertaken. However, it is the researcher's believe that the structure of the findings and the availability of all of the individual maps provide enough clarity for the understanding of the findings.

The final limitation in the present study was that the observations were conducted primarily in Arabic and English, with Italian occasionally being used during participant group

interactions. The data collected was audio recorded and subsequently translated and transcribed into English in order to avoid missing any meanings and to understand the field data in its original context. There is, however, a risk of some loss of meaning in this analysis and in the presentation process to a minor degree due to the problem of translation.

7.2 Areas of Future Research

The methods and findings of the present study might spawn several new avenues of research. The most appealing is the development of the naturalistic knowledge management system recommended as an extension to the BI tools used by the organisations. Furthermore, it would be interesting to measure exactly how significant the adaptation of such a system by an organisation is likely to result in the improvement and efficiency of decision making in comparison to the status quo. Another opportunity, which initially presented as a limitation in this study, is the opportunity to investigate multiple organisations in the industry with different BI systems in place. This could add richness to the data and help investigate whether some systems are more useful when facing naturalistic decisions than others are. Furthermore, the unique way that the companies gather and process their data would also help to understand how BI systems affect the speed and efficiency at which data becomes available for end-users in naturalistic situations, and whether some systems are simpler and more efficient to use than others are.

Another potential avenue for future research concerns the use eye-tracking technologies, which would shed a light on how decision-makers interact with the system, what data they use and why, during live observations. Some eye-tracking manufacturers also offer wireless connections whereby the researcher can observe the decision process and the decision-maker's interactions with the BI system from an offsite location, thus limiting the researcher involvement or presence in the decision-making process.

CHAPTER 8

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CHAPTER 10

APPENDIX

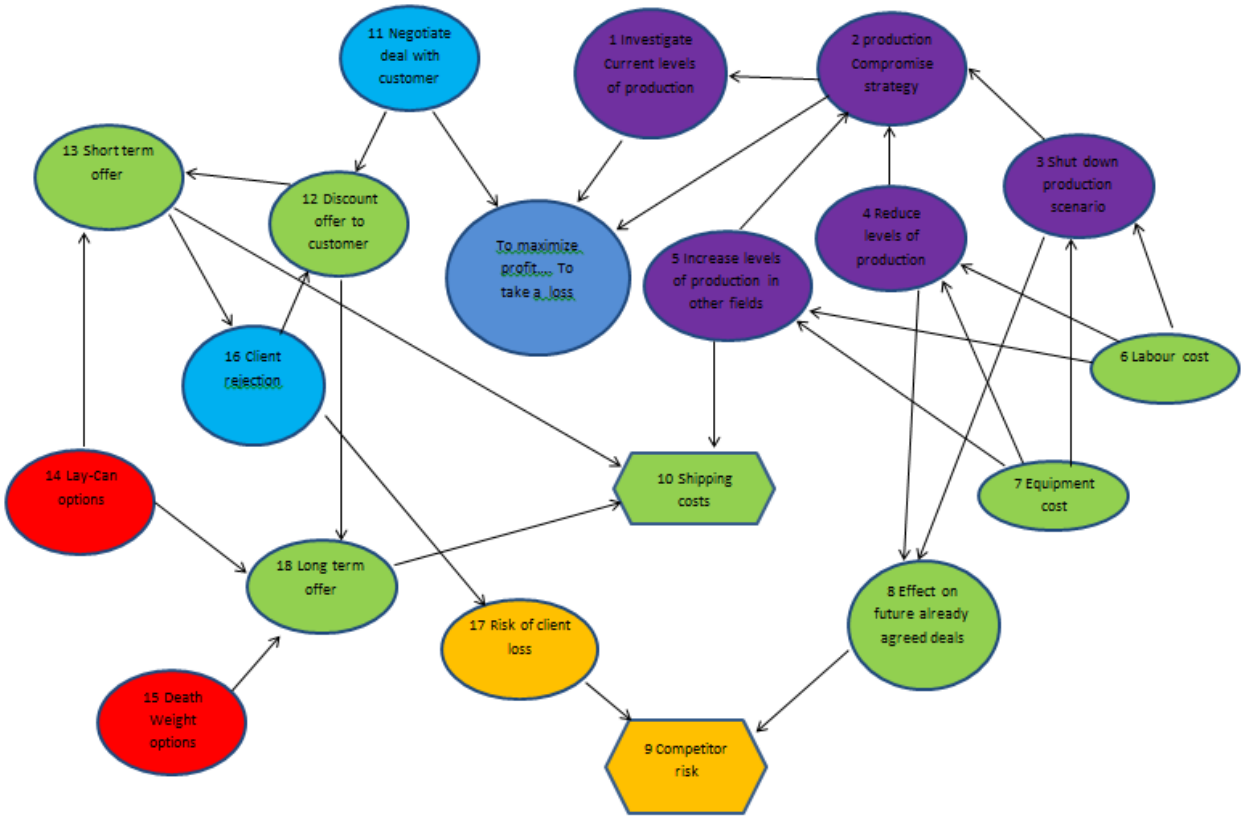
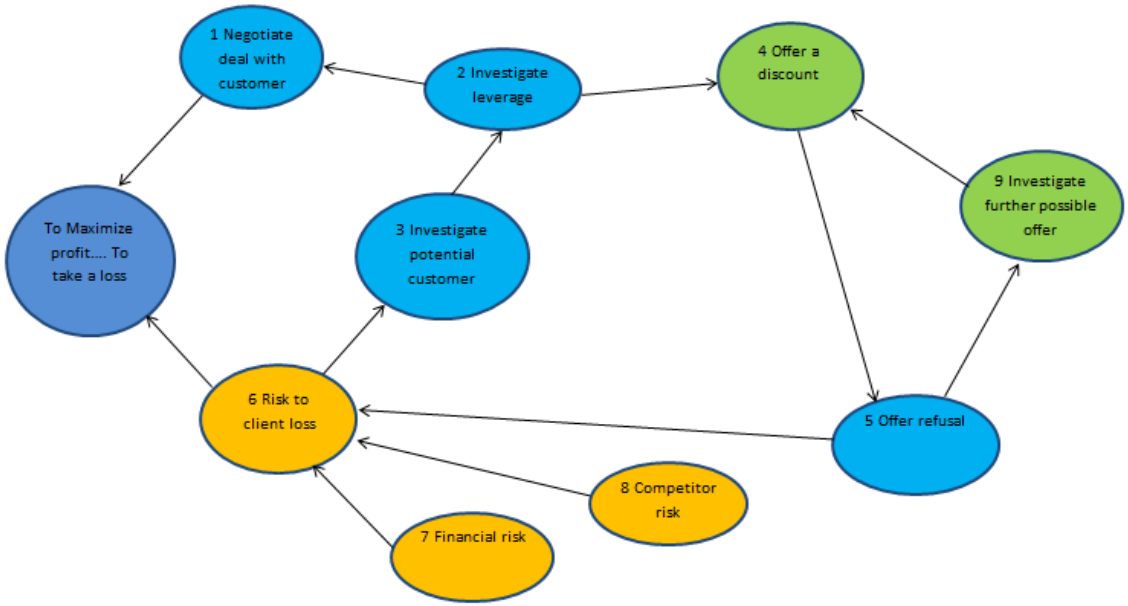


Figure 39 CM S1P1

Figure 40 CM S1P2



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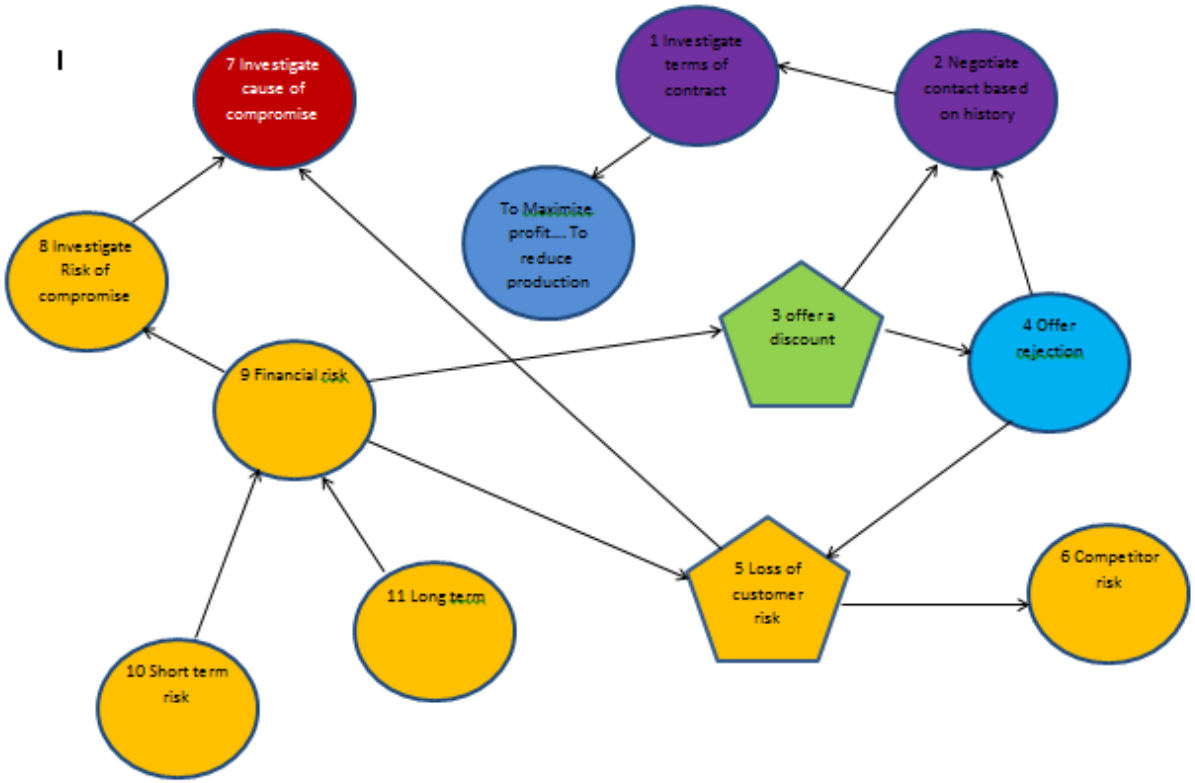

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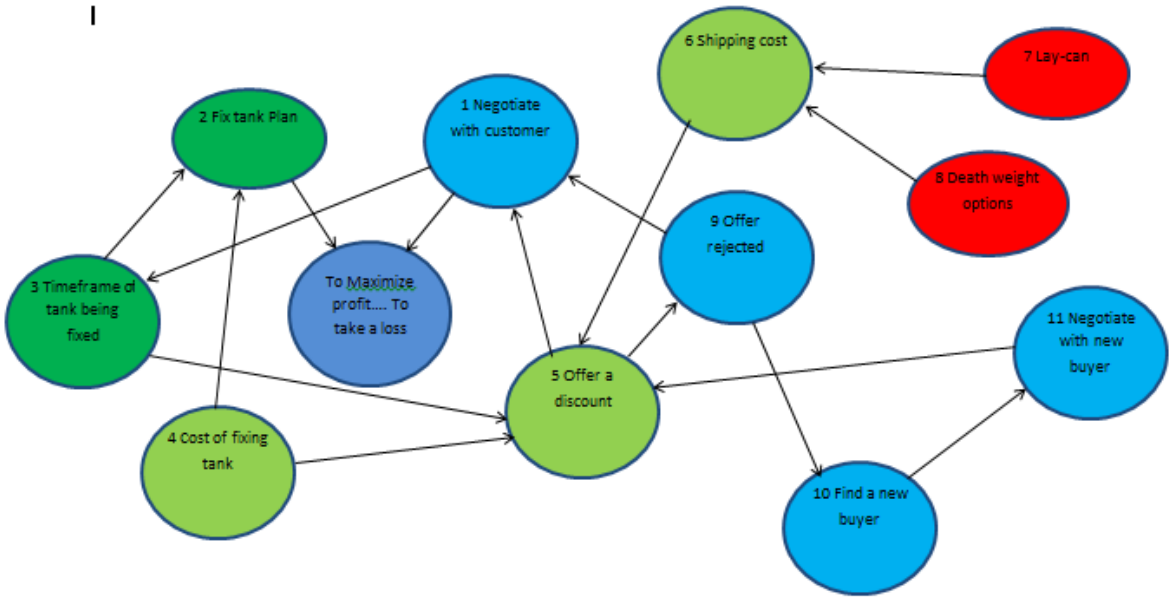

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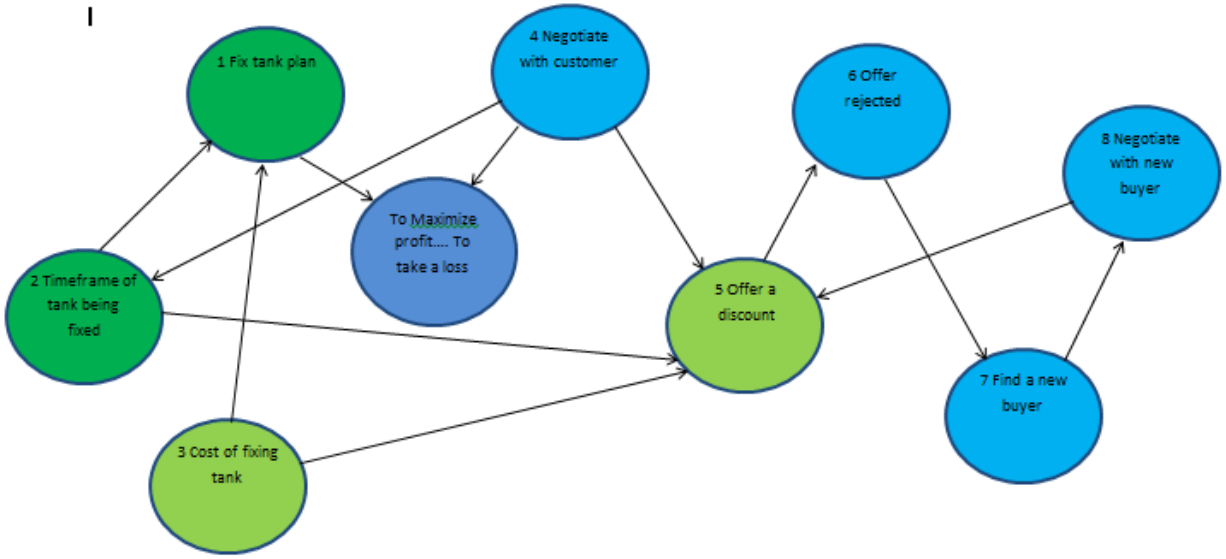

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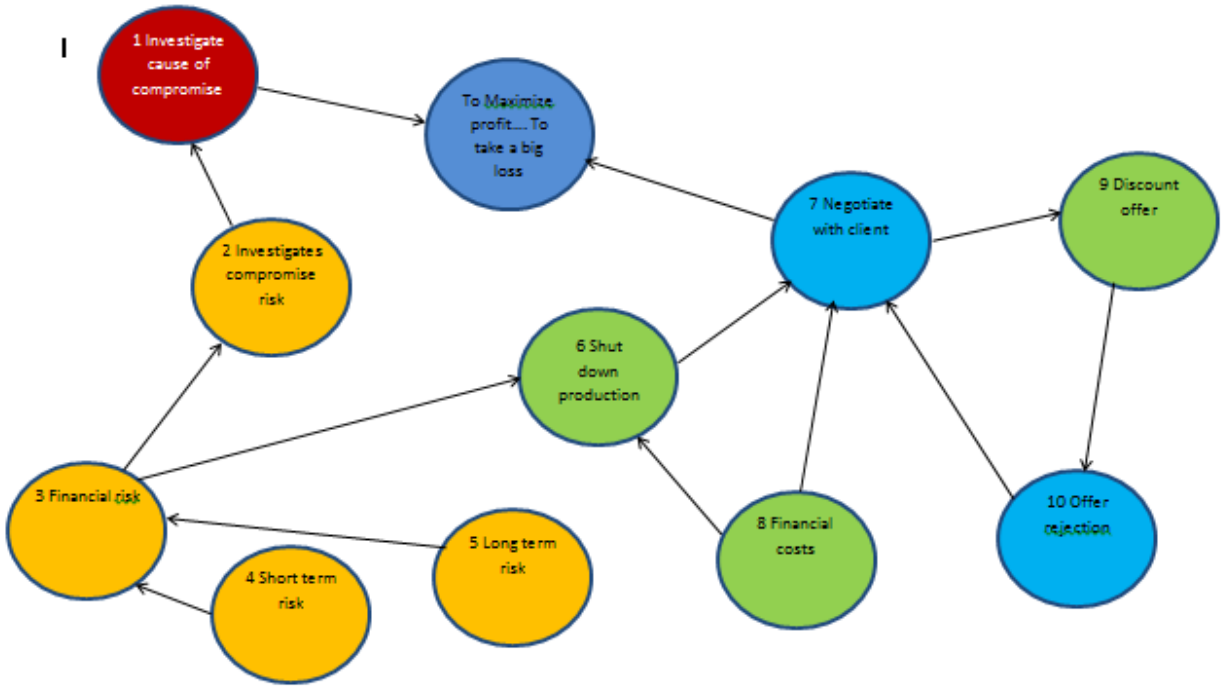

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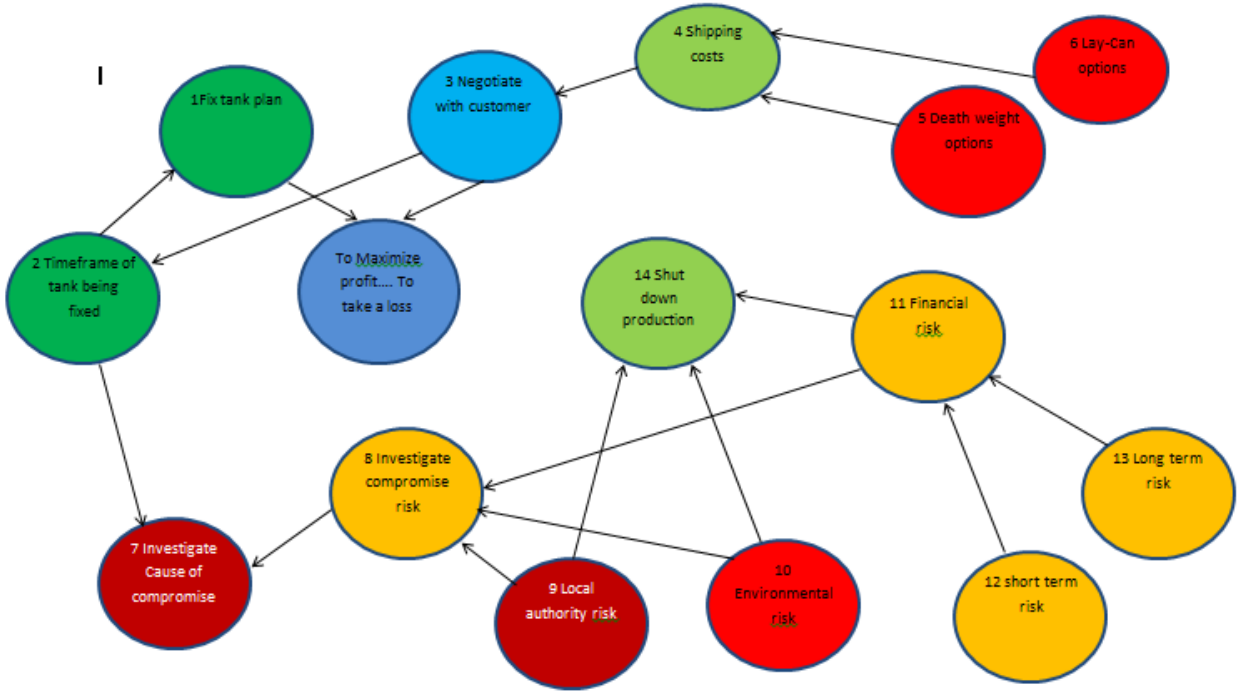

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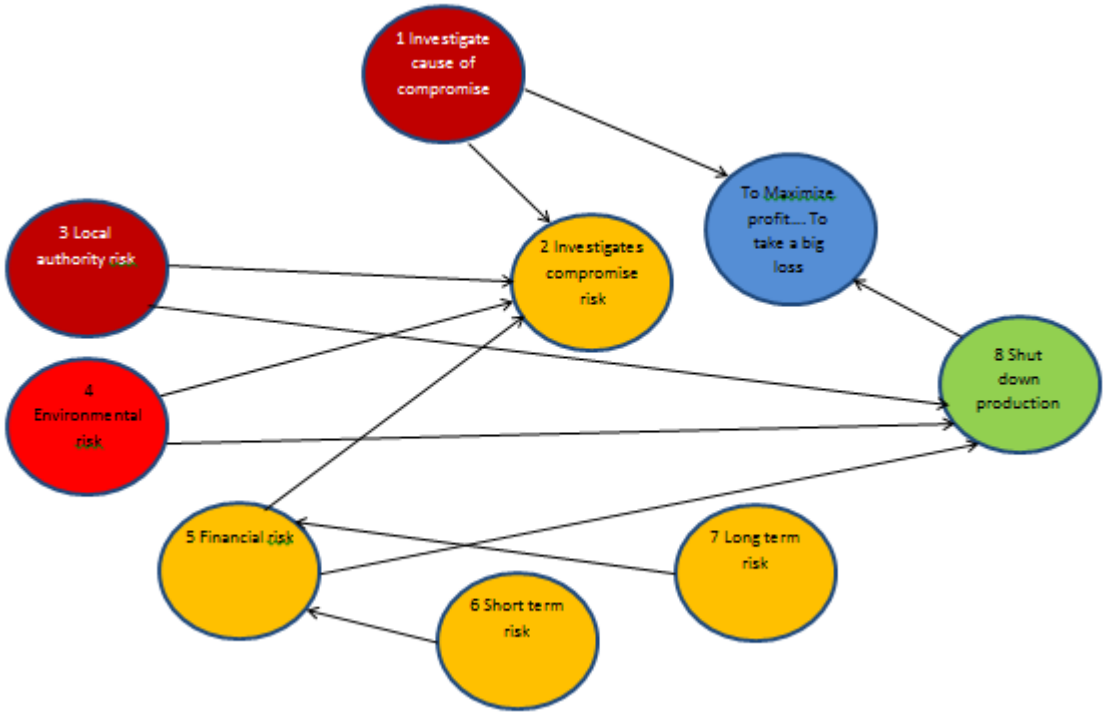

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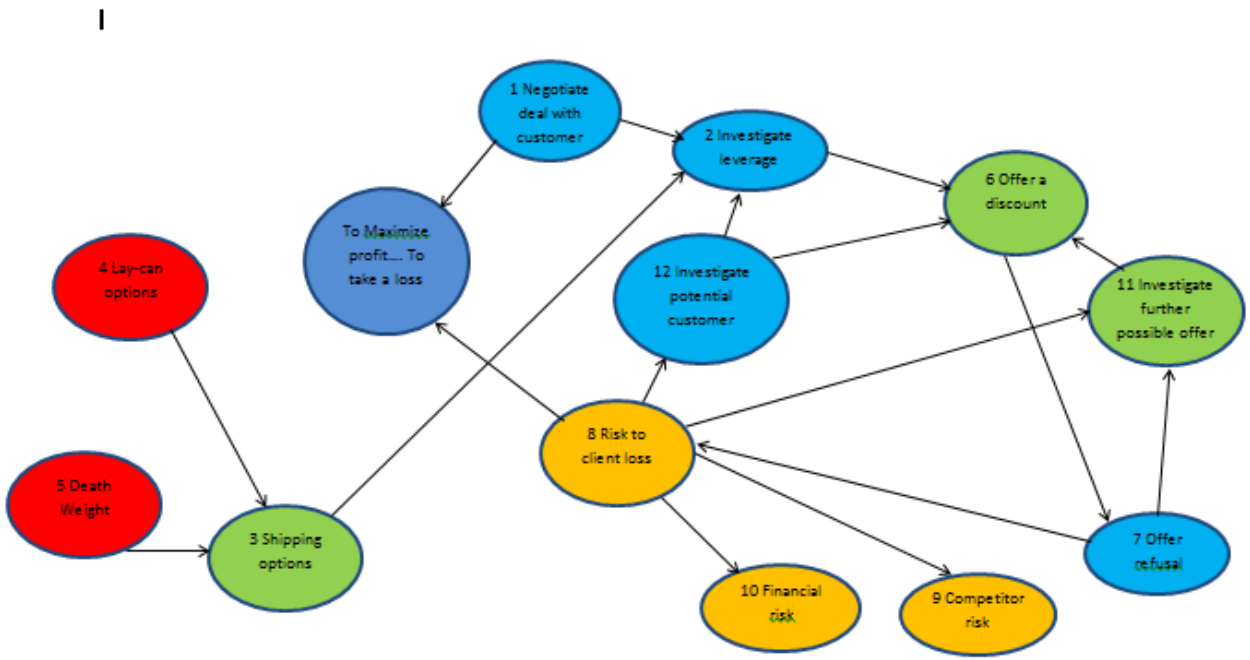

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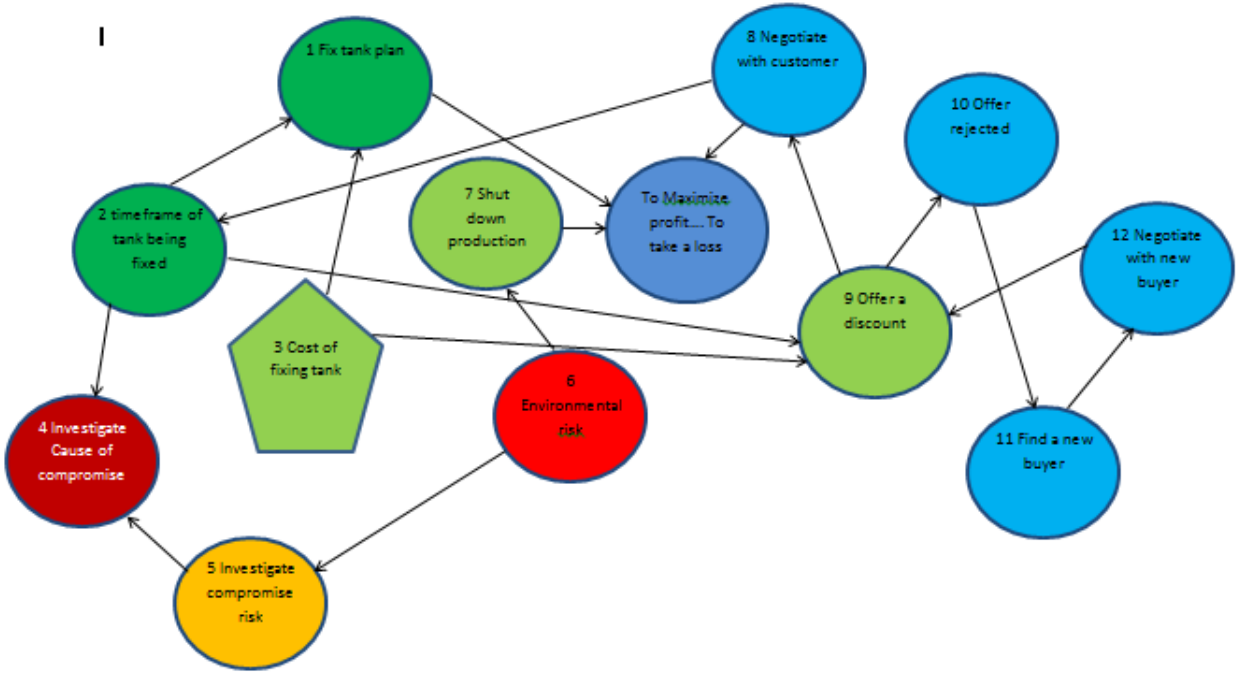

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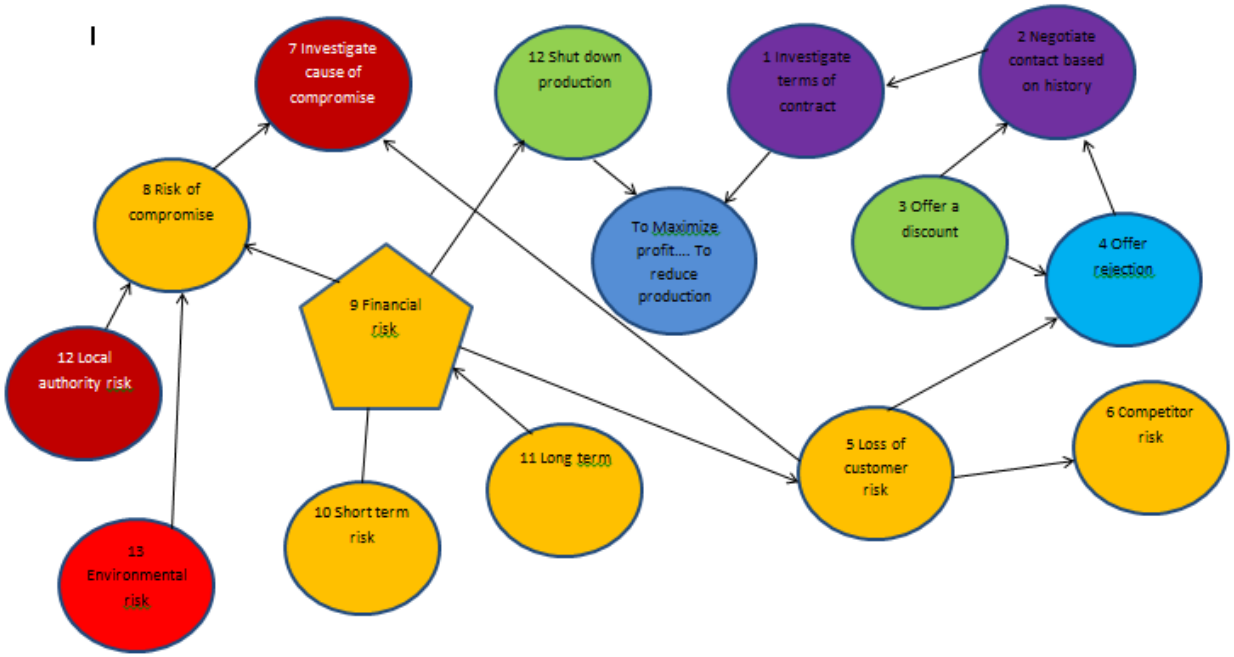

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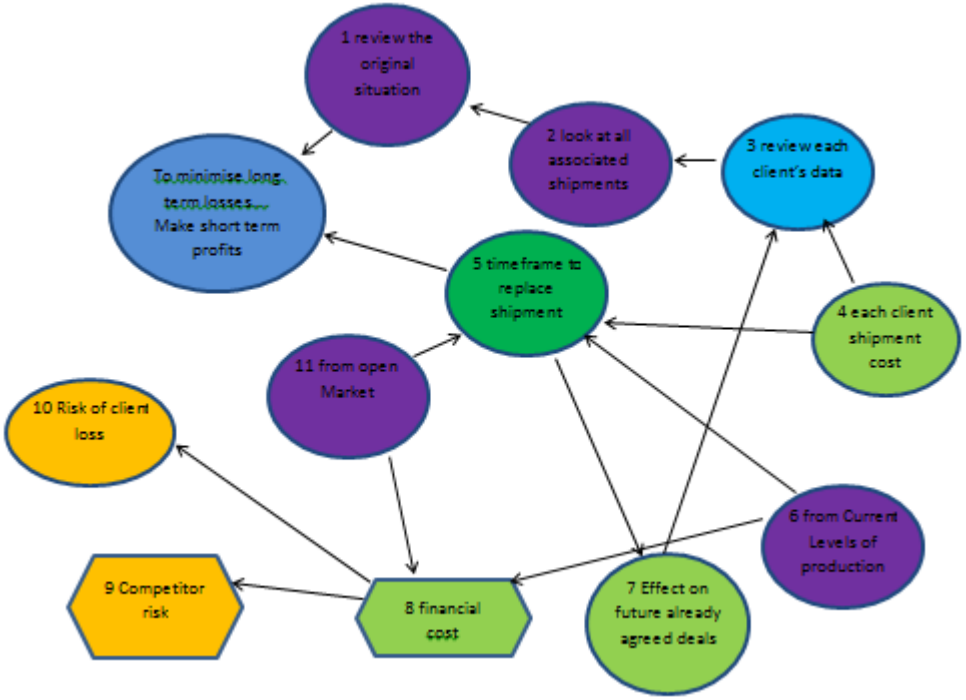

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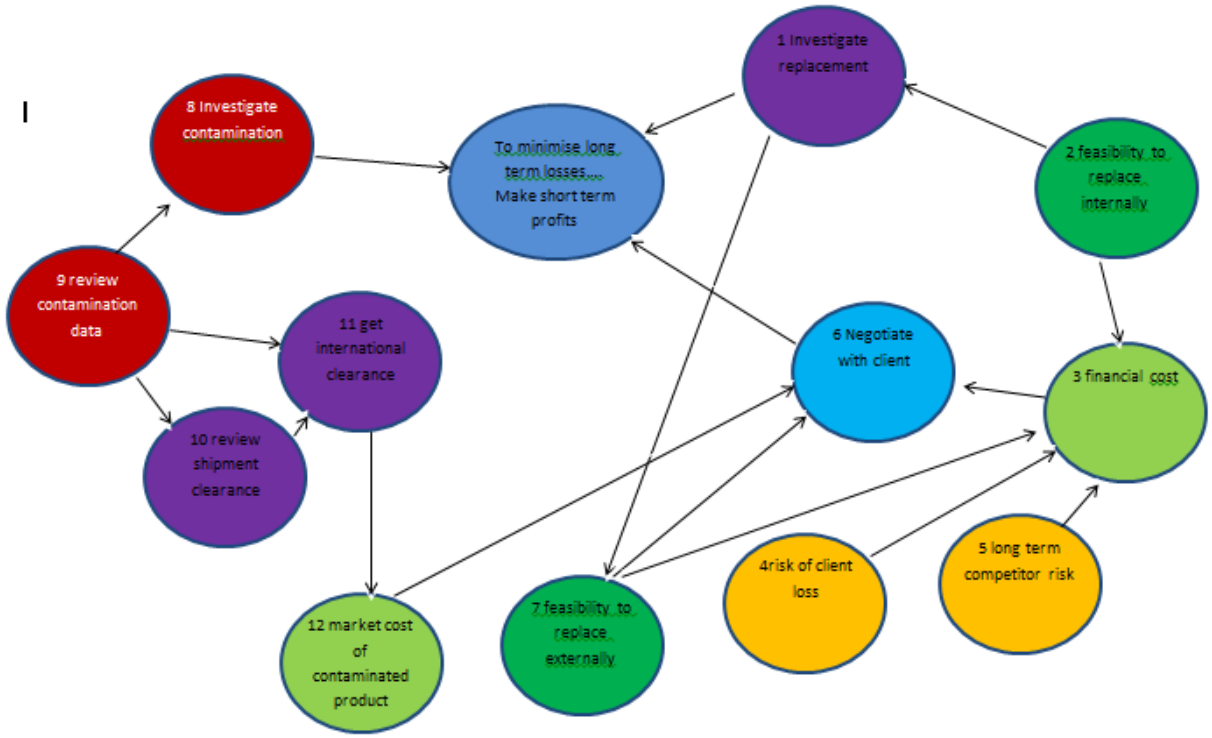

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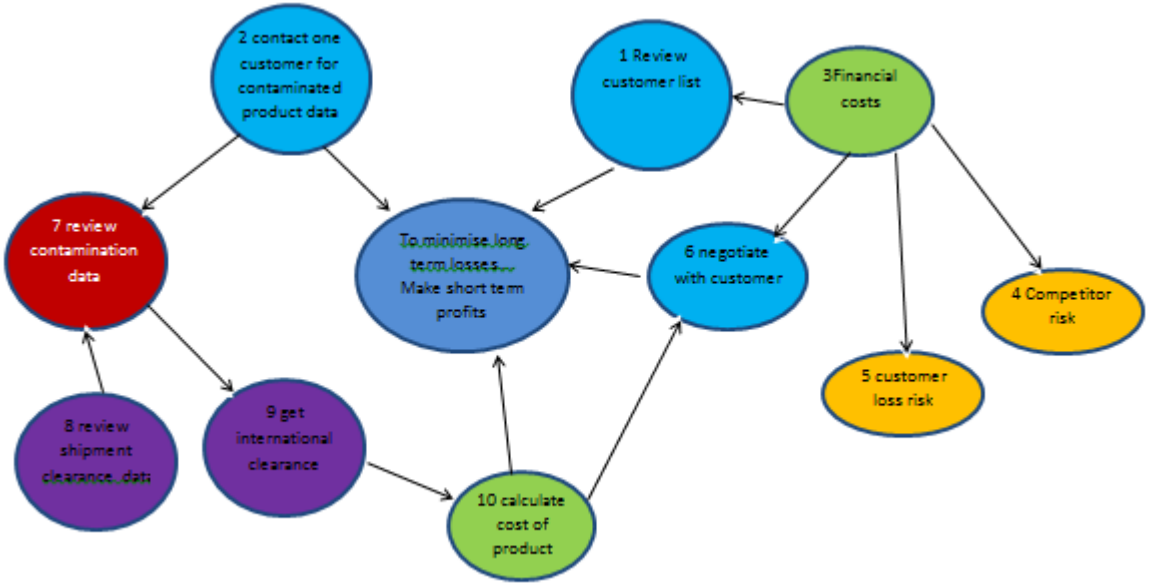
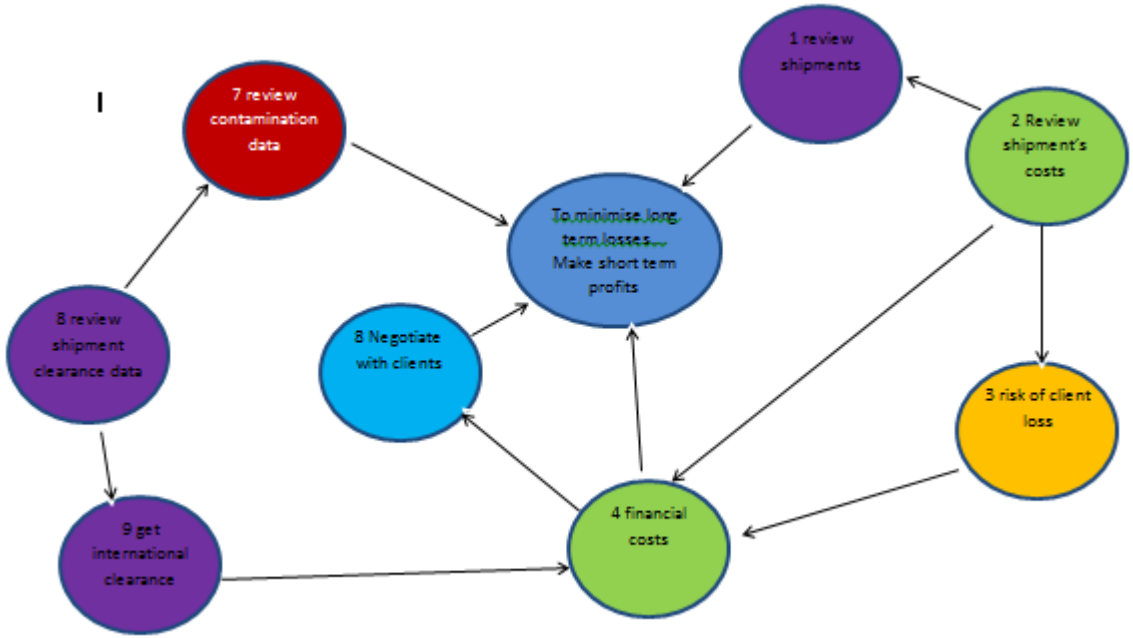


Figure 53 CM S2p3

Figure 54 CM S2P4



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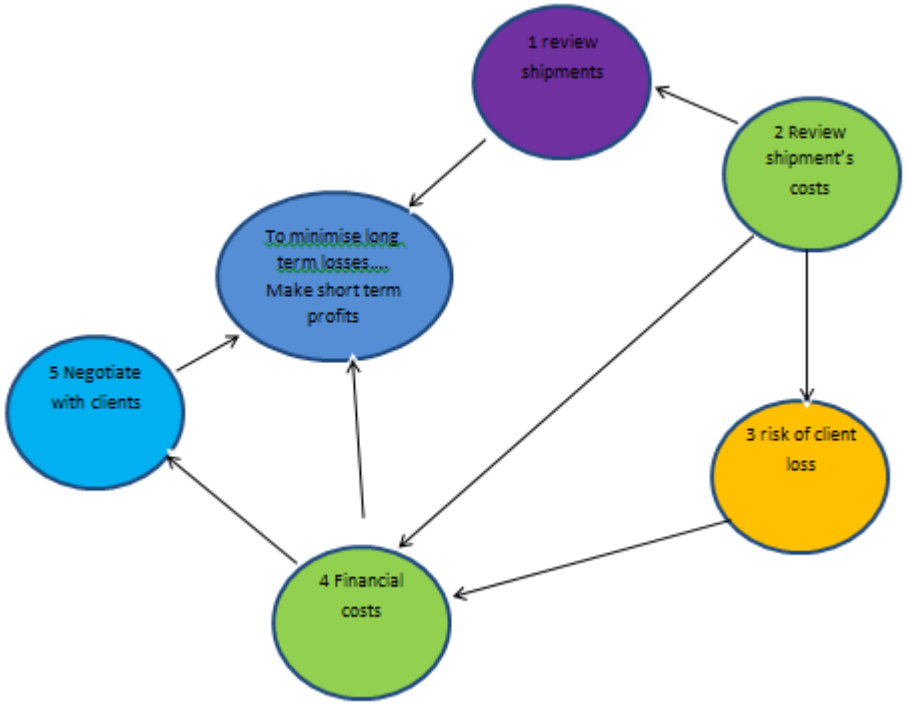

Figure 56 CM S2P6

Figure 57 CM S2P7

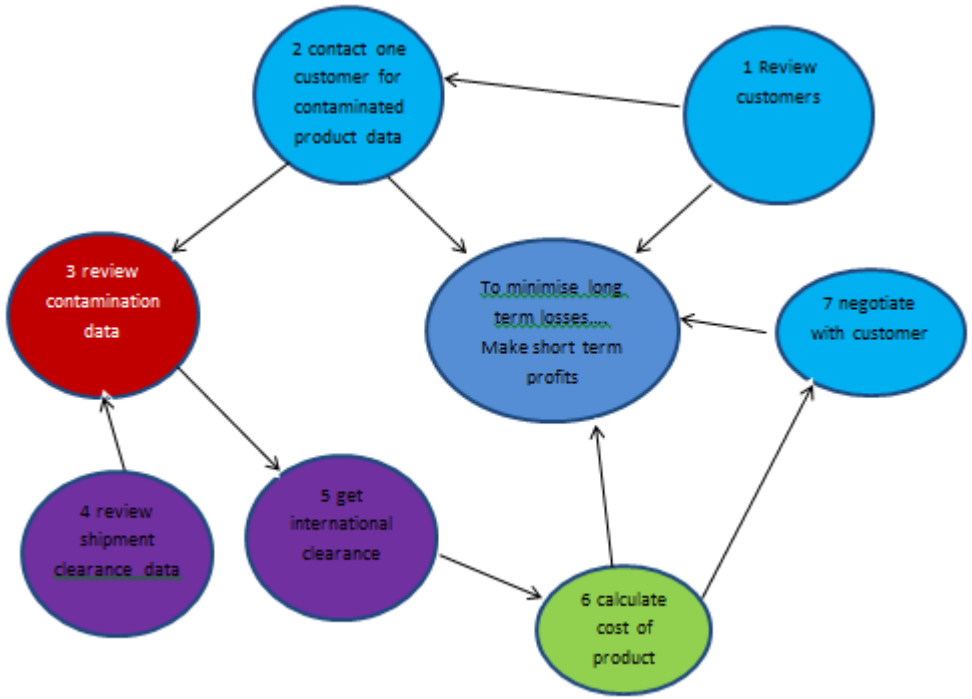

Figure 58 CM S2P8

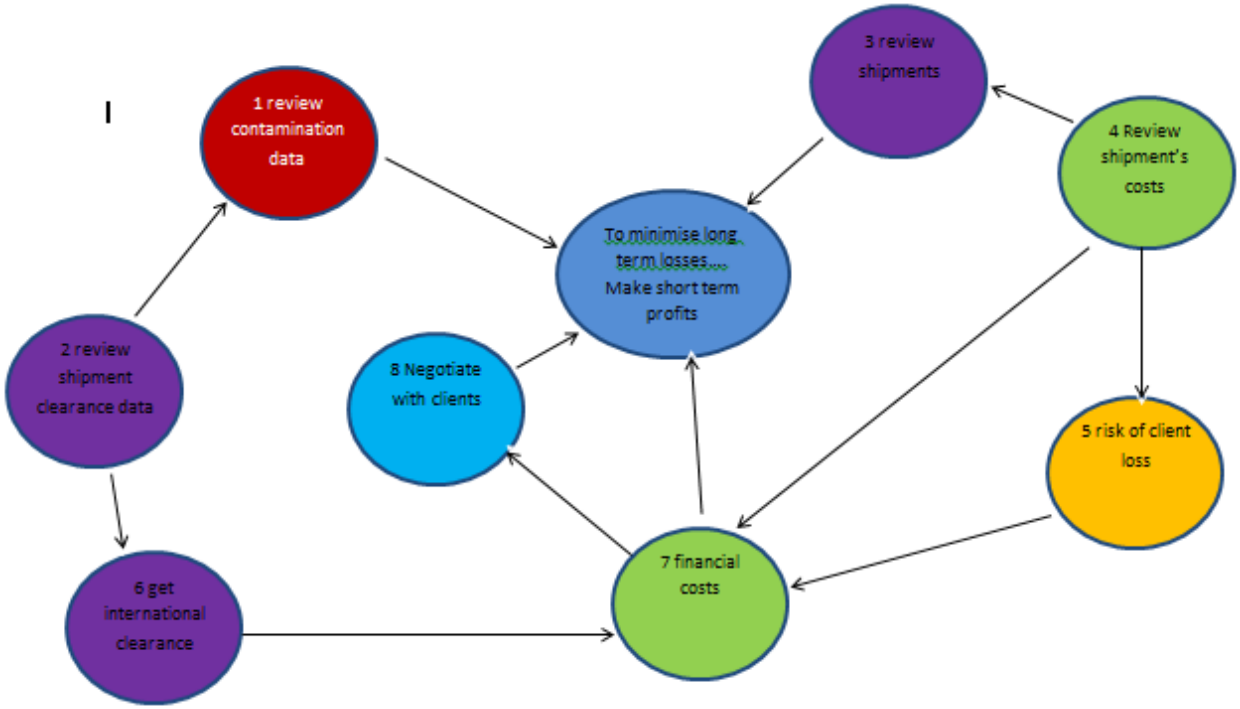

Figure 59 CM S2P9

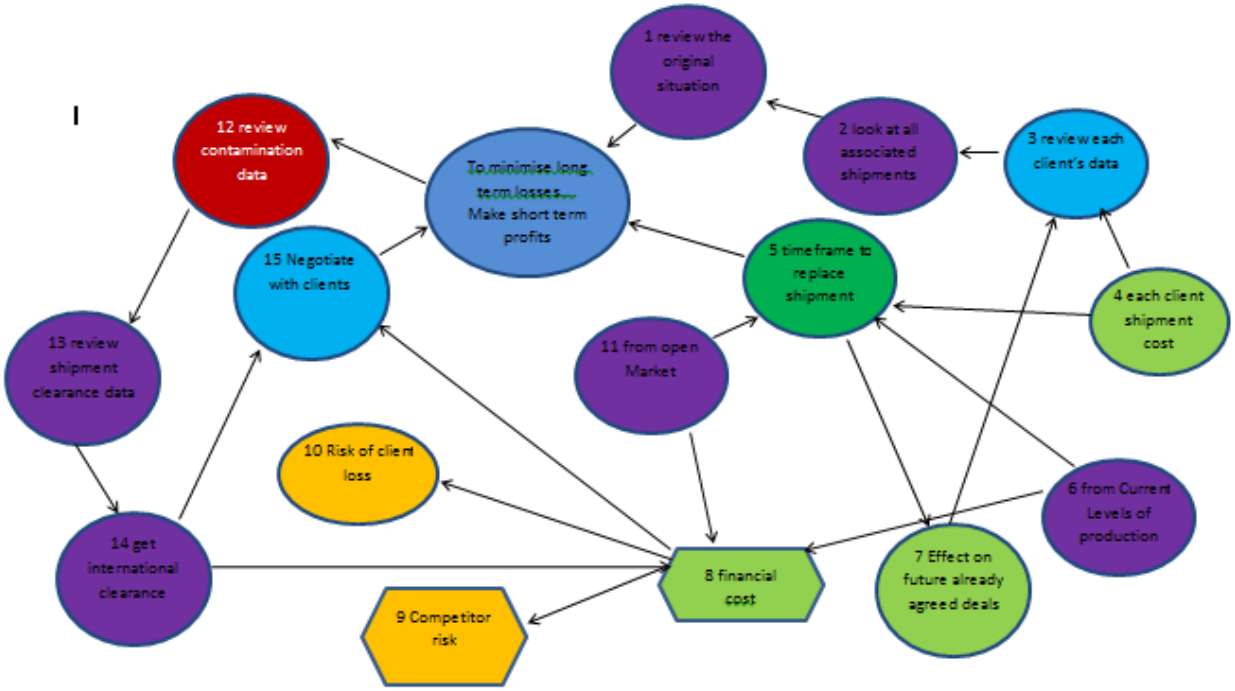

Figure 60 CM S2P10

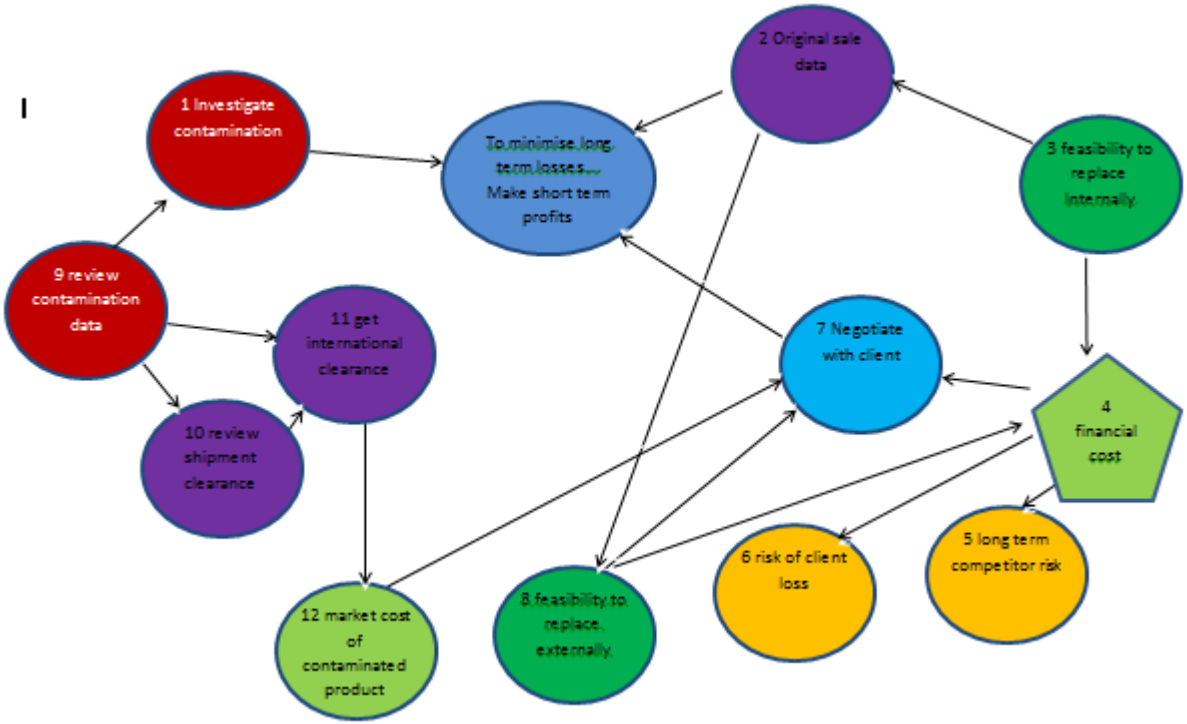

Figure 61 CM S2P11

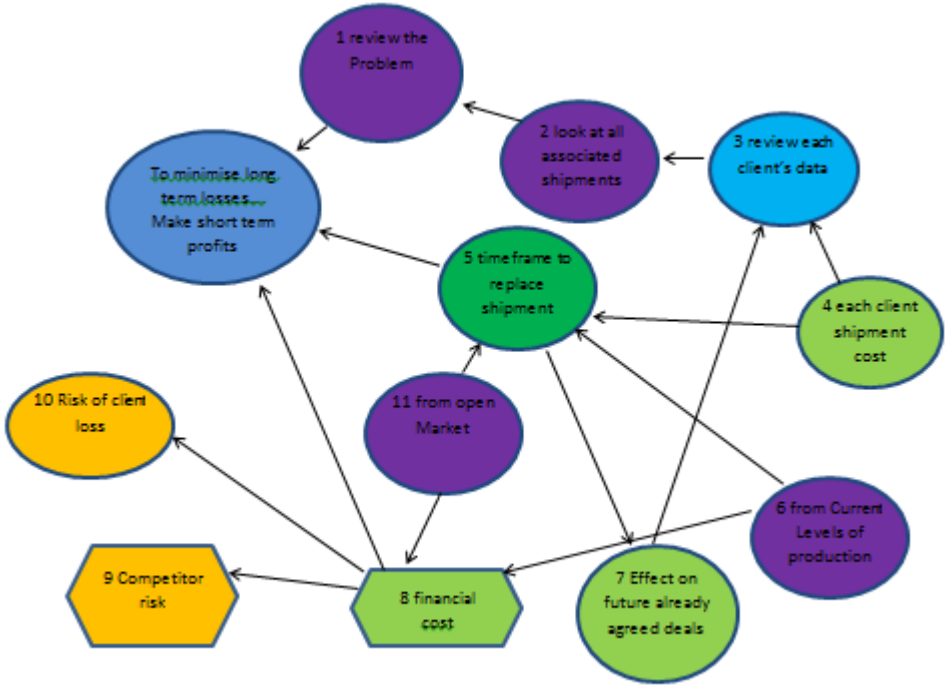

Figure 62 CM S2P12

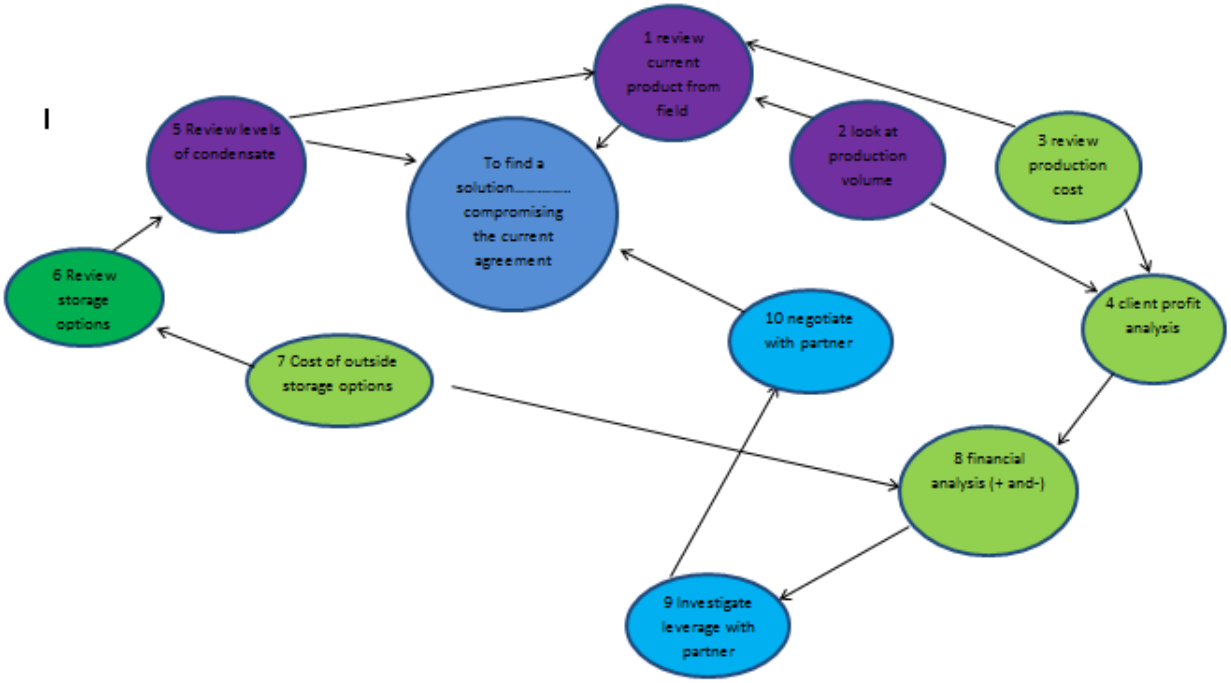

Figure 63 CM S3P1

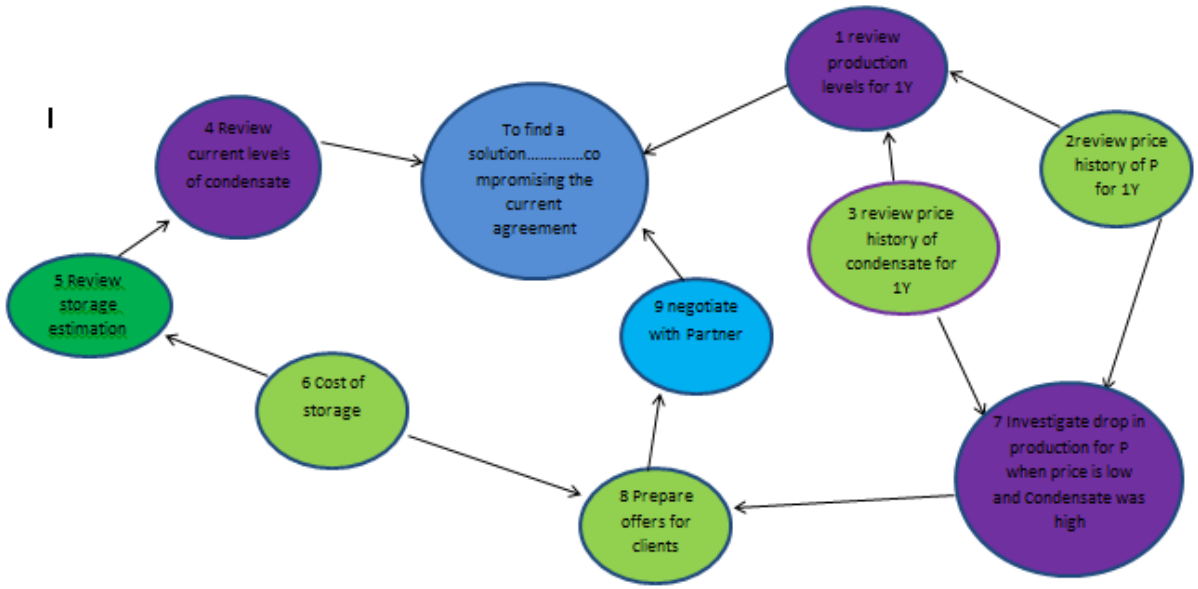

Figure 64 CM S3P2

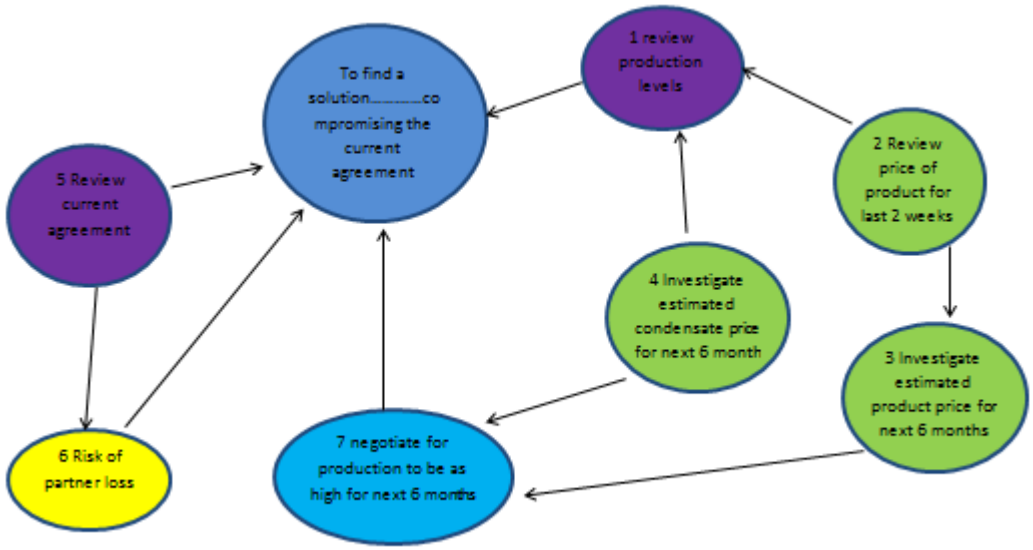

Figure 65 CM S3P3

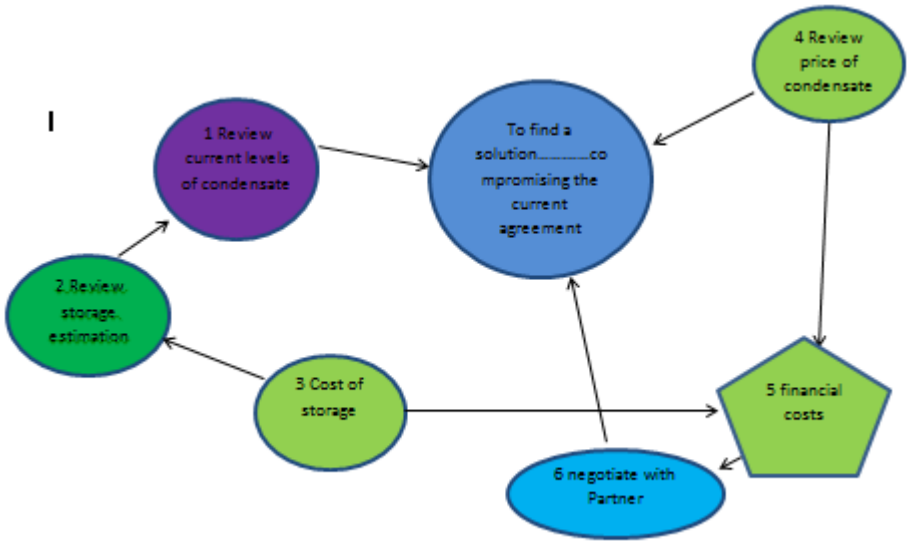

Figure 66 CM S3P4

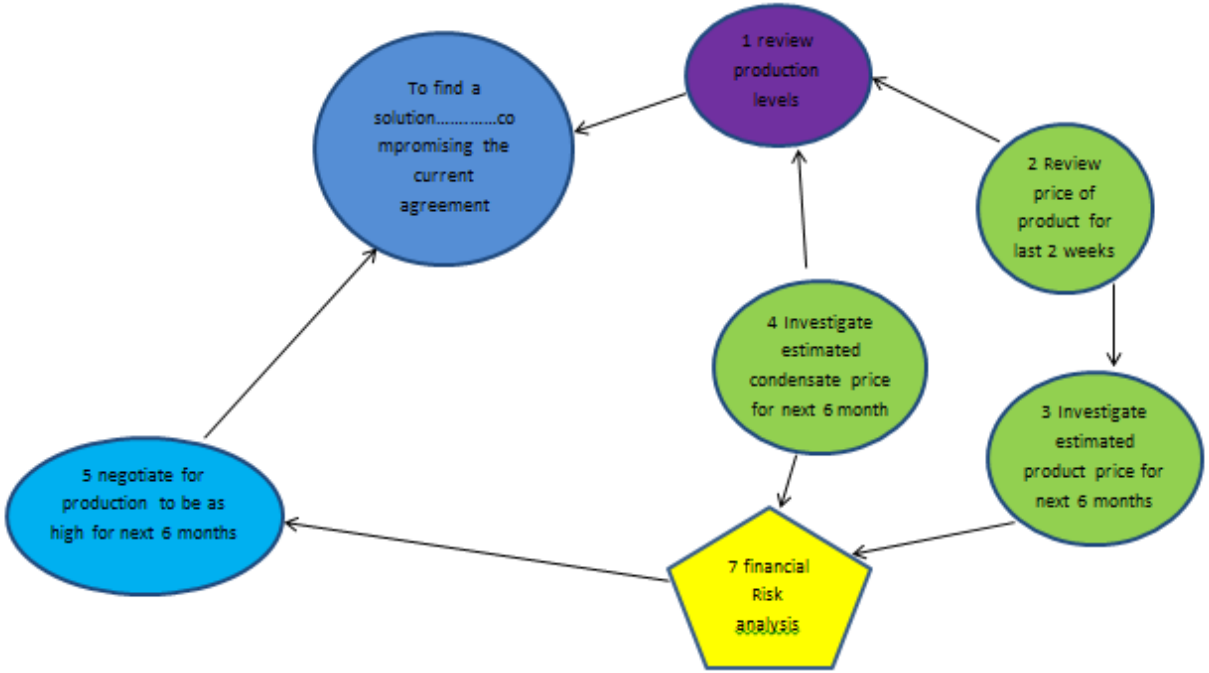

Figure 67 CM S3P5

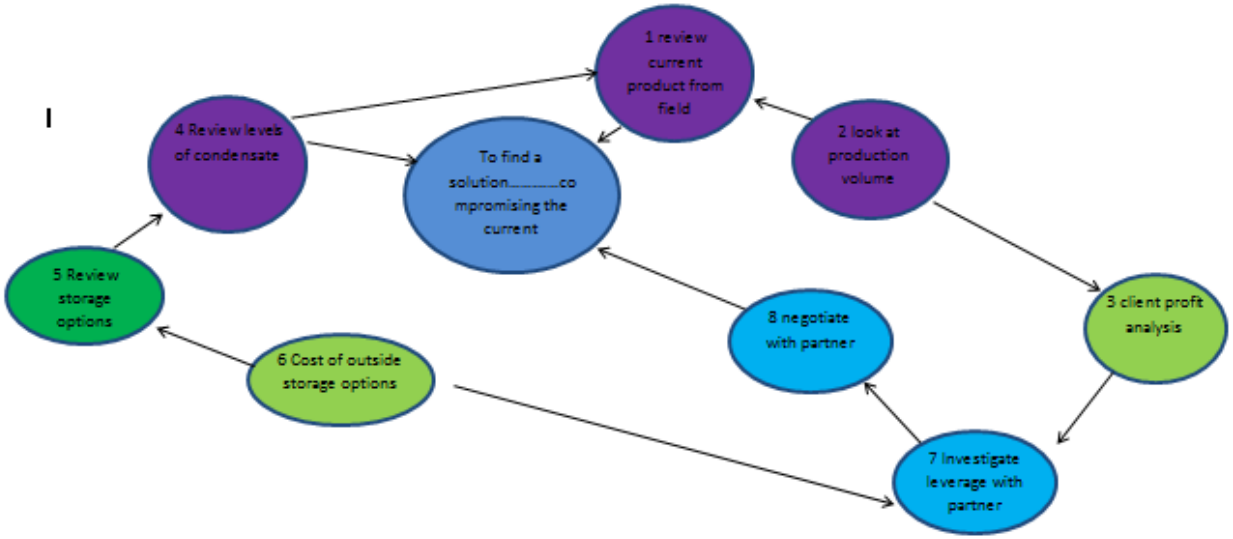

Figure 68 CM S3P6

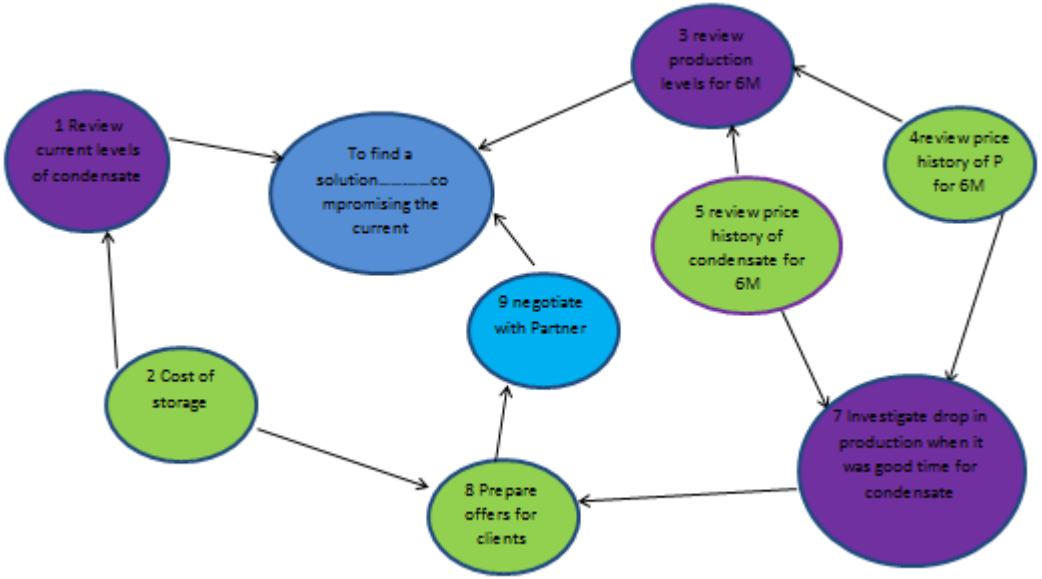

Figure 69 CM S3P7

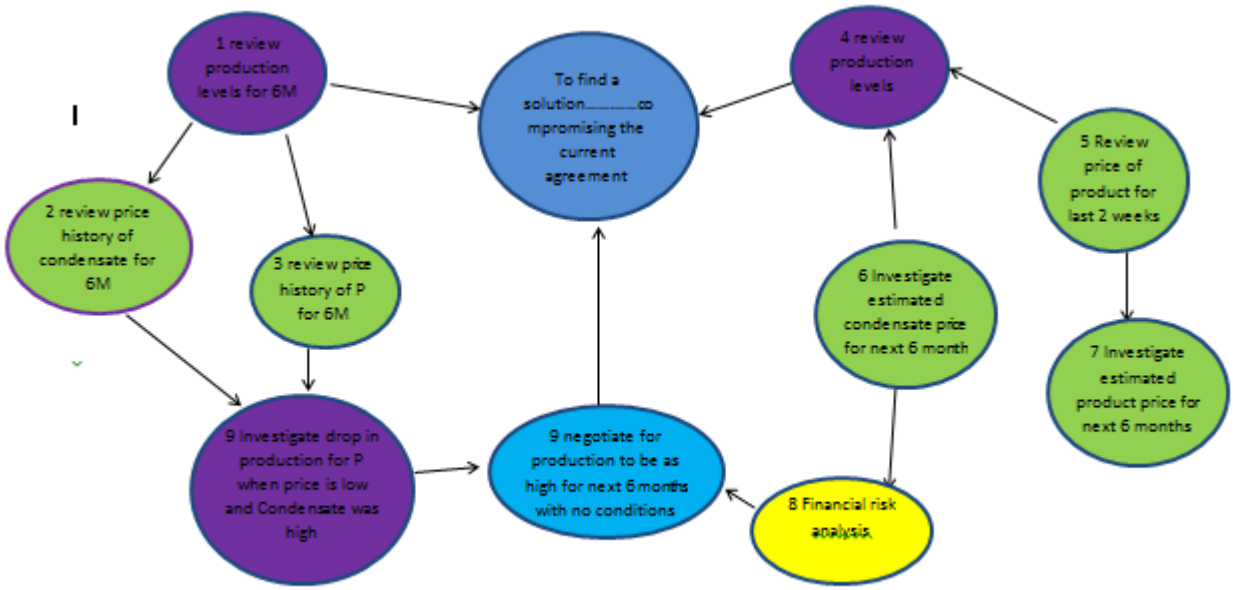

Figure 70 CM S3P8

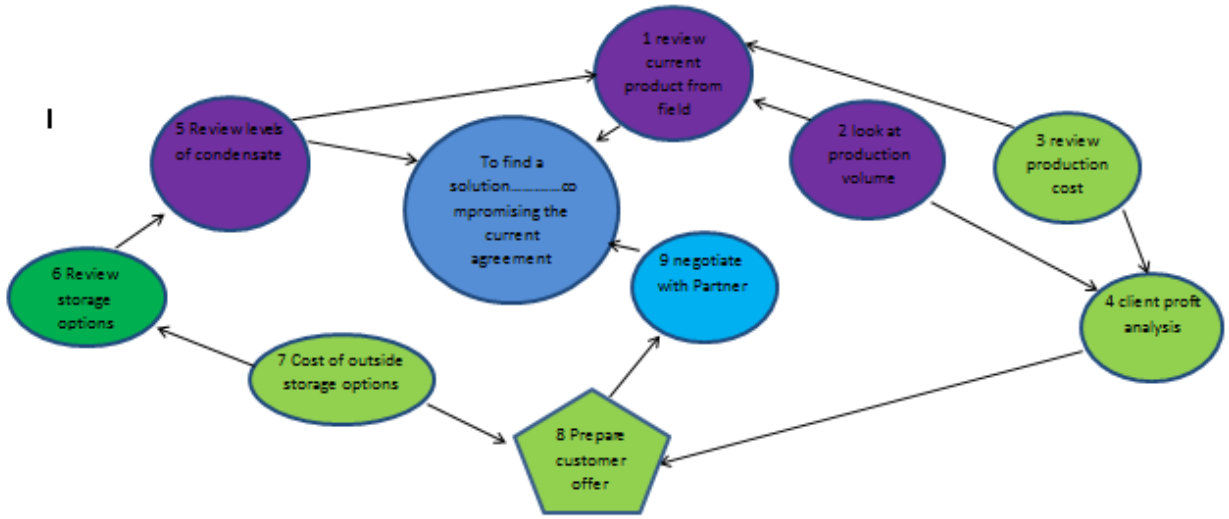

Figure 71 CM S3P9

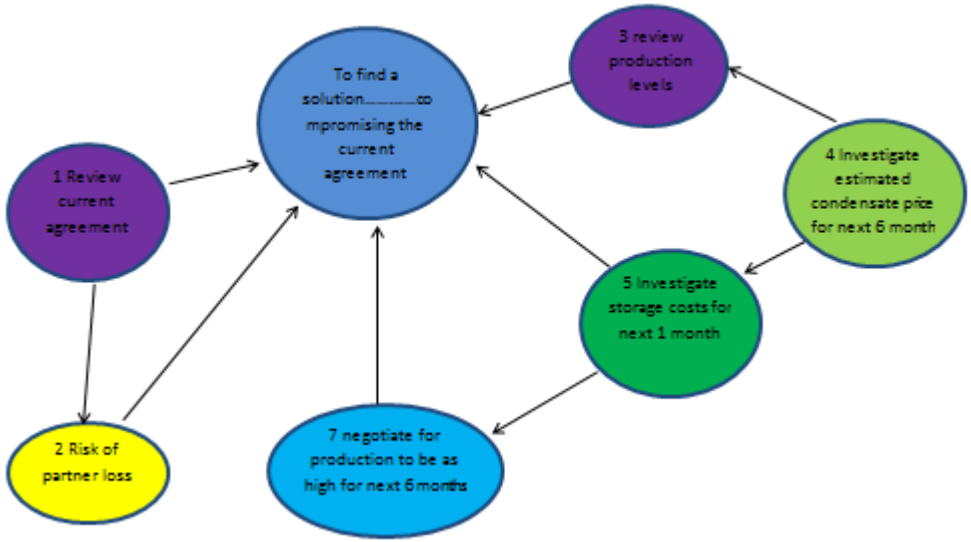

Figure 72 CM S3P10

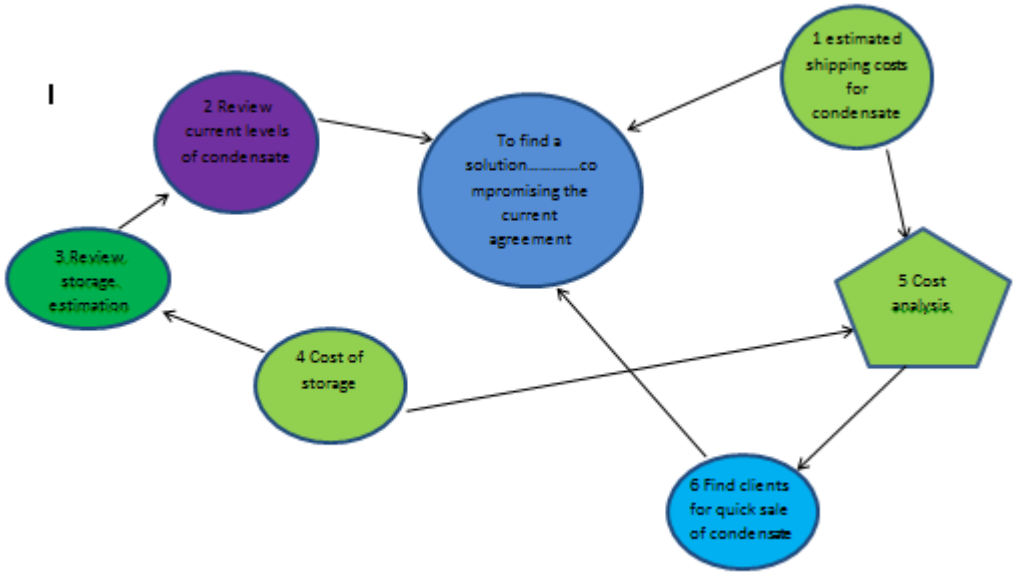

Figure 73 CM S3P11

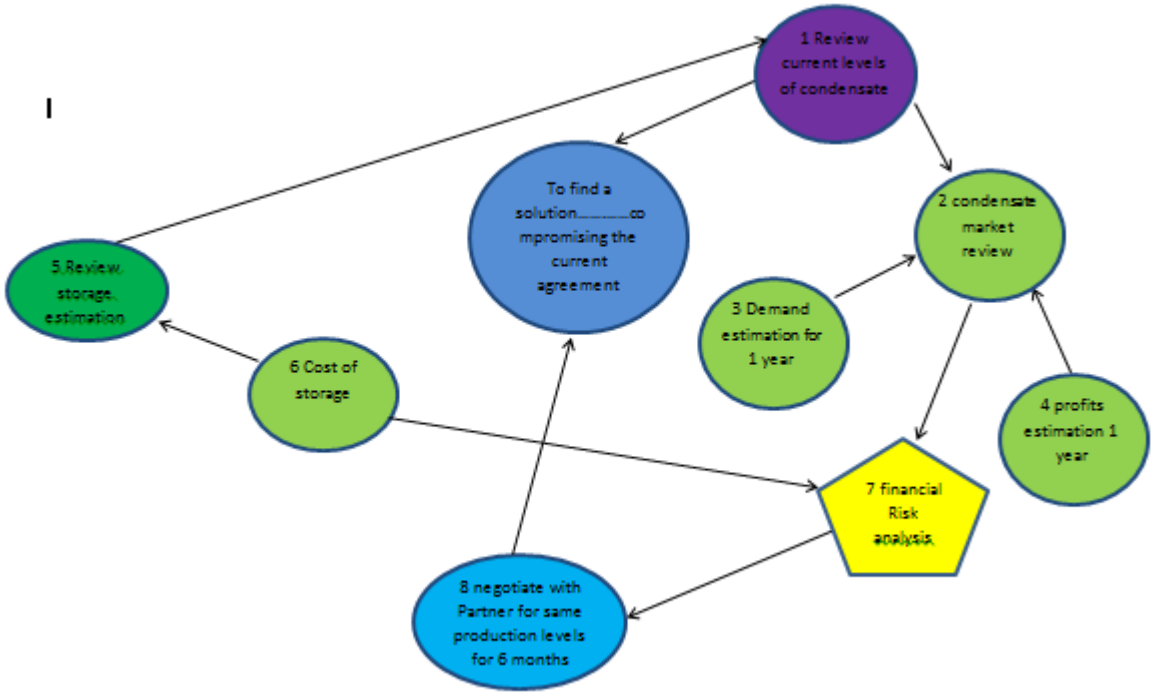

Figure 74 CM S3P12

Figure 75 CM S4P1

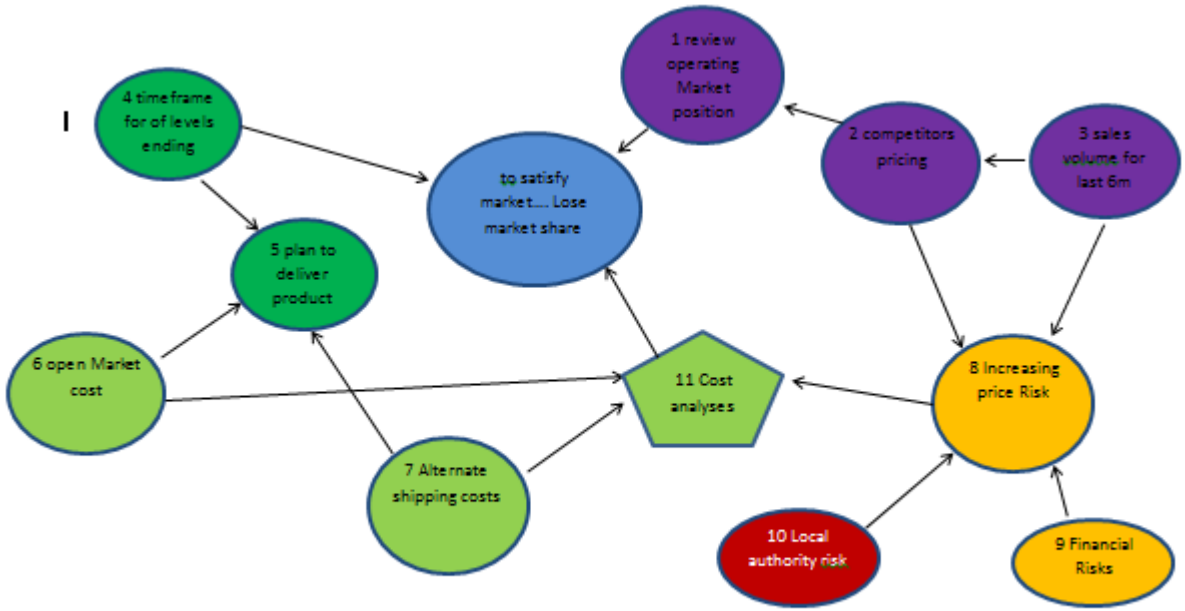

Figure 76 CM S4P2

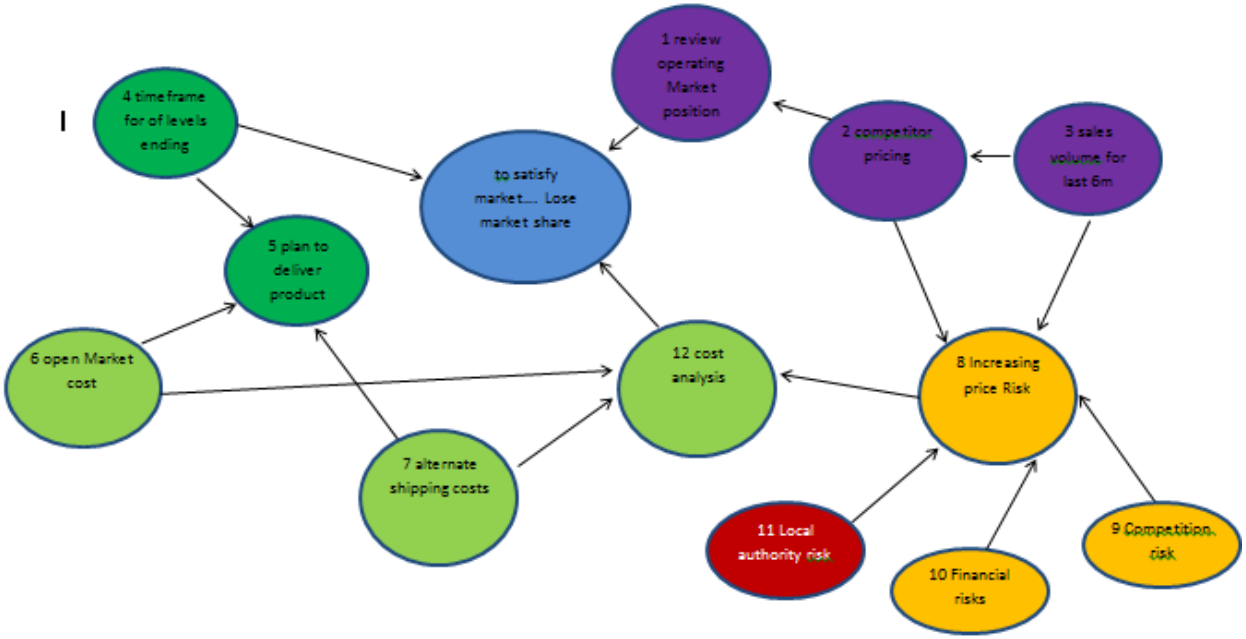

Figure 77 CM S4P3

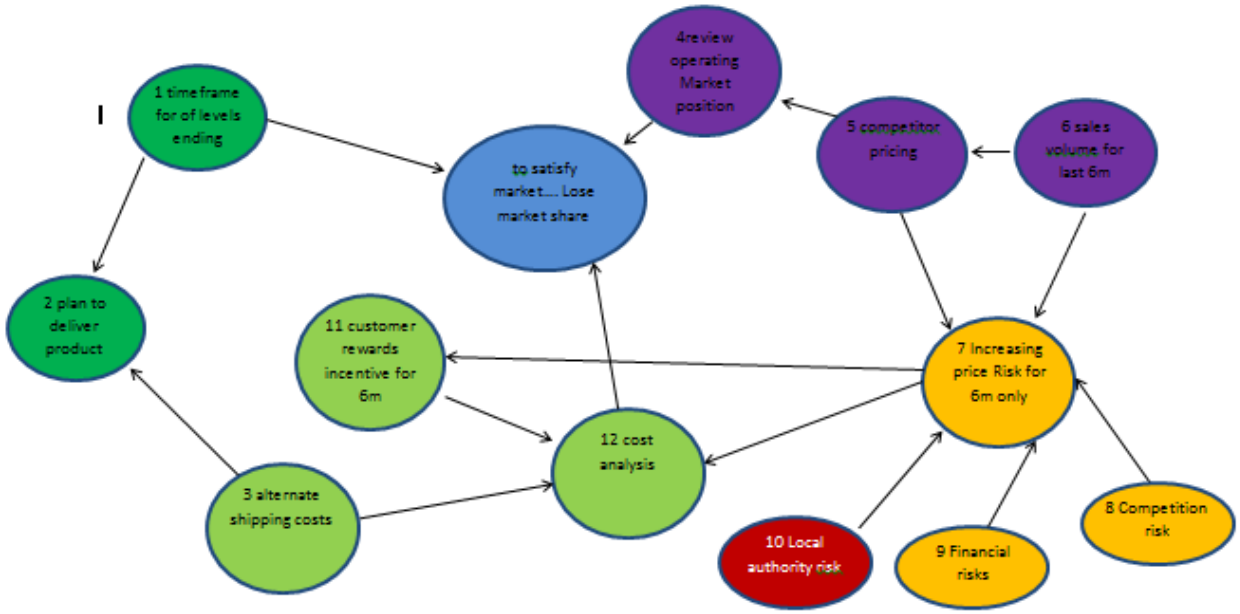

Figure 78 CM S4P4

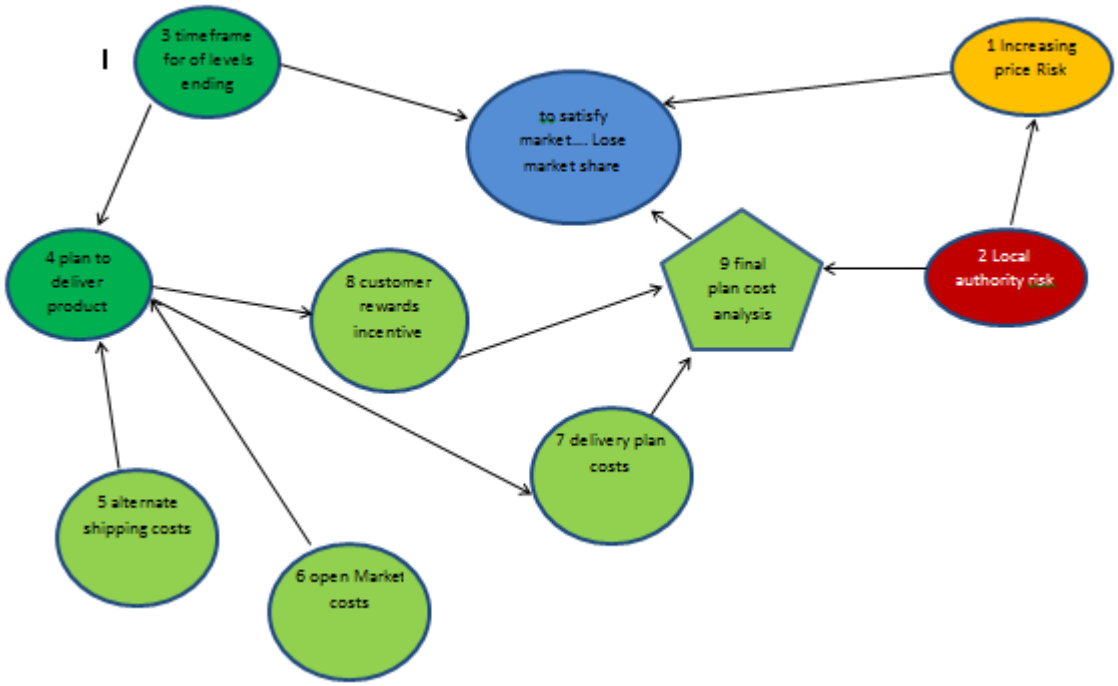

Figure 79 CM S4P5

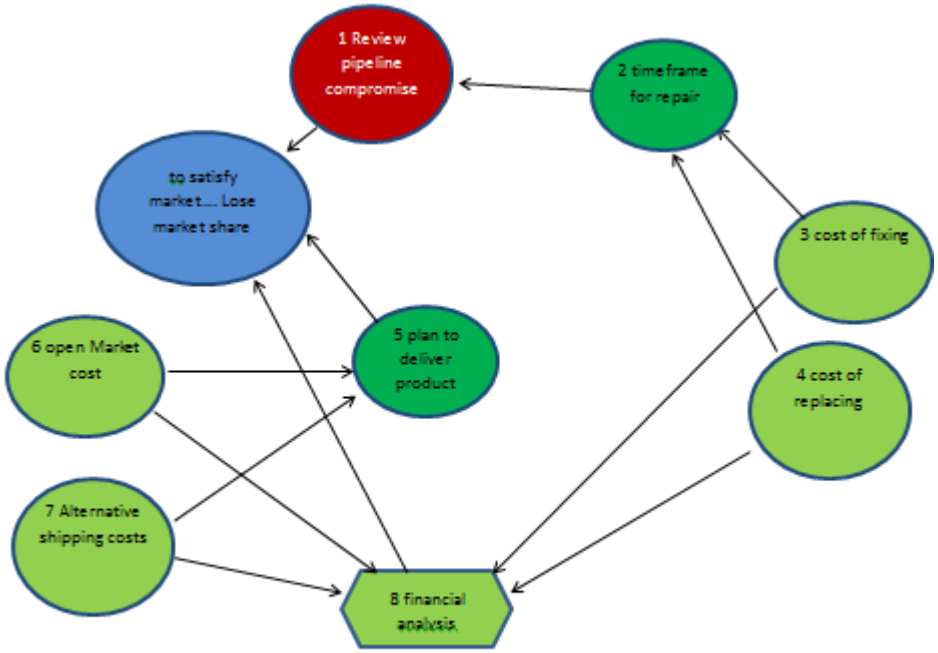

Figure 80 CM S4P6

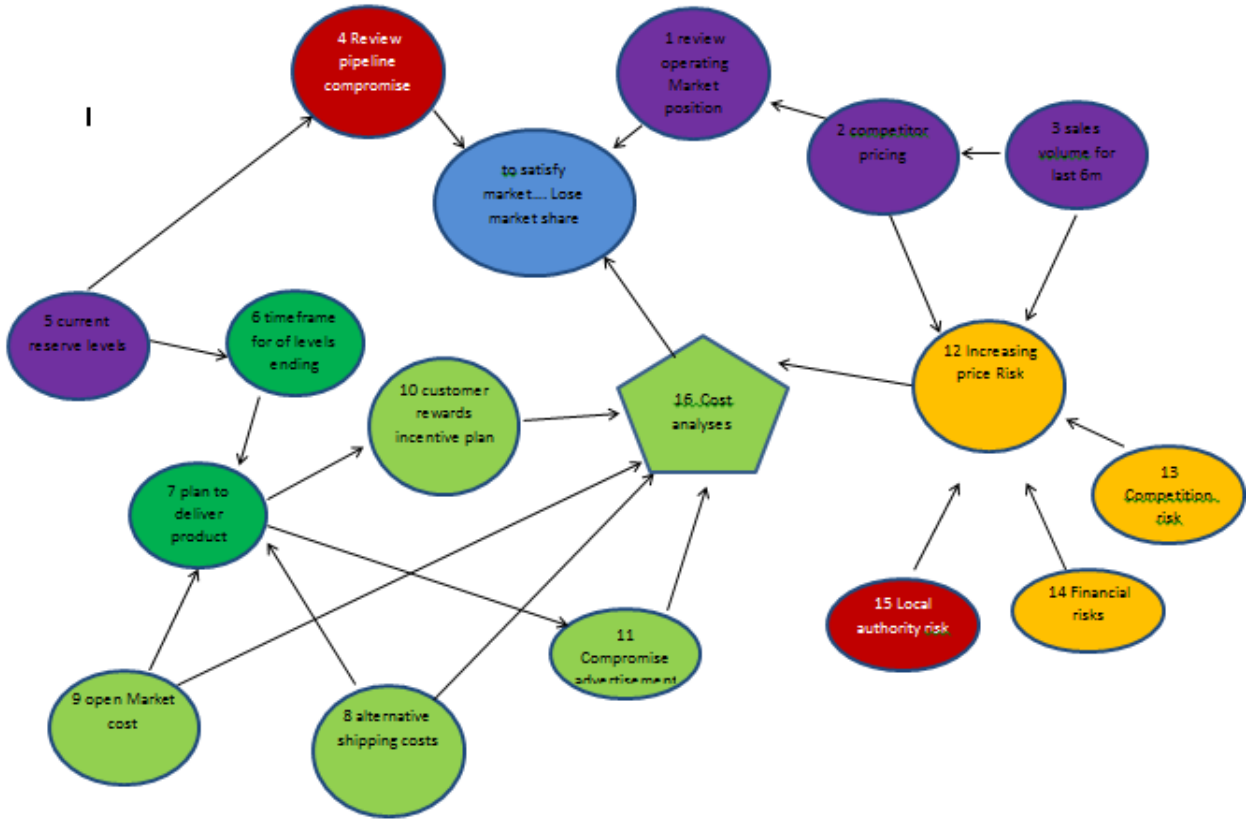

Figure 81 CM S4P7

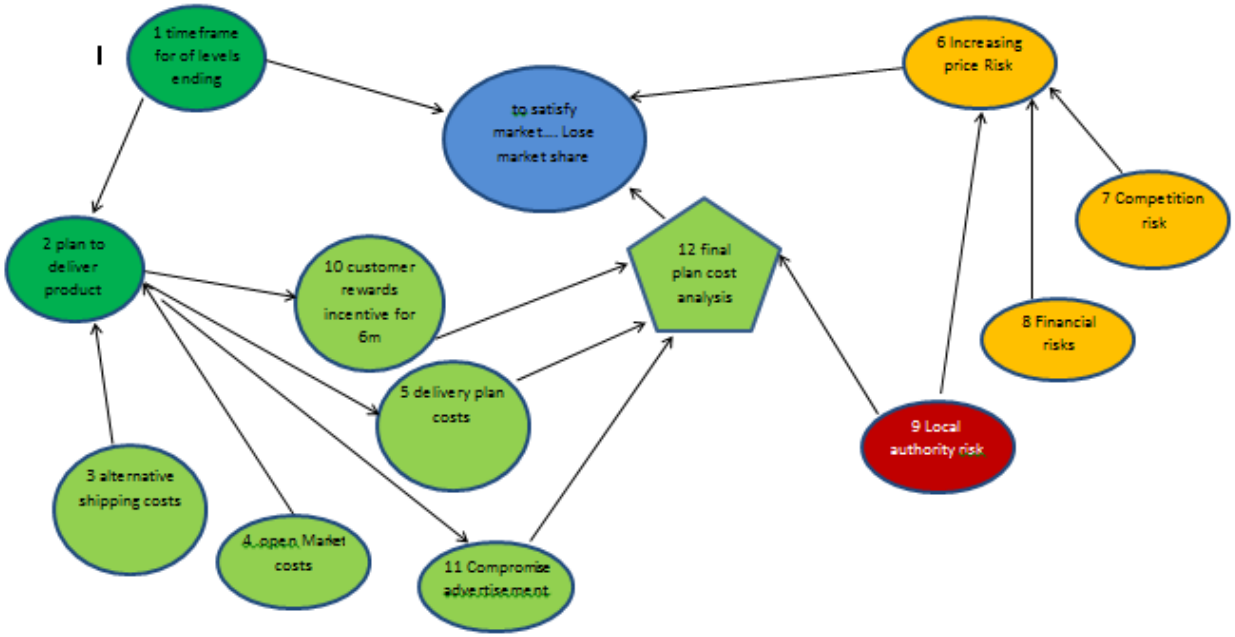

Figure 82 CM S4P8

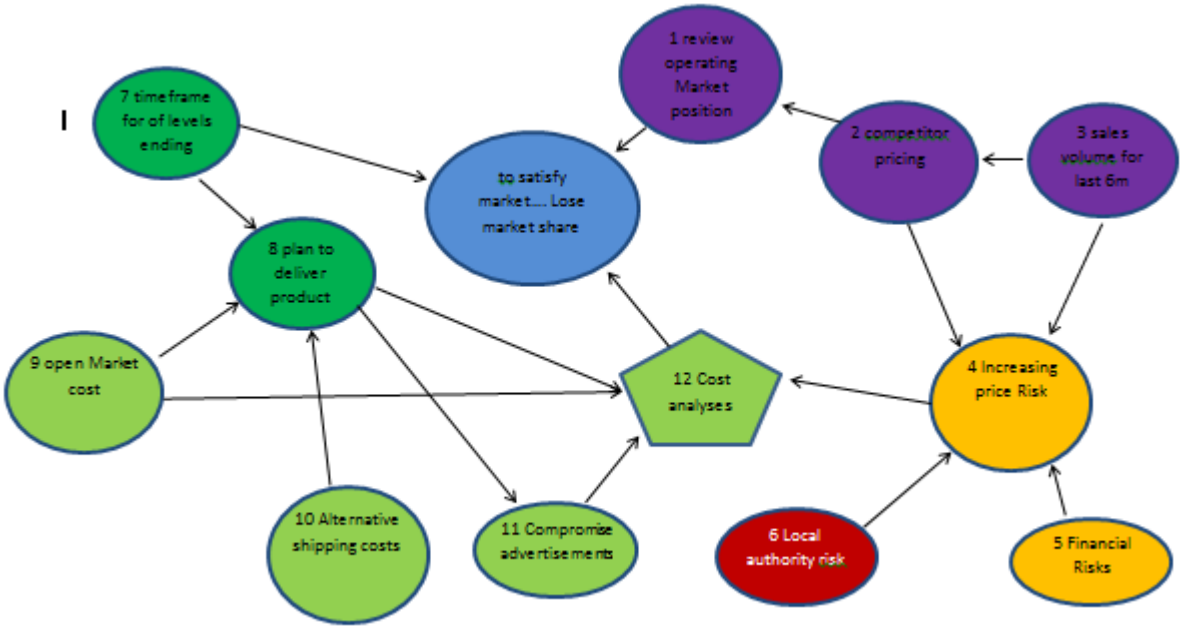

Figure 83 CM S4P9

Figure 84 CM S4P10

Figure 85 CM S4P11

Figure 86 CM S4P12

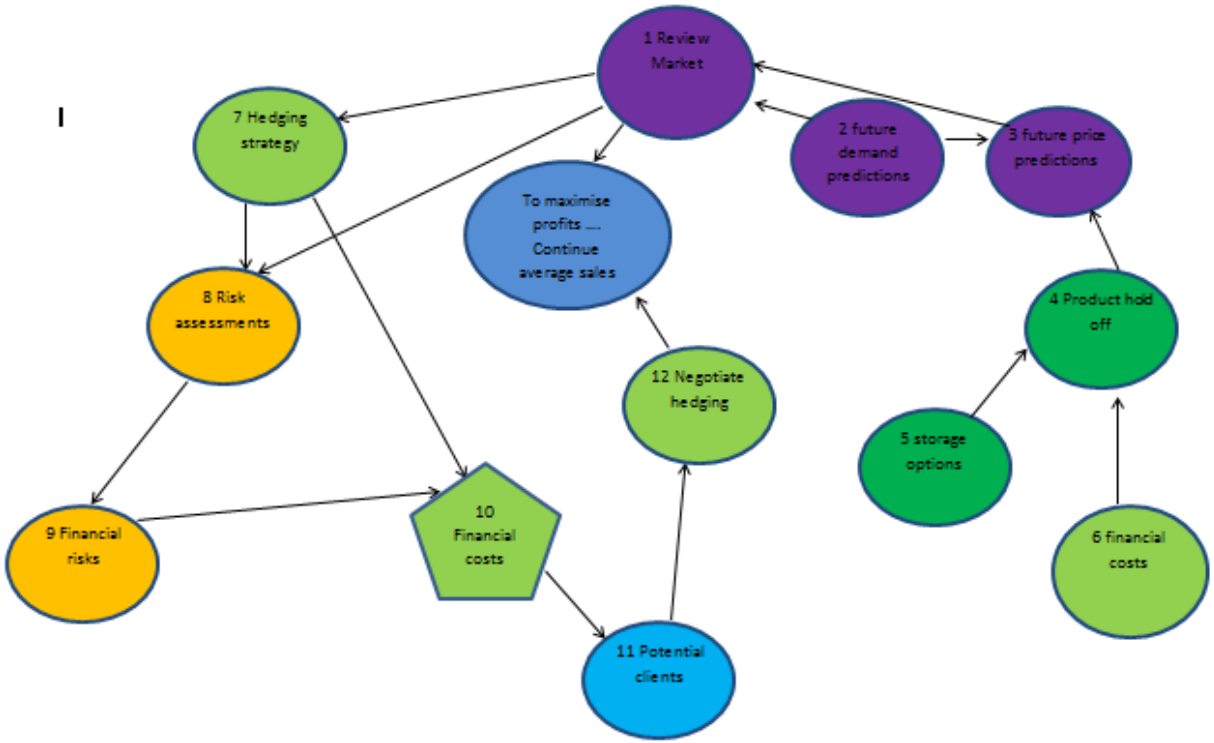

Figure 87 CM S5P1

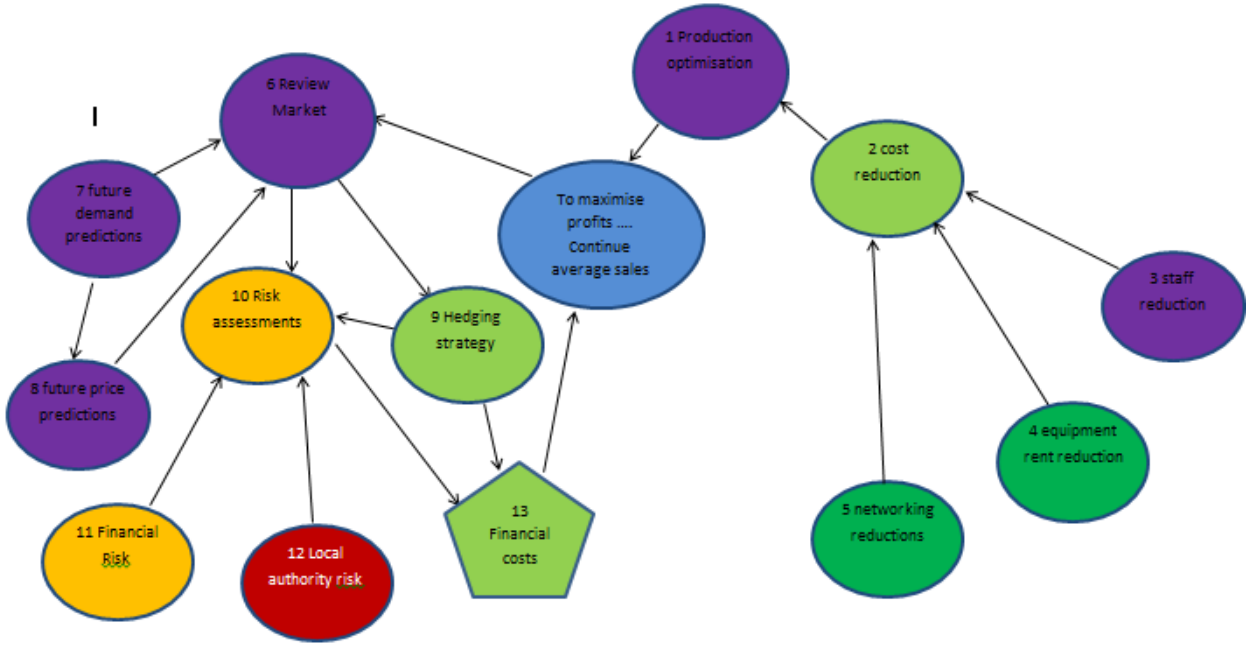

Figure 88 CM S5P2

Figure 89 CM S5P3

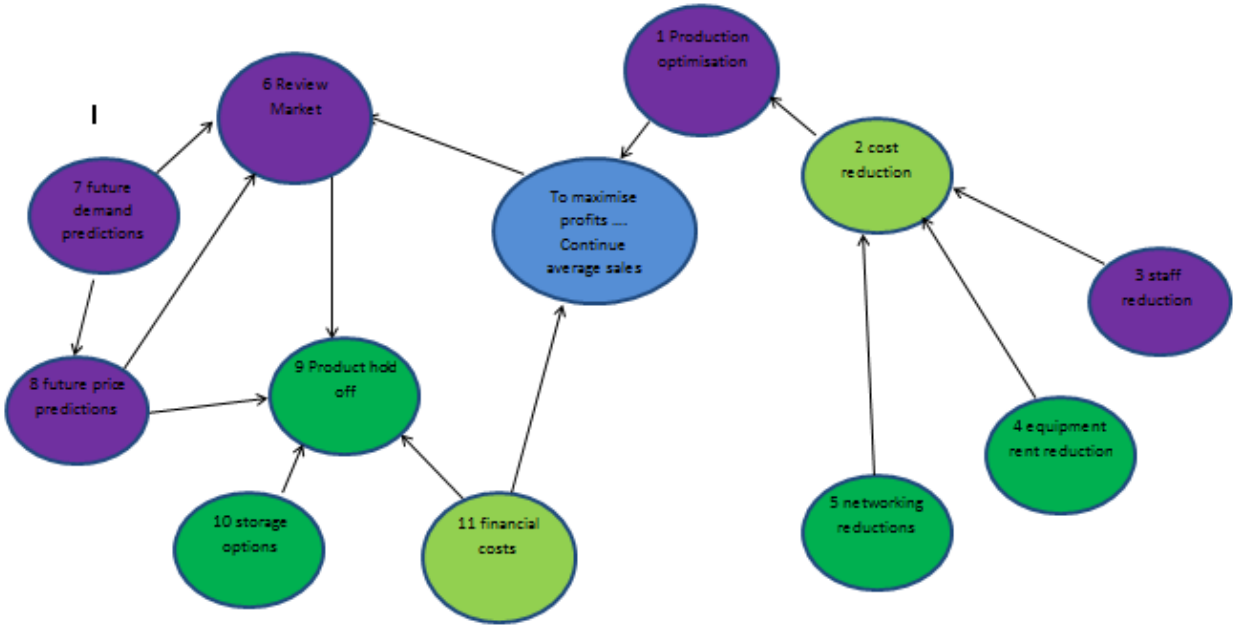

Figure 90 CM S5P4

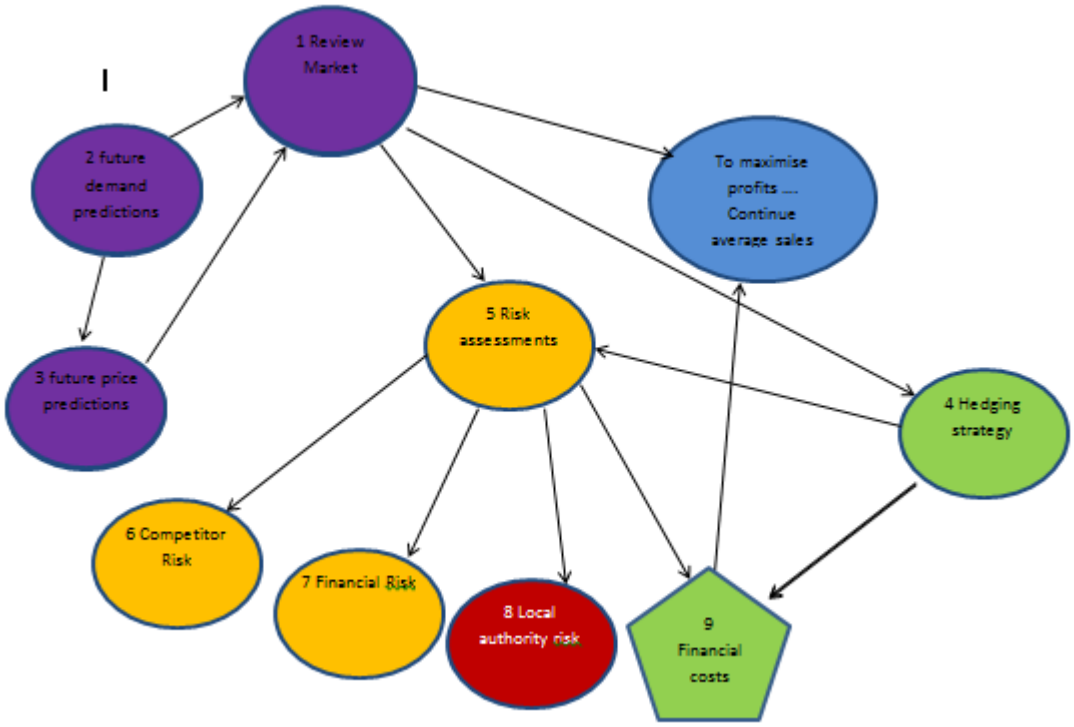

Figure 91 CM S5P5

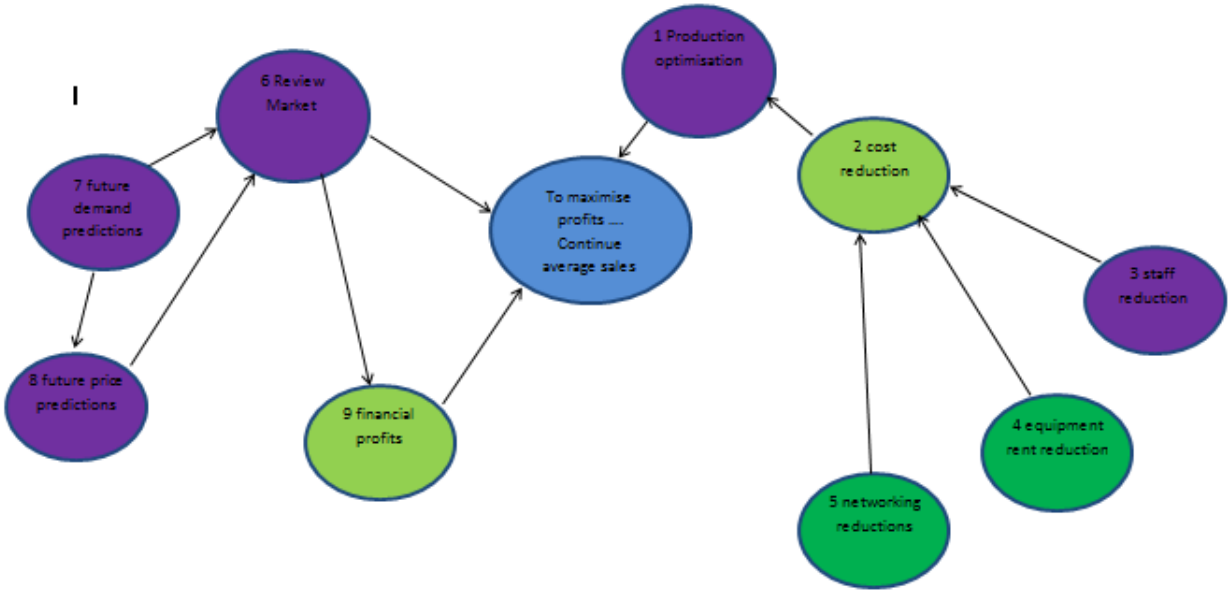

Figure 92 CM S5P6

Figure 93 CM S5P7

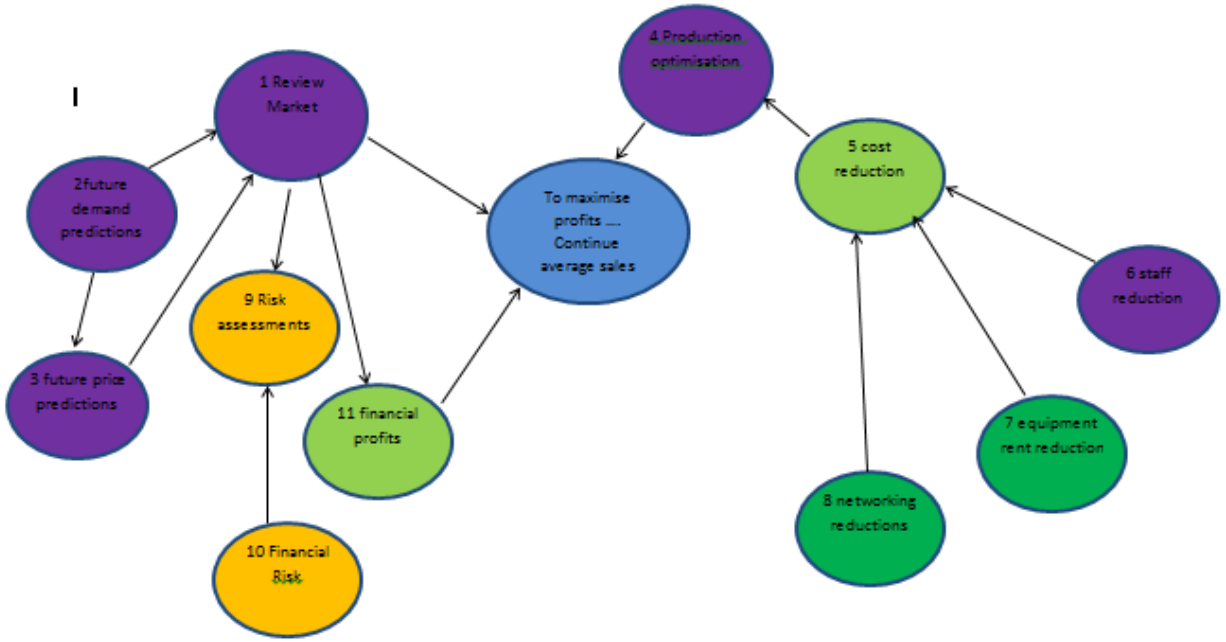

Figure 94 CM S5P8

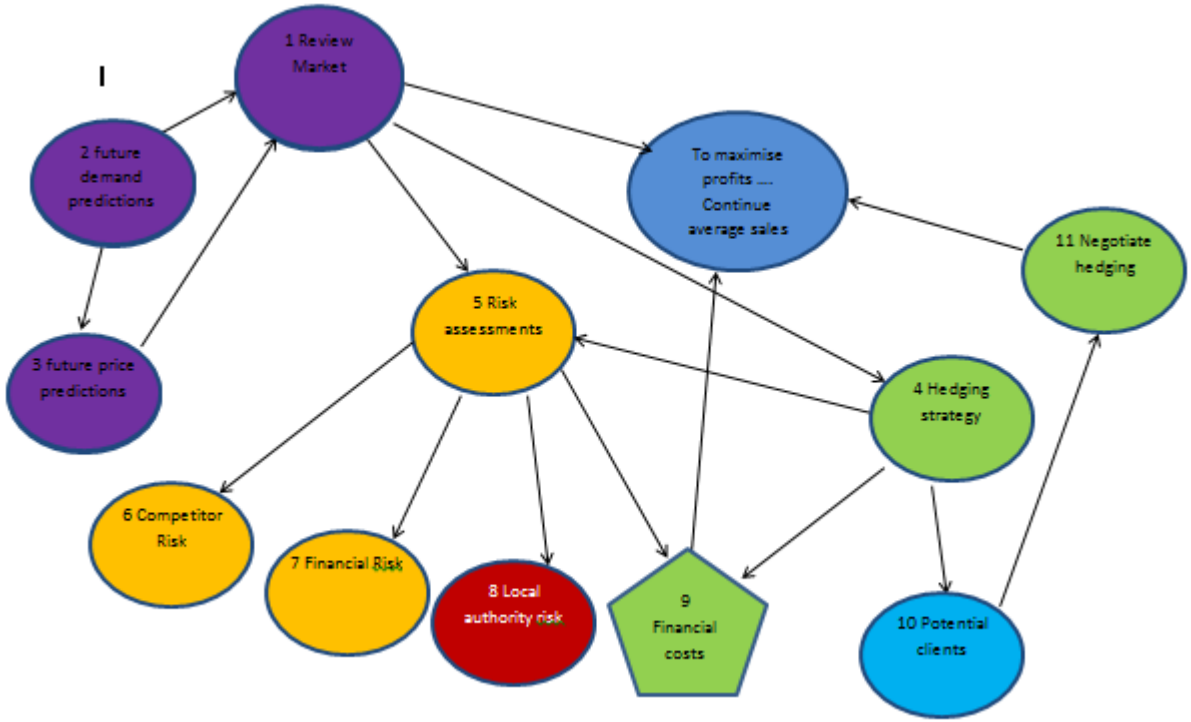

Figure 95 CM S5P9

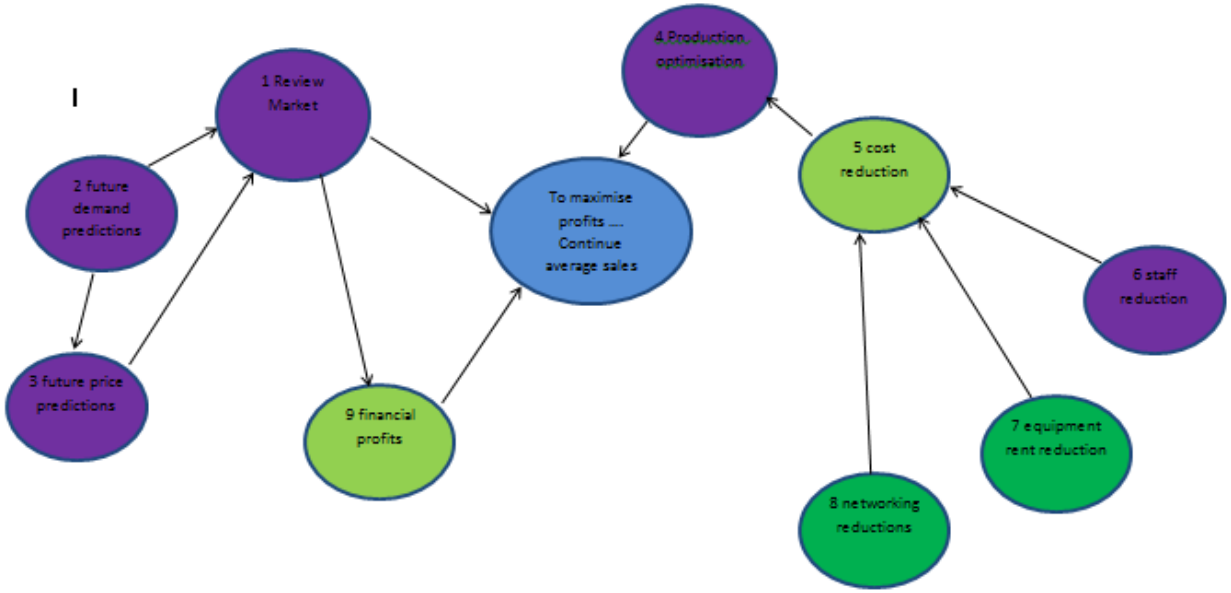

Figure 96 CM S5P10

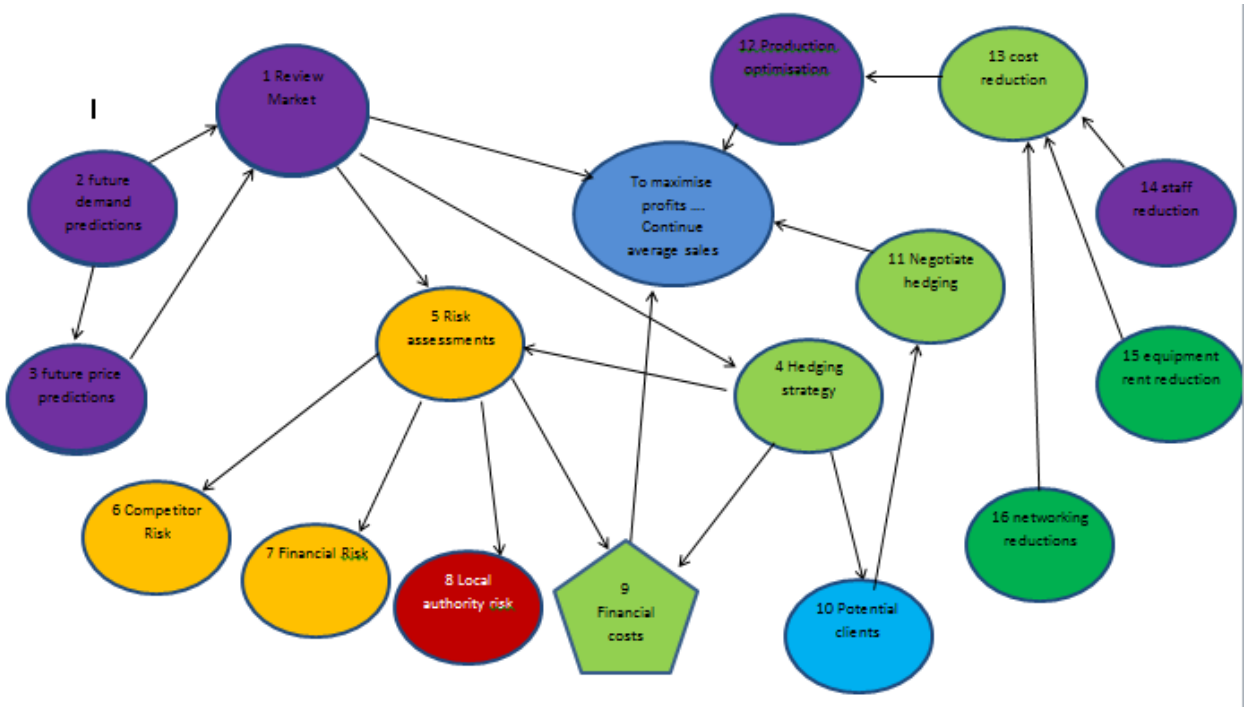

Figure 97 CM S5P11

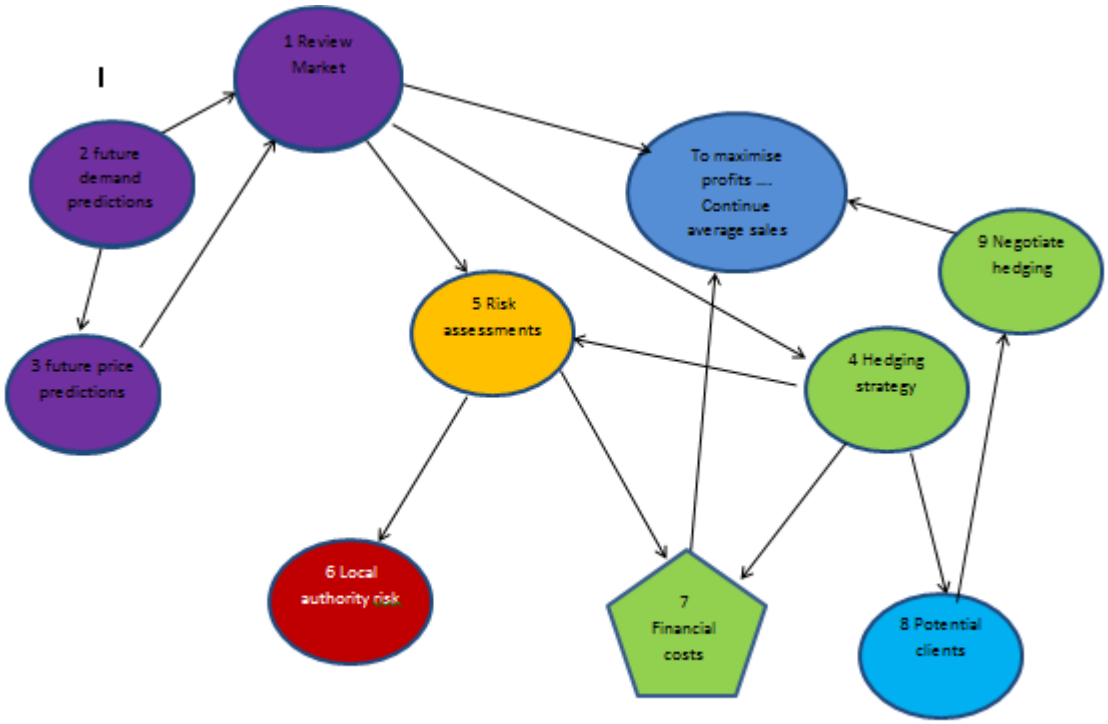

Figure 98 CM S5P12

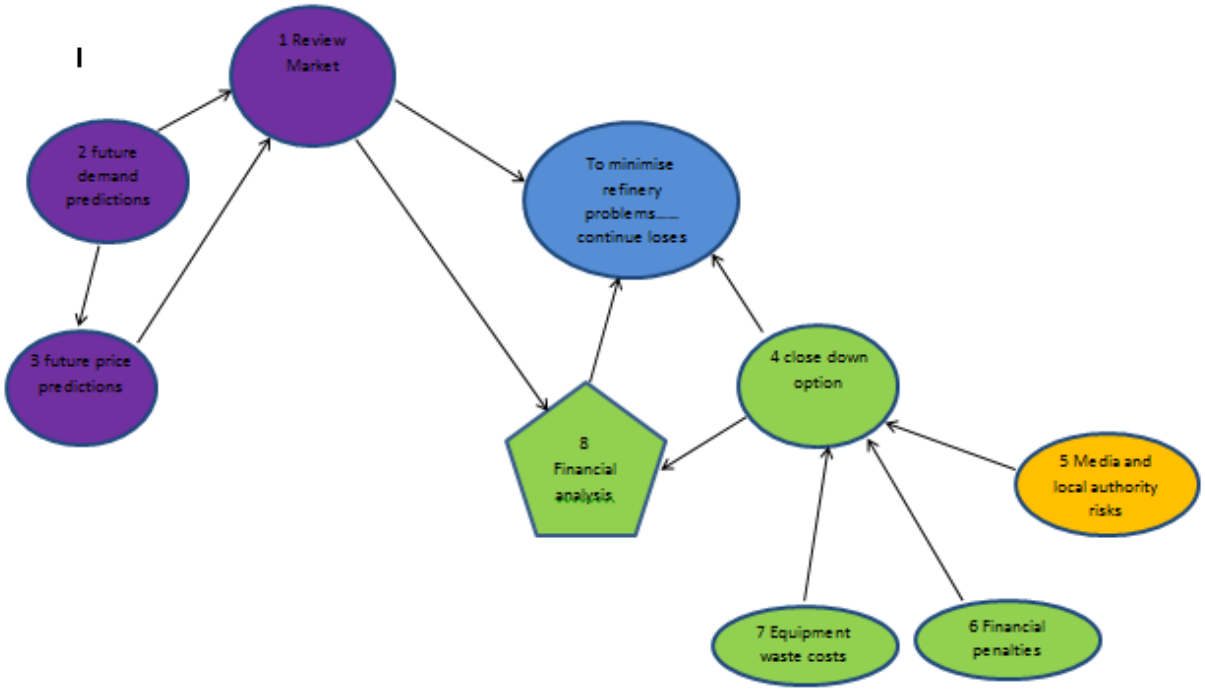

Figure 99 CM S6P1

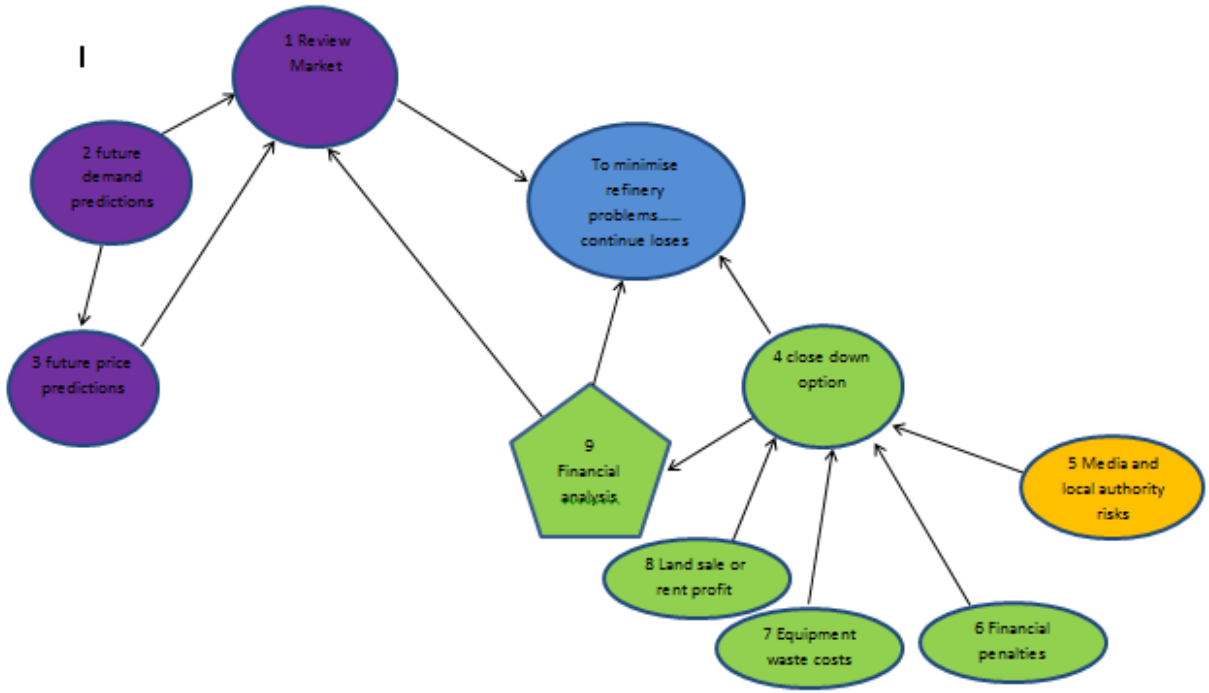

Figure 100 CM S6P2

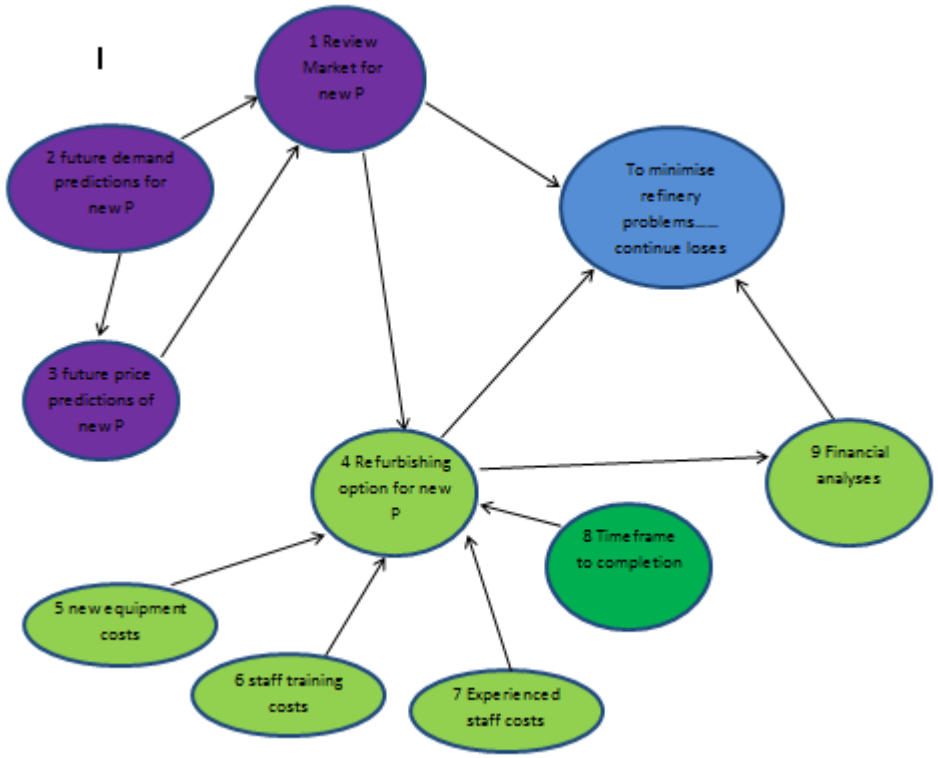

Figure 101 CM S6P3

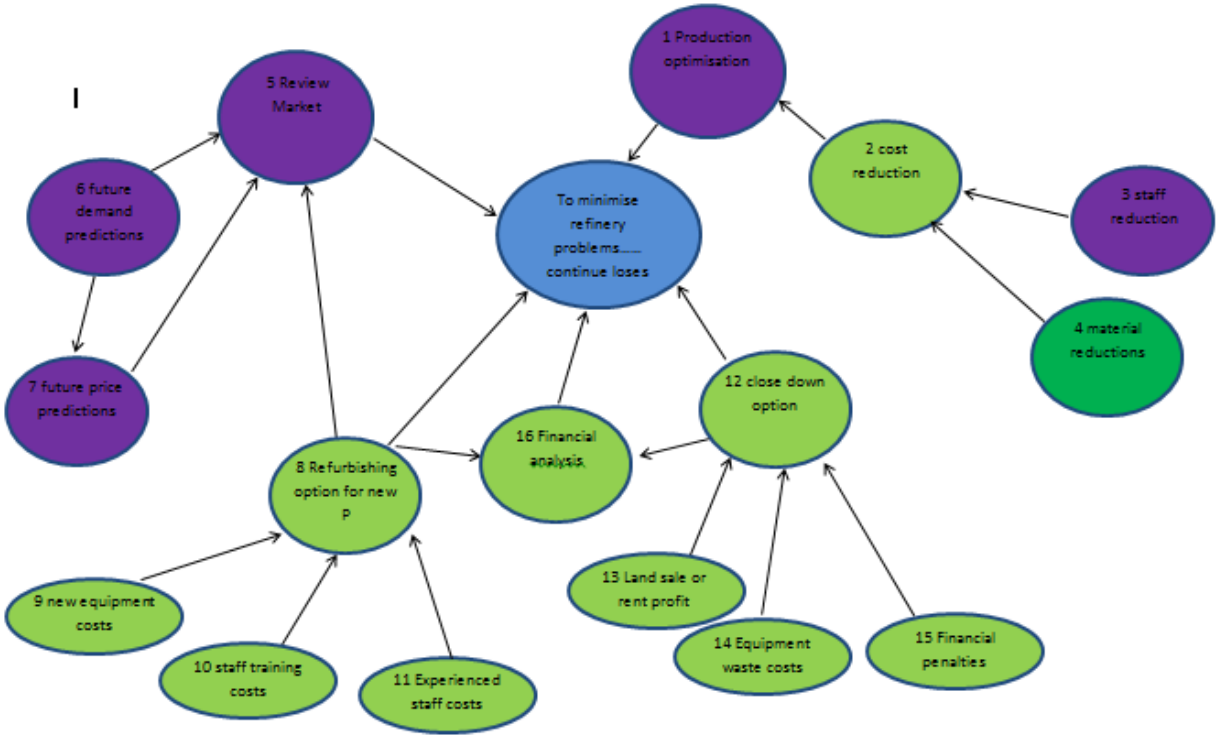

Figure 102 CM S6P4

Figure 103 CM S6P5

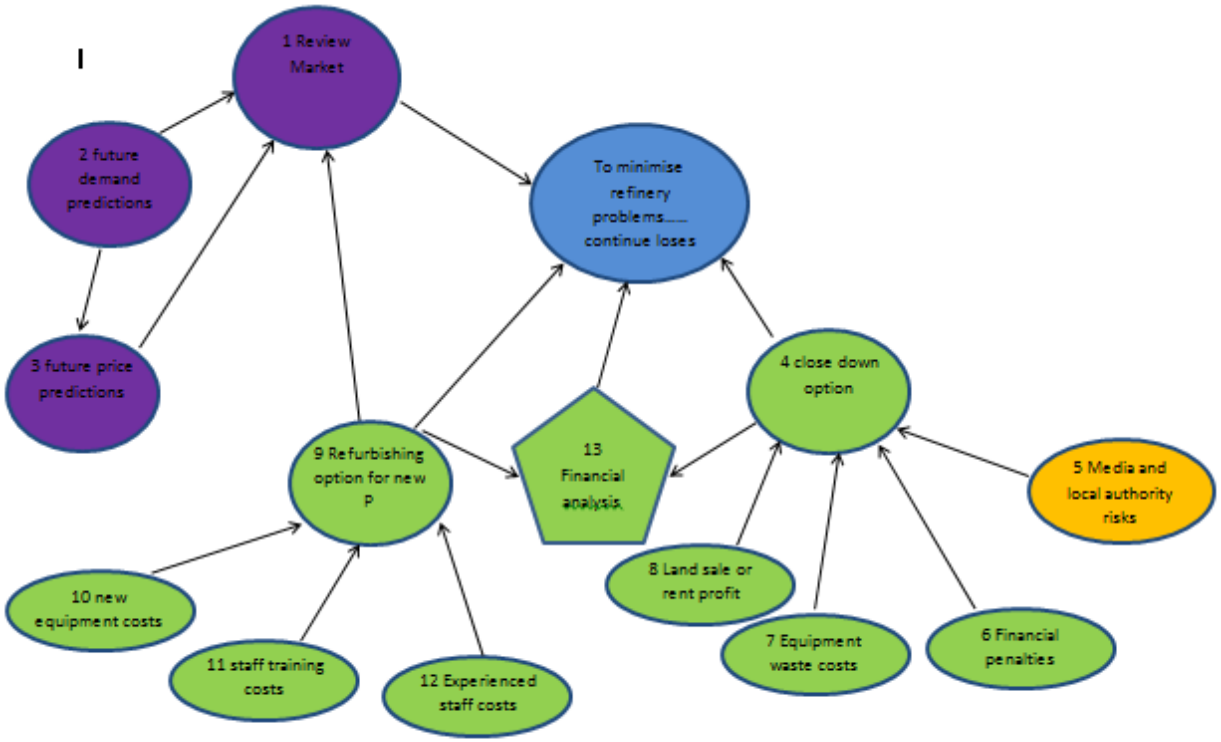

Figure 104 CM S6P6

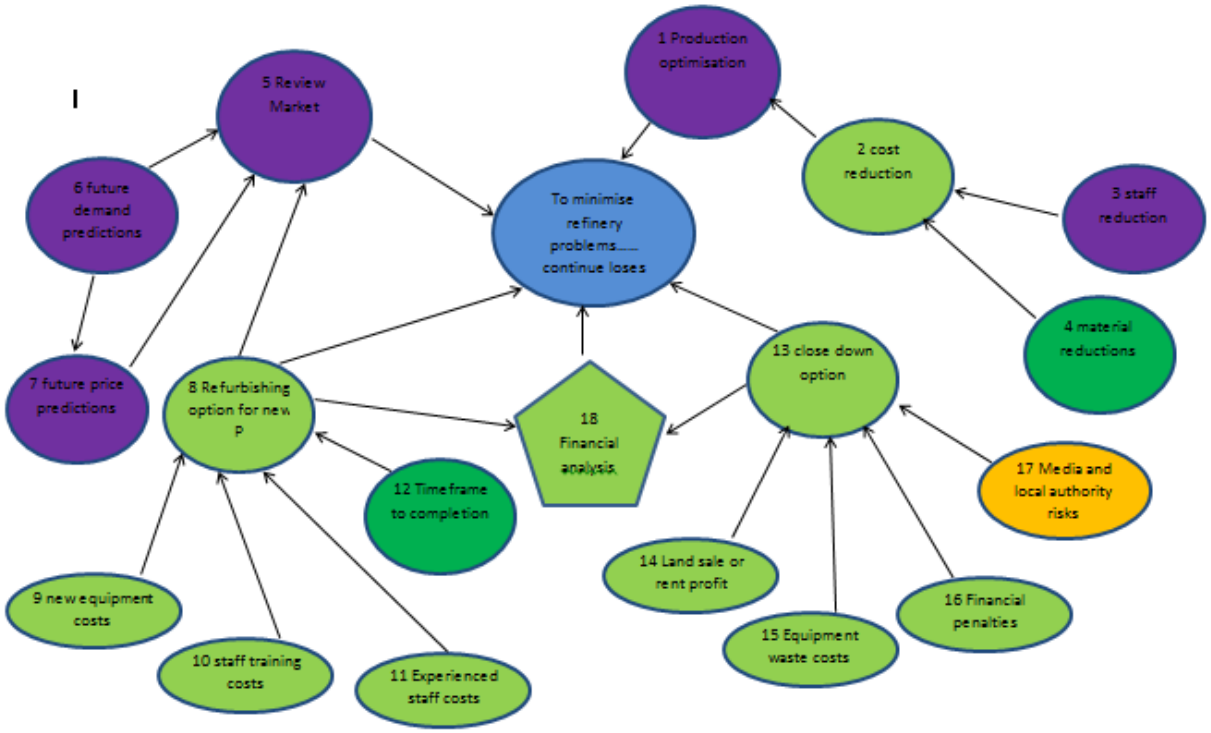

Figure 105 CM S6P7

Figure 106 CM S6P8

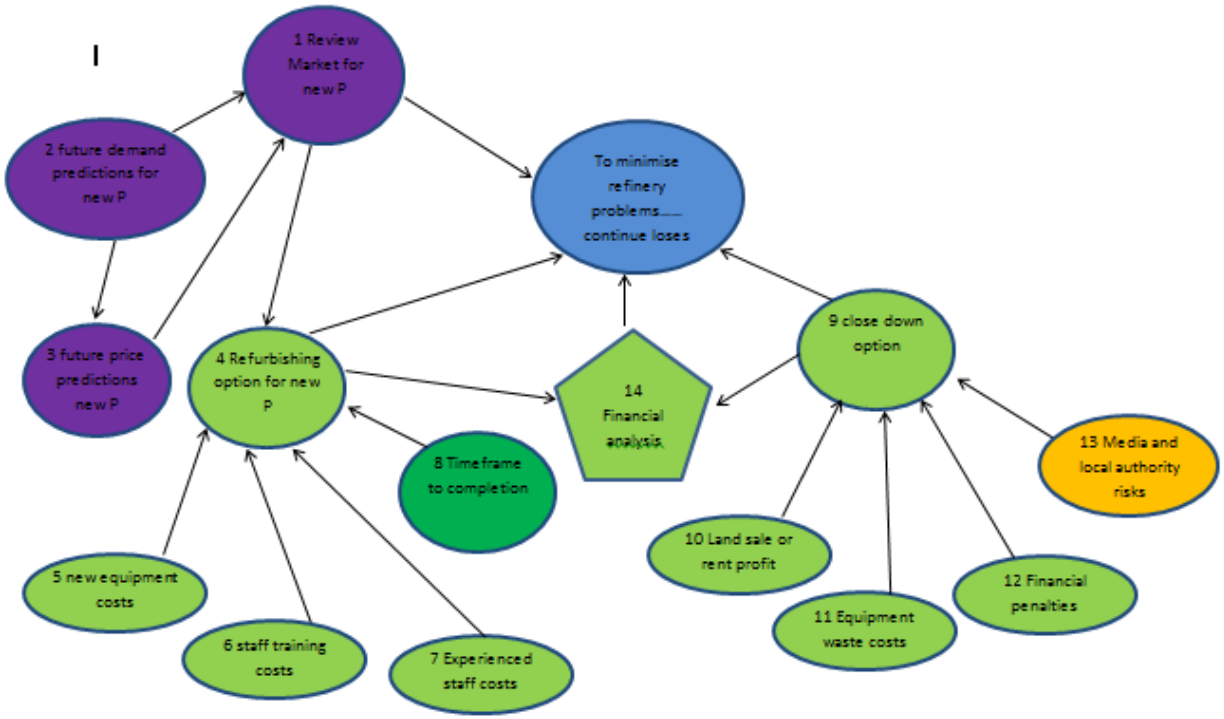

Figure 107 CM S6P9

Figure 108 CM S6P10

Figure 109 CM S6P11

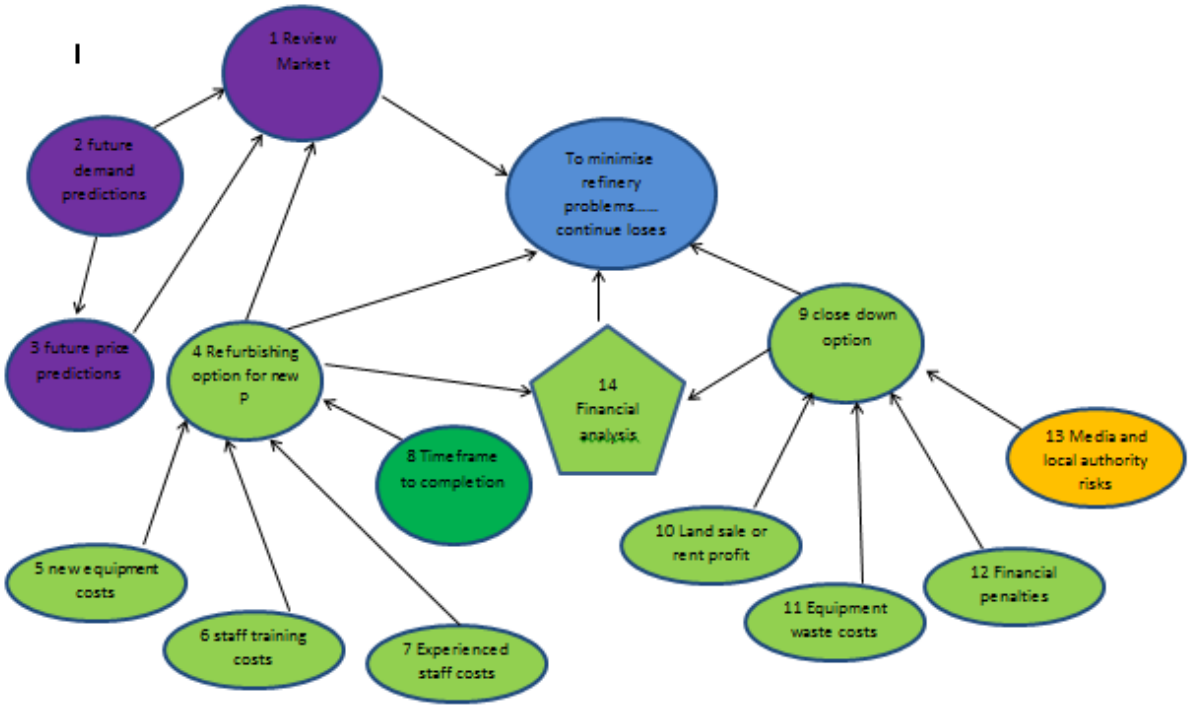

Figure 110 CM S6P12