Managing Risk in Operations: A Multi-Level Study

By

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Declaration

This thesis is submitted to the University of Warwick in fulfilment of the requirements for admission to the degree of Doctor of Philosophy. The work presented here is my own, and was performed at Warwick Business School, University of Warwick.

Abstract

This research explores the management of risk in operations. It explores the different structures influencing the treatment of risk and the influence on managerial risk taking behaviours. There is limited understanding within the extant literature of the different treatment strategies for risk in operations and what influences selection of treatment strategy. This research employs an abductive approach iterating between the theoretical and empirical. There are four levels of analysis: the firm, the function, the group and the individual. The research was conducted in two European Energy companies. The research found that there is a complex interaction between organizational structures and individual perceptions in managing risk. Corporate risk structures have limited influence on the selection of risk treatments. The specification of business function (service or asset focus) informs the process of risk management and use of systems. Use of systems and valuation techniques underpin the risk prioritization process and specifically the assessment of risk. There is an order of decision influences that reflects the Levers of Control (Simons, 1995; 1998): Risk treatments are prohibited by boundary systems. Secondly, individual's beliefs influence positive selection of treatment, and third where a treatment has not been selected through beliefs, the performance system is consulted. The performance system is most likely to influence selection of risk acceptance or risk mitigation. It is found that classification of risk has more than a semantic influence on perception and risk treatment; it can prohibit uses of certain treatments and inform priority. Understanding of the decision process matures and increases in complexity in senior managers. It is found that the performance system has influences on manager's beliefs and in the long term, reflecting vision and mission the implementation of boundary conditions.

Abbreviations

BSC: Balanced Scorecard

BSI: British Standards Institute

CEO: Chief Executive Officer

CFO: Chief Finance Officer

COSO: Committee of Sponsoring Organizations of the Treadway Commission

CRO: Chief Risk Officer

DUU: Decisions Under Uncertainty

EAM: Energy asset Management (FCORP)

EFA: Exploratory Factor Analysis

EGEN: Energy Generation (GRS)

ERM: Enterprise Risk Management

ERS: Energy and Retail services (GRS)

FCORP: French Corporation

FD: Finance Director

FRET: FCORP Retail (FCORP)

GRS: German Retail, asset and services

ISO: International Standards Organization

KPI: Key Performance Indicator

KRI: Key Risk Indicator

MCS: Management Control System

M^C: Map Centrality (see section 6.2.2)

M^D: Map Density (see section 6.2.2)

N^C: Node Centrality (see section 6.2.2)

PMS: Performance Management System

PP: Performance Prism

RAROC: Risk Adjusted Return on Capital

VaR: Value at Risk

Chapter 1

1. Introduction

This research is concerned with the management of risk in operations. Mikes identifies the gap in understanding (2009:19) as:

What do risk managers do and what function and structural arrangements organize their activities? … How are control systems used by decision makers?

This research extends this understanding from an Operations Management standpoint.

1.1 Research Rationale

The idea for this research began as I worked as a general manager in an energy company. I had operated across a number of functions, roles and variety of levels in management. As I became more senior, and exposed to increasingly strategic considerations, it became apparent that my management of resources in operations and through change was underpinned by an overarching requirement to manage risk. For example, I was managing my resources against a conflicting set of demands from different clients, trying to minimise the potential for defaulting against well-established contracts, choosing a path that would expose the operation to a minimal level of financial or reputational loss.

I found it difficult to reconcile the actions of my colleagues, who seemed to be taking risks, where I felt constrained by the requirements on me from the firm. As I changed from retail (sales and service), to asset (power generation) and finally to trading I sought reference points to what was successful risk management. Understanding of this was poorly defined.

On seeking promising practice from practitioner and academic sources I found that risk management was understood within the finance discipline, and less well defined in operations management. Understanding from financial disciplines aligned to my role in trading, but did not explain the risks I was managing in retail and asset management. The primary tool available to me in steering the operation was the company's performance management system.

The performance management system, and specifically the Balanced Scorecard, appeared as a tool for aligning operational objectives with strategic requirements. But there was a gap in understanding as to how a performance management system is used to manage risk, risk taking or even the perception of risk. As my responsibility for employees increased from a handful to a few hundred, and across multiple locations I became increasingly reliant on the performance management system as a tool to direct the operation functions. The risks I was managing were increasing in magnitude (i.e. value) and complexity (i.e. integration of risks). With this increased responsibility, the aggregation of risks being reported and managed had changed from transactional (cost-benefit) to complex priority and risk-bearing decisions.

My concerns were discussed with the company's executive management team. It appeared that I was not the only manager interested in developing an understanding on how to manage risk through the organization with more precision. My enquiry led me to understand a hidden process of risk management, driven by the corporate functions, laden with reporting requirements and with limited operational engagement.

I returned to the executive team with a developed understanding of the process, but felt this was still poorly understood. Risk management was becoming an increasingly important discipline within the sector, and the complexity was increasing because of growing political and public interest in the energy sector. The executive team felt that the practitioner literature was limited and shallow in its understanding of risk management levers. That understanding was based on a simplified and mechanistic process of data collection and stakeholder management. They felt it missed the complexity of the energy sector's environment, where there are many different stakeholder demands and many different types of risk being faced. The Chief Finance Officer (CFO) supported this concern, and articulated the business imperative behind developing an improved understanding of performance managing risk:

"I want to understand the mechanisms available to me to change our risk management process, whether we can operate like financial institutions in our assessment of risk, or whether we are fundamentally different. I wish to be able to desensitise certain aspects of our organisation and turn-on others." CFO, UK Energy Company.

During early analysis, it was apparent that although trading activities existed as part of some energy companies, the greatest complexities arose where organizations were reconciling the different issues in pure risk (the risk of loss). There were issues in running parallel pure and speculative risk (the potential for loss and gain) management processes. It was this reconciliation that was not effective.

Looking beyond my company, it was apparent that energy companies showed an intent to develop their risk management process, wishing to make this a function for competitive advantage and not just a process *'of hygiene'* (i.e. a task required of them by regulators and auditors). There was a common question, whether financial institutions should be a model for risk management, and replicated in energy. This was a reflection on the Basel Accord (2006; 2009), which defines banking supervision requirements through a set of voluntary standards and risk classifications, therefore the question was asked:

"Should the energy sector adopt the classification defined by the Basel Accord as a suitable standard for their risk management process?" CFO, UK Energy Company.

Scanning the environment that was accessible to me, there seemed a large variety of different performance systems in use; some were used to record performance and others to direct activity and priority.

This is where the interest developed for developing a deeper understanding of the performance management of risk in the energy sector. This research clearly has managerial implications, but as the next section shows it has the potential to make a theoretical contribution.

1.2 Theoretical Background

Understanding of management of risk in operations is covered across several bodies of work: **Performance measurement** (Bourne et al., 2000; Neely & Austin, 2002; Otley, 2008) and **performance management** (Franco-Santos et al., 2007 Neely, 2005; Otley, 1999), **risk management** (Chapman, 2006; Cohen & Kunreuther, 2007; Kleindorfer & Saad., 2005) and **behavioural science** (Kahneman & Tversky, 1984; Pennington & Tuttle, 2007; Peterson & Beach, 1967; Tversky & Kahneman, 1992).

The **performance measurement** and **management** literature is well established. It has a long lineage both in Operations and Performance Management (e.g. Bourne et al., 2000; Neely & Adams, 2002; Otley, 1999) and Management Accounting (Anthony, 1965; Mikes, 2011; Power, 2005; 2009). There is a difference in focus between the Operations Management and Management Accounting communities. Management Accounting has been developed with a financial focus (cf. Mikes, 2009). Operations Management has been more holistic in its understanding, it has developed an interest in both the breadth of stakeholders and the mapping of strategy into objectives (cf. Kaplan & Norton, 2008). Over the last decade these two communities (i.e. performance management and measurement) have converged on a discussion that is now harder to separate (cf. Otley, 1999).

The literature on *control systems* (Anthony, 1965), *performance management systems* (Kaplan & Norton, 2008) and *performance measurement systems* (Bourne et al., 2000; Neely, 2005) overlaps (cf. Franco-Santos et al., 2007). It may appear to be a semantic issue between the different terms *management* and *measurement*. However the literature does clarify that the performance measurement system is a wholly encompassed aspect of the performance management system (Otley, 2008). Reconciliation of these classifications is not well defined with management control system literature, so leaves ambiguity in the literature.

The **risk** literature is less well defined. It is diverse and the boundaries of the subject are fuzzy. As a topic that has interest across all disciplines, discussion of risk is heavily intertwined in a breadth of subjects. There are a number of approaches to describing this body of work: community specific discussions of risk (i.e. the banking sector), discipline based perspectives (e.g. supply chain, Cohen & Kunreuther, 2007), project management (Raz & Michael, 2001), and theoretical discussions of risk (e.g. inherent and residual risks and the meaning of probability, cf. Zwikael & Sadeh, 2007). There are research themes on different aspects of the risk cycle (e.g. valuation techniques, Chapman, 2006). Finally, there are defined risk management frameworks (e.g. Enterprise Risk Management) and risk standards (e.g. Committee of Sponsoring Organizations of the Treadway Commission, 2004). All of these bodies of work provide an understanding of risk and how it may be managed.

The literature on risk appears to be dominated by discussion of different classifications of risk (cf. Power, 2005), and defining appropriate risk management cycles (COSO, 2004; 2004b). This again is more than a semantic issue (Power, 2005). Operational risk is a description of risk from the Basel Accord (Basel Committee, 2005; 2006), and banking sector explicitly. It is a risk originating from people, processes and systems (Basel Committee, 2004). This is different to risk in operations (Lewis, 2003). Risk in operations is broader in understanding; it includes a multiplicity of risk types (cf. Dey 2004), and a description of risks occurring in the transformation process. However, understanding of Operational risk is important in the body of risk literature. It is often confused as a term, and used extensively by practitioners. It is well defined in its relationship with Credit and Market risk and the associated valuation approaches. In practice there was confusion in the term, as either a specific and technical classification or a more general *catch-all* term (Power, 2009).

Besides the sector-specific definitions of risk, there is a body of work discussing industrial approaches to risk management. These are the risk standards or frameworks. Current thinking is that risk management should be an iterative process (BSI, 2009; Chapman, 2006). It should cycle through: *identification, assessment, analysis, treatment and control*.

The best known of the risk management frameworks is ERM (Enterprise Risk Management). ERM provides definitions, process and structure for managing risk (Beasley et al., 2010). However it is understood that implementation is often imperfect. There are a number of standards that pertain to an ERM approach; these have different focuses and definitions embedded within each (e.g. COSO ERM).

Referring to practice, risk management effectiveness is viewed as a product of its decisions. These decisions are discrete, with limited choices to be made, for example mitigation (cf. Slack et al., 2010), risk transfer (Sharpe, 1997) and termination (Hopkin, 2012). This simplicity is surprisingly limited in coverage as a complete discussion in extant literature. There is empirical and theoretical discussion of risk treatments (i.e. outsource, Teng et al., 1995), but this is conducted either as individual treatments or at an abstract level that has limited insight into how these different choices are influenced.

The third body of work reviewed is from the **behavioural sciences**. This is a large body of knowledge, which has many features and sub-topics. The sub-topic of interest is *decisions under uncertainty*. This literature (e.g. Kahneman & Tversky, 1984; Peterson & Beach, 1967; Pennington & Tuttle, 2007; Tversky & Kahneman, 1992) provides an explanation to many of the human factors seen in risk management. Prospect Theory is highly cited and critically reviewed, as a theory to understand the influence on risk decisions. Prospect theory provides a link to many of the different concepts underpinning an understanding of decisions (Kahneman & Tversky, 1984). They define the different decision-making strategies that people use (Payne et al., 1988), how time pressure affects these decisions (Pennington & Tuttle, 2007), and further how weighting (Wedell & Senter, 1997), bias (Hsee & Hastie, 2006) and aversion (Wiseman & Gomez-Meija, 1998) can be of influence. This knowledge provides an understanding that risk is a subjective phenomenon, which has direct impact on the organization and the individual.

In bringing these different bodies of work together, four theoretical frameworks are discussed: *Calculative Cultures* (Power, 2005), *ERM Ideal Types* (Mikes, 2009 & 2011), *The*

Levers of Control (Simons, 1994; 1995) and *Principle Agent Theory* (Eisenhardt, 1989). The rationale behind using these frameworks is explained in sections: 2.3.3, 2.3.4, 2.8.7 and 2.6.13.

So, although there are a few well-established frameworks and theories to understand the management of risk, there is a gap in understanding as to how organizations and managers control risk decisions. Risk treatments (e.g. mitigation), are the strategies organizations can deploy (Hopkin, 2012). The influence of different controls, performance systems and behaviour are not understood as to their effect on selecting these risk treatments. Is this a matter of individual beliefs and frames of reference or is this a rational and consistent process of treatment selection? Where there is an environment presenting a multiplicity of risk types (e.g. safety and reputational risk), there is a lack of understanding as to the different perspectives these risk types engender.

1.3 The Purpose of this Research

The purpose of this research is to understand **the treatment strategies for risk in operations** and **what influences selection of treatment strategy;** therefore contributing to the knowledge of managing risk in operations. As this research is situated as a study in operations, this research distinguishes between managing risk as the potential for risk and reward, and risk as the management of loss, arising from operational activities (e.g. power generation).

Inherent in these questions, the different levels of the firm need to be understood as to their influence on risk management and evidence the inputs and outputs of the process. Each level of the organization, starting at the firm (representing the central and corporate perspective) provides an understanding of how the next level is being managed. Performance system literature (e.g. Bourne et al., 2000) suggests that mature and integrated approaches support an iterative development and check on strategy. The performance system (or control system) can be understood as a mechanism to develop and communicate objectives and measure activities against objectives. In large corporations (as seen in the energy sector) the use of performance systems are desired to be a framework that disseminates these objectives and measures across a distributed (both technically and geographically) organization. This research takes a top-down approach (in order of: firm, function, managerial group and finally individual) to reflect one view of the performance system.

The Business-Units (BU) report into the corporate functions, they are the next level of the organization. These are semi-autonomous organizations delivering to a specific market, often independent of other BUs. There are several cases available for comparison, but the greatest polar examples are the retail functions (selling power and gas to the market) and the generation functions (the production of Power).

It was observed during the design of the research that different management communities existed within these functions, relating to levels of authority in the organization. These communities have access to different types and degrees of resource (i.e. employees and capital). There was a presumption that different management communities have different levels of strategic and operational demands and therefore access to knowledge (cf. Yang et al., 2009), this forms the third level of analysis: the group-level.

The most granular unit of analysis is the individual. The organization is made up of a structured collection of individuals, each which bring with them different experience, judgement and personal contingencies (e.g. risk aversion).

These four levels of analysis provide the structure of this research; each level informing the next on how to operate and potentially how to manage risk. The research method also has to reflect this evolution of the frame of reference; this is the use of the abductive approach.

1.4 Contribution of the Research

This research makes contribution to both theory and practice. The analysis found that replicating *Operational risk* practices (from the financial community) is not appropriate for the energy sector. Its purpose is different and does not reflect the multiplicity of risk types in the energy sector. Further, there were differences in the desired and observed influences, for example ERM adoption was meant to influence the design of the risk management process, whereas this influence was limited as it did not permeate into the BUs; where local culture and market influences dominated. Academically there is ambiguity in the literature, there is limited understanding of how different levels of the firm interplay.

It was found that the corporate functions focus on standards and communication. The business units operate in specific disciplines, and define the system and micro-processes in their organizations. In moving to a study of managerial groups, the focus becomes the mental models existing within these communities. Finally, individuals reflect their own beliefs, sensitivities to measures and personal experience in decision-making. This is clearly a multi-level phenomenon.

The research extended understanding of Simons' (1995) Levers of Control. It found the levers have order of influence. Further, that managerial belief was affected by the classification of risk. The research showed different decision models existed between senior and middle managers. Fundamentally, the influence of function has great bearing on the risk management process, risk perceptions and behaviours.

A framework identified for risk classification offers the practitioner a standardised approach to integrate different risk types. Academically it exposes the challenges in managing an environment which has a multiplicity of risk types.

For practice, this research responds to the question of what structures and influences are in force to manage risk in operations, this is seen as a process of selecting risk treatments. This research exposes the influences on the different paths to treatment selection; where each treatment (or absence of) infers different levels of risk taking or aversion.

This research highlights a number of further research opportunities, which through extension would provide a greater understanding of the phenomena of risk management in operations. From the results there are opportunities to extend this understanding into other sectors that demonstrate similar multiplicity of risk types.

1.5 Research Structure

This research uses an abductive method. Abductive methods cycle between observations of the environment and explanations. At each phase the research reviews the findings, leading to a set of observations, which the next phase of research then seeks to develop. The adoption of an abductive approach is an iterative approach to extend theory or offer new theory. It is a cycle of theory matching, observation and suggestion (cf. Dubois & Gadde, 2002). Figure 1.1 summarises the structure of this research.

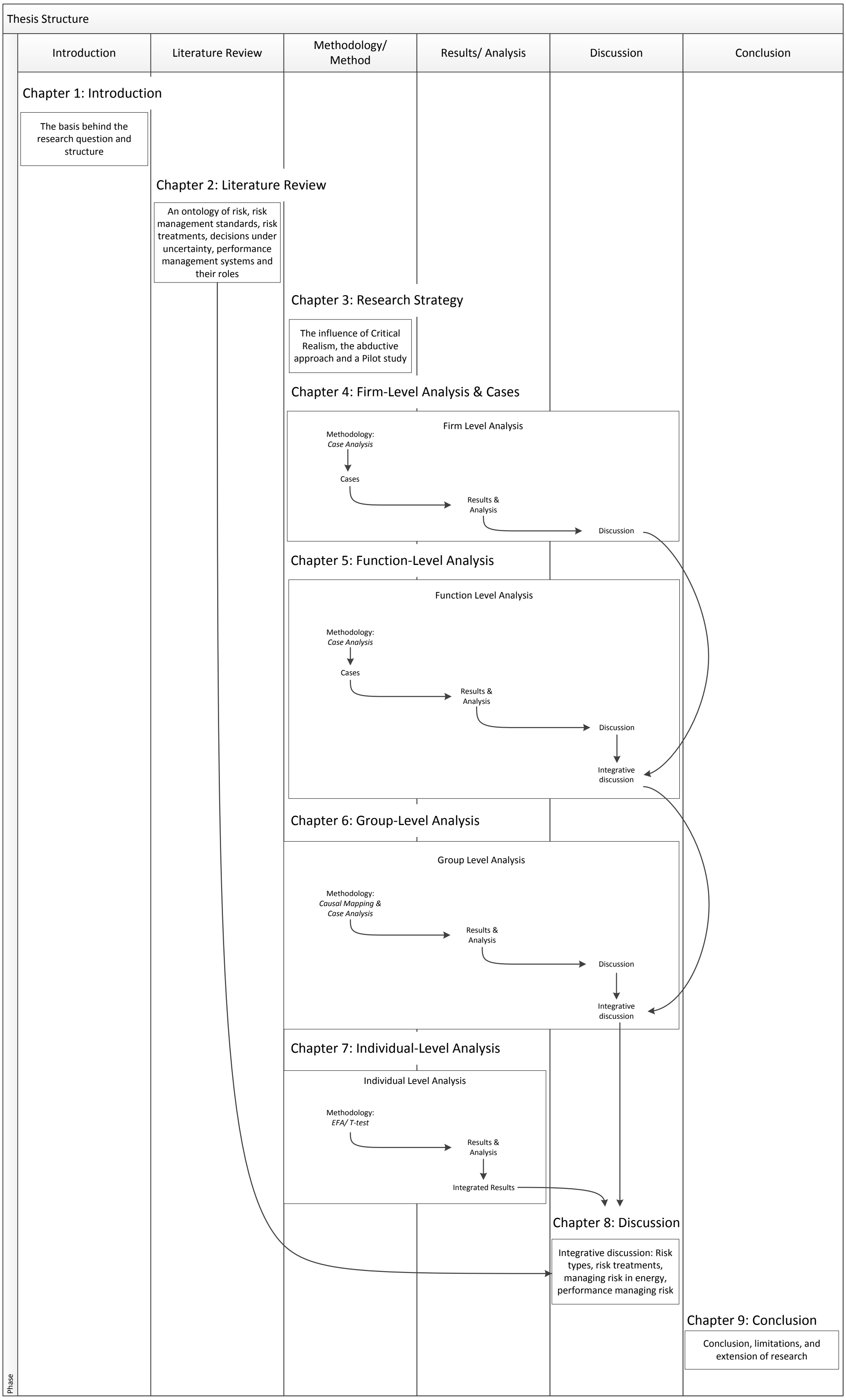

Figure 1.1 Research Structure

Following the introduction, a literature review is presented (Chapter 2); this is broken into three main sections: Risk, Decisions Under Uncertainty and Performance Systems.

Chapter 3 is the research strategy; it provides a structure and philosophical stance relevant to the whole thesis.

Chapters 4 to 7 report the four levels of analysis. Each chapter contains a description and justification of method. Next, results and analysis are presented, and finally a discussion (first within the level, secondly between levels). The levels of analysis are as follows:

- Chapter 4, Firm-level: Exploratory Case Study, thematically analysed;
- Chapter 5, Function-level: Exploratory Case Study, thematically analysed;
- Chapter 6, Group-level: Exploratory Case Study, thematically analysed and casually mapped;
- Chapter 7, Individual-level: Statistical Analysis of perceptions and risk treatment use.

Chapter 8 synthesises the different points of understanding and develops a new model of cause-consequence, and extensions to the levers of control and treatment selection. It concludes with a discussion of the impact to practice, and a sponsor summary (responding to practitioner questions).

Chapter 9 is the conclusion, summarising the contributions to theory and practice, limitations and extensions to the research.

Chapter 2

2. Foundational Literature

There are three main bodies of work reviewed in this chapter:

- Risk (including ontology of risk, risk management standards, risk in operations, Operational risk and risk treatments);
- Decisions under Uncertainty; and
- Performance Systems.

The literature on risk spans many disciplines and its boundaries are imprecise. Risk is discussed as a product of risk and reward in the finance community (Damodaran, 2002), as a focus of control of imprecision in the accounting community (Zebda, 2011), as a source of loss in Operations Management (Slack et al., 2010), Supply Chain (Kliendorfer et al., 2003) and Project Management (Huchzermeier & Loch, 2001). In Performance Management literature the focus is on risk as a strategic concern (Kaplan & Norton, 2008), as well as a representation of the organization's culture (Mikes, 2009; Power, 2005), it is seen as a highly practical discipline with precise valuation methods (i.e. Value at Risk [VaR]) (Tang, 2006) but yet can be subjective in nature (Kapteyn & Teppa, 2002).

The management of risk is the main theme of this research. The first section covers the academic perspective of risk: *The Ontology of Risk* (section 2.1). Next, practitioner risk management standards (section 2.2), and following, two main bodies of risk management literature are reviewed:

a) The financial perspective of risk, this is a review of Operational risk (section 2.3). Operational risk (Basel Committee, 2005; 2006) is the first point of reference both as a term in industry and as a community that the energy industry wish to emulate;

b) Risk in operations and Supply chain risk (2.4), is reviewed as a rich body of risk literature. Kleindorfer & Saad (2005) are a valuable point of reference in this domain.

The final risk section (section 2.5) covers *risk treatments* (e.g. Insurance). Each treatment is analysed in turn.

The second section (section 2.6) reviews a number of concepts from the psychology literature and specifically Decisions Under Uncertainty. This is a broad field of work, it begins with the understanding of Prospect Theory (Tversky & Kahneman, 1984). This provides an entry point for discussion of a number of sub-themes in this literature: a) Intuition and reasoning, b) Framing, c) Decision strategies, d) Time pressure, e) Information load, f) Rationality, g) Informational attributes, h) Weighting and i) Biases. These are chosen in context of the relationship between the risk management and performance management processes.

The third section (section 2.7), reviews the performance management literature. The boundaries of the performance management and control system literature are better defined than the risk literature. This is a field dominated by a number of clearly defined approaches: The Balanced Scorecard (BSC) and the Performance Prism (i.e. "Contemporary Performance Measurement Systems" Franco-Santos et al., 2012), and from the management accounting literature, the discussion of Management Control Systems (MCS). To develop beyond specific implementations (i.e. BSC), and in line with the philosophy adopted, the performance system is deconstructed into a number of functions.

Figure 2.1 summarises the relationships between domains of knowledge.

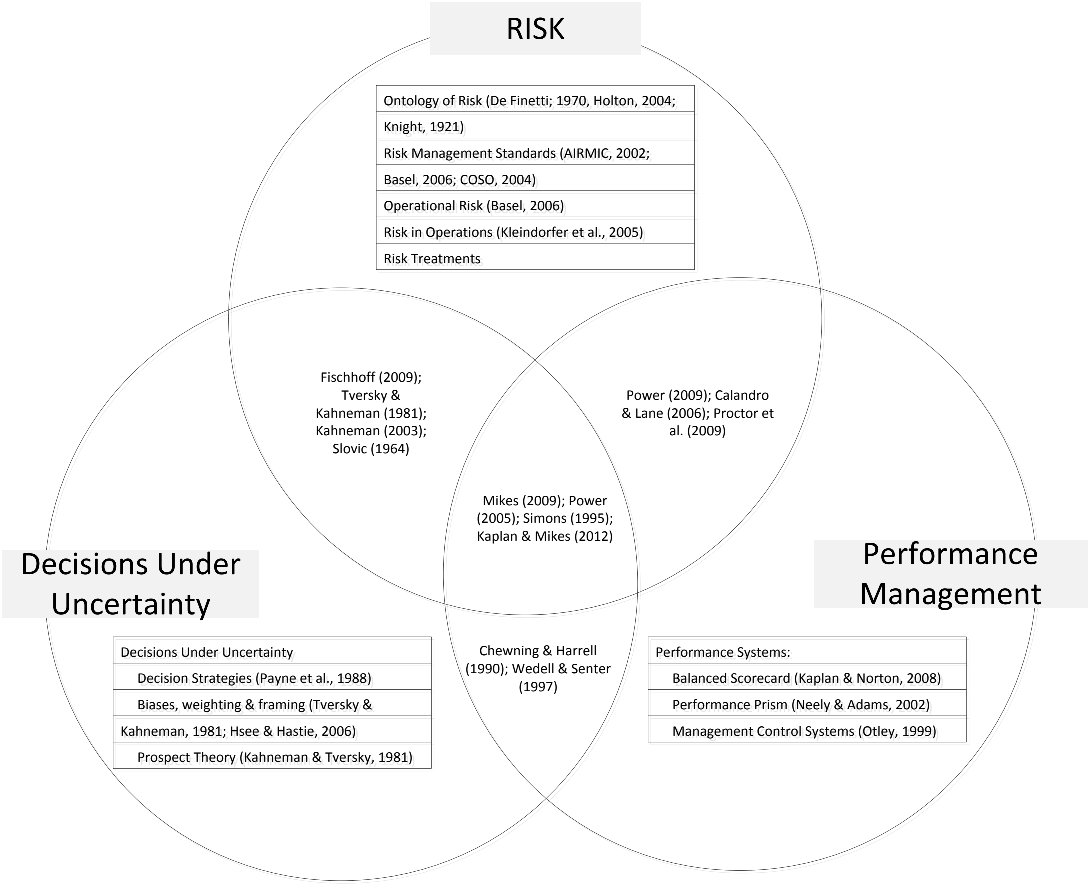

Figure 2.1 Overview of Bodies of Literature

2.1 Ontology of Risk

The term *risk* is derived from the classical Greek *ρίζα,* literally translated as *root* or more appropriately *cliff or crag*; originating as a nautical concept of 'navigating among cliffs'. The meaning of *risk* is a potential for hazard or hazardous activity (Klein, 1967:1350). The normal or non-technical meaning in current usage infers possibility of loss (financial loss); associated terms include *"danger, gamble, chance, liability"* (Simpson & Weiner, 1989:XIII 987). Association with terms *chance, gamble* and *unfavourable contingency* highlight the imprecise definition in common usage, and the conceptually mediated nature of the term.

When defining risk, the challenge is a comparison between competing paradigms (e.g. the finance and operations communities). It is a search for a definition that overcomes imprecision apparent in common usage (cf. Chapman & Cooper, 1983).

When defining risk there are ontological disputes[1], not apparent in common usage. The term can be understood in either an objective or a subjective sense. The objective view exhibits a positivist's standpoint, as it assumes uniform access to knowledge and that quantitative representation of risk is reality, regardless of individual context. The subjective view of risk is aligned to a Realist or Constructivist philosophy, where risk is a socially mediated construct, based on the perception of the individual.

Knight (1921:233) defines risk as *"measureable uncertainty"*. This differentiates the term from chance or luck. It is a definition cited in social sciences (e.g. Shane & Venkataraman, 2000), decision sciences (e.g. Slovic, 2000), and organisational behaviour (e.g. Teece et al., 1994). Knight narrows his definition that *uncertainty* has two potential offspring: *measurable uncertainty* and *unmeasurable uncertainty*. *Measureable uncertainty* is risk, the other uncertainty.

Risk defined as *measureable uncertainty* infers *probability* in the definition of risk, and whether measurability is considered as subjective or objective. Knight (1921) is able to balance this dichotomy by viewing the two sources of measurability as *a priori* or statistical. *A priori* is a calculation based on deductive reasoning, and statistical is based on past experience (to calculate the future). Although now dated, Knight's view is still considered *"the principle source for our understanding of uncertainty"* (Spender, 1998:240).

Knight (1921) suggests that an *a priori* approach is dominant in business almost to the point of exclusion of the statistical approach. It is a view disputed by financial and insurance communities; because of their prolific use of statistical techniques, for example VaR (Allen & Bali, 2007; Basu et al., 2011; Chavez-Demoulin et al., 2006; Jarrow & Yu, 2001; Palomba & Riccetti, 2012; Santos et al., 2013; Tang, 2006). His concept may be best summarised through his comment that *"unmeasurability"* is *"unknowability".*

[1] The study of ontology is the study of what is being. Understanding whether objective probability exists is an issue in defining risk (Finetti, 1970).

Finite intelligence prevents absolute outcomes from being predicted (Knight, 1921). This supports the subjective position, as intelligence is specific to the individual or group. Knight therefore takes the view that measurability is subjective to the individual it concerns.

De Finetti (translation by Machi & Smith, 1970) emotively proposes a thesis that *"Probability does not exist"*; this is contradictory, that in calculating objective probability, an assumption of perfect knowledge forms the basis of facts from which to calculate risk. If knowledge were perfect, it follows that there are no unknowns. Therefore there are no random events; every action is to have a causal mechanism. It becomes our subjective understanding of them that differs. Where all the nuances of events and triggers that affect outcome are understood, objective probability becomes certainty, (e.g. a man jumping from a plane without a parachute, Holton, 2004). Here, there is no risk, only certainty (of death). All the events and triggers are understood to conclusion. To apply this across all potential situations requires an extension of existing beliefs, and assumes that our understanding of the world and society is complete. Knowledge of the world and society is incomplete, but *"probabilities are subject to change as our information improves"* (North, 1968:13). The value of De Finetti's emotive proposition is an erosion of the term *objective probability* and moves to reinforce *subjective probability* as the convincing interpretation. North (1968:13) supports this: *"We must conclude that the probability assignment depends on our present state of knowledge".*

De Finetti's and Knight's perspectives are linked by Holton (2004). The definition of risk requires *exposure* (Holton, 2004). Holton sees Knight's separation of *objective* and *subjective* probability less as a discussion of knowledge rather as the division between human beliefs and whether probabilities can be real. Holton's contribution is the consideration for *exposure*, or relationship with a Being. The risk of an event occurring where there is no subject, to have *exposure* without subject makes risk materially irrelevant (Holton, 2004). Because risk is latent, e*xposure* must be extended to *exposure to the proposition of the event*, this is supported by Harland et al. (2003: 53) where "*extent of exposure to a risk*" is a requirement. This supports Knight's view of unknowability, as a consequence where the impact is owned. It seems difficult to reproduce a grammatically and logically valid conversation that doesn't establish *exposure* in risk. By the nature of language, risk is uncertainty of outcome to something or someone.

Risk is therefore comprised of uncertainty (Knight, 1921), subjective probability (Finetti, 1970) and ownership; what Holton (2004) describes as *exposure*. This provides a grounding to review the specific and practitioner discussions of risk. In management science (e.g. Gan et al., 2004) and psychology (e.g. Slovic, 2000) there is an assumption of these considerations; although they are largely consistent with this understanding. The next section changes perspective from a theoretical discussion of risk to practitioner descriptions of risk, as loss or imprecision.

2.1.1 Risk as Loss or Imprecision

Having deconstructed the ontological description of risk, recent literature segments the term risk, often within specific contexts. Different communities describe risks by different terms, for example: financial loss (Basel Committee, 2006), reputational damage (Eccles et al., 2007) and reward (Al-Binali, 1999). Although there is commonality between disciplines, there is a difference between the financial definitions of risk as *variability* (the possibility and impact of inaccuracy or imprecision), and in operations as incident or accident (loss of availability) (cf. Kaplan & Mikes, 2012). The difference between finance and operations perspectives is discussed in section 2.3. Operation's perspectives have greater focus on negative outcomes (cf. Kaplan & Mikes, 2012), described as *downside risk*. But *downside risk* is inseparable from opportunity for financial gain (Law, 2009:485). This infers that risk is imperfection in output of an event. Thus both positive and negative outcome is included within the term. Risk in finance, is more broadly situated as:

> *"The likelihood that we will receive a return on an investment that is different from the return we expected to make" (Damodaran, 2002:32)*

or:

"Variance from the mean" (March & Shapira, 1987)

The interpretation of risk as *downside risk* maps to Knight's perspective of risk as probability of loss or *unfavourable contingency*. This is seen in examples from the Operations Management and Supply Chain communities. For Harland et al. (2003:52), risk is *"a chance of danger, damage, loss, injury or any other undesired consequences."*, or as *"...probability of loss"* (Gillet, 1997; Mitchell, 1995).

The difference between Knight's *unfavourable contingency* and March and Shapira's *variance from the mean*, is the contention between distinct disciplines (i.e. the Financial and Strategic communities). Variance from the mean indicates the potential for impact as loss or gain, and highlights probability.

These definitions support both *upside* and *downside* outcomes of risk. Banks (2004) provides a language for these differences. Together upside and downside consequences are termed *speculative risk* (Banks, 2004:4; Williams, 1966:577). Where only the negative consequence (i.e. risk of loss) of an event is described, this is *pure risk* (Banks, 2004:4). Both of these definitions are largely undisputed. In an industrial context risk is considered more of an issue of loss than of potential reward: *"Risk today connotes less opportunity for gain and more possibility of loss. Risk is broadly thought of as involving a threat, hazard, danger or some form of harm"* (Gephart et al., 2009:147).

Therefore risk may be a statement of imprecision resulting in loss (pure) or as loss or gain (speculative). The next section reviews a description of the risk as pre-treatment (inherent) or post-treatment (residual).

2.1.2 Residual and Inherent Risk

The terms *residual risk* and *inherent risk* are another lens to describe risk (cf. Zwikael & Sadeh, 2007). In definition it has association to the management of *downside risk*, as it is reflects on the treatment of negative outcome. *Residual risk* is the risk left in an environment post-treatment (Bell et al., 2001). *Inherent risk* is the risk that exists in the environment prior to treatment (Bettman, 1973). The relationship between the two terms is the treatment being employed, and the reduction of perceived exposure to risk.

Inherent risk is described in a number of different communities but dominated by analysis of auditor's judgements, for example Bell et al. (2001) and Taylor (2000). Inherent risk is not restricted to auditing and medical communities; it is used to understand activities such as product and service design (Shariff & Leong, 2009). A definition of Inherent Risk is *"the latent risk a product class holds for a consumer…"* (Bettman, 1973:184). Removed from the context of marketing research, the definition of inherent risk may be better understood as: The pre-treatment level of risk, (i.e. the latent risk that exists in an environment or process). The valuation may be based on either qualitative or quantitative appraisal (Mikes, 2009; 2011).

Residual risk is the post-treatment level of risk, the relationship between inherent risk and residual risk described as: *"to reduce inherent risk to an acceptable level. In contrast business risk is by definition, a residual risk that, in principle, cannot be eliminated or reduced below a certain level."* (Bell et al., 2001:36). This definition assumes that treatment is effective and complete in its application. Figure 2.2 provides a visual representation of residual and inherent risk as understood from these descriptions.

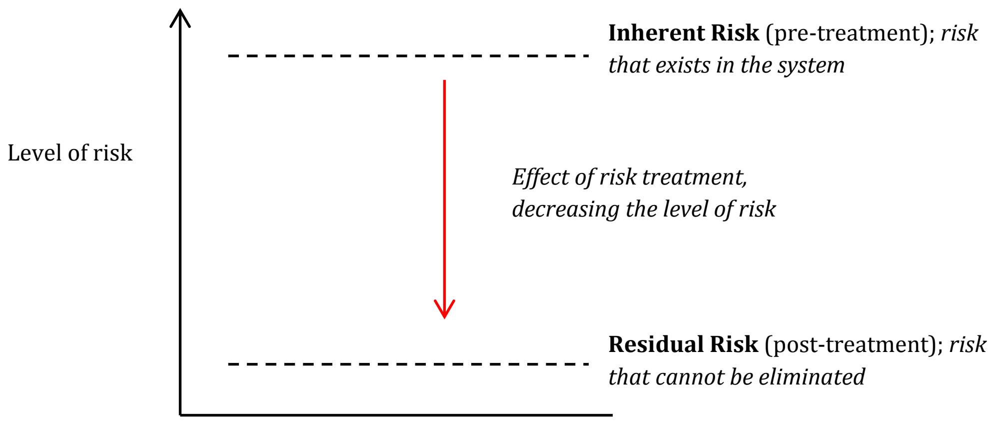

Figure 2.2 Relationship between Inherent and Residual Risk

Bettman's (1973) and Bell et al.'s (2001) definitions of residual and inherent risks are specific to an individual risk. They do not describe the relationship it has with the environment or the causal influence of the risk. A description of this relationship is provided, as *specific*, *systematic* or *systemic* risk.

2.1.3 Defining the Relations of Risks

Specific, *Systematic* and *Systemic* are descriptions of the source of risk. It is unusual in the literature to see these different classifications discussed in parallel with the technical classification. There is a focus on either the type of risk (e.g. financial risk) or a discussion of the context (e.g. a systematic risk). These different relationships are irrespective of *speculative* or *pure* definition. Instead they specify the inter-relationships of risks between organisational and industrial boundaries. *Specific*, *systematic* and *systemic* risk, are terms of process, organizational and market relationship.

- *Specific risk* is a risk that affects an individual or individual company; its existence is brought about though history, culture, and position. (cf. Kasperson et al. 1988:184).
- *Systematic risk* is a risk that affects all players in the market; regardless of history, culture, market position the risk exists in the marketplace itself (cf. Kaplan & Mikes, 2012; Pfohl et al., 2010).
- *Systemic risk* (Ackermann et al., 2007; Kaplan et al., 2009), is *"the risk or probability of breakdown in an entire system"* (Kaufman & Scott, 2003:371) a macroeconomic *"chain-reaction or domino effect of sequential failures"* (Bliss & Kaufman, 2006:59). These are large-scale breakdowns, caused by highly correlated exposures result in a domino effect on the system (Elsinger et al., 2006). Systemic Operational Risk (Patrick, 2012) or Operational risk as a cause of systemic risk (Andreas, 2010) is a more fundamental risk, which may span multiple sectors and industries. Examples can be seen in the 2007/9 financial crisis, where banking failures led to realisation of risks within the insurance sector. This ecology of risk, as a series of inter-related system failures is specifically identified by the Basel accord (Basel Committee, 2006:s.49 xvi). Although with hindsight, Basel's omission to regulate against this risk category may attract significant criticism.

The definitions discussed in sections 2.1.2 and 2.1.3, show that beyond the description of risk as *variance from the mean*, or in a practitioner focus the discussion of a cause or type (i.e. reputational risk), risk has a number of different relationships used to describe it:

- Risk as a statement of untreated or treated state (inherent or residual);
- Risk as a statement of relationship (specific, systematic or systemic).

These classifications are not mutually exclusive; therefore a risk in operations may be described both in terms of its state (a residual risk) or the relationship it holds (a systematic risk). These terms permeate into the language and expressions of risk within the organizations and risk management standards; they have a specific meaning in their usage.

At a practitioner level, moving beyond the detailed classifications and descriptions of risk, risk management standards are considered, providing a framework for risk management and risk management activities. The risk management standards are a set of codified approaches. Their development is driven by a desire to standardise approaches.

2.2 Risk Management Standards

This section of the literature review outlines what is meant by a risk management standard and its purpose. It highlights that the standards are contextually benign and designed to be a framework that may be applied across a variety of industries. There is a similarity of process order advocated by the different standards; it provides a structure by which to understand the risk management process.

A *Risk Management Standard* is understood to be a definition of the strategic process of risk management including setting of objectives, routines for identification, analysis and the approach to treatment and control of risks (Federation of European Risk Management Associations, 2013; Hopkin, 2004:57). Risk Management Standards provide consistency in terminology, process, structure and adoption of best practice in managing risk (AIRMIC, 2002). There are six risk management standards occurring across sectors with regular usage[2]:

a. A Risk Management Standard AIRMIC/ ALARM/ IRM (2002);
b. Australian/New Zealand Standard AS/NZS 4360 (2004);
c. Enterprise Risk Management Integrated Framework COSO (ERM COSO) (2004);
d. ISO31000 International Standard (2009);
e. BSI British Standard BS ISO31000 (2008, 2011);
f. Criteria of Control (CoCo), Canadian Institute of Chartered Accountants (1995).

There is an increasing number of sector specific standards being developed, e.g. NHSLA Risk Management Standard (2013), this is the National Health services Litigation Authority Risk Management Standards. There is no such standard identified in the Energy sector.

From the standards identified above, three are of importance in the context of this research:

1) BS31000 (British Standard 311000: 2011 as basis of analysis);

2) ERM Committee of Sponsoring Organisations of the Treadway Commission (COSO, 2004);

3) AIRMIC/ALARM/IRM, A Risk Management Standard (2002).

AIRMIC and BS310000 are standards known to be in use in the European Energy sector (2009). Use of The Australian Standard (AS4360) could not be evidenced in the energy sector (2009), probably because ISO31000 replaced AS4360 between 2003-2006. Prior to this AS4360 was the most widely recognised approach to risk management (Hopkin, 2004:57). ISO31000 is an applied standard for certification of good practice, recognised by the British government, and a trusted standard for specialist risk management practitioners (Chapman, 2006).

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[2] *Two pieces of legislation, not considered risk management standards, but understood to have an impact on the discipline (Chapman, 2006), because they legislate on the practice of risk management, are: 1) Sarbanex Oxley Act in the USA (2002); 2) Financial services and Markets Act in the UK (2000), and the earlier Hampel Committee (1998).*

COSO is supported by: the American Accounting Association (AAA), the American Institute of Certified Public Accountants (AICPA), Institute of Management Accountants (IMA), the Institute of Internal Auditors (IIA) and Financial Executives International (FEI). Organizations in the energy sector, e.g. Électricité de France (2009) could be found that explicitly used this standard.

The energy companies refer internally to their use of Enterprise Risk Management (ERM) as a methodology for risk management, for example RWE (2009) and E.ON (2009). In their definitions it was not clear whether ERM was an adoption of a prescribed standard or a philosophy toward risk management. However, Chapman (2006) describes ERM as:

> *"a systematic process embedded in a company's system of internal control (spanning all business activity), to satisfy policies effected by its board of directors, aimed at fulfilling its business objectives and safeguarding both the shareholder's investment and the company's assets… this process is to manage and effectively control risk appropriately."* (Chapman, 2006:8).

It is found that ERM approaches are embedded within a number of different standards (e.g. COSO). Instead of ERM specifying a precise process, it indicates an approach toward risk management, a move from silo to integrated approach (Chapman, 2006). It is understood that ERM is an overlapping term or even a risk management methodology; sometimes used in conjunction with COSO (i.e. COSO ERM).

Chapman's (2006) description is arguably a description aimed at the private sector and with an Anglo-American influence (because shareholders, not stakeholders are represented). However it is a description highlighting the integrated and strategic nature of ERM. ERM adoption is driven by a desire to manage risk more holistically (Liebenberg & Hoyt, 2003), and is associated with internal control and audit. Both COSO and the British Standard refer to the practice of ERM:

> *"Enterprise risk management is a process, effected by an entity's board of*

directors, management and other personnel, applied in strategy setting and across the enterprise, designed to identify potential events that may affect the entity, and manage risk to be within its risk appetite, to provide reasonable assurance regarding the achievement of entity objectives." (COSO, 2004b:2)

"Risk management is not a stand-alone activity that is separate from the main activities and processes of the organization. Risk management is part of the responsibilities of management and an integral part of all organizational processes, including strategic planning and all project and change management processes." (British Standards Institution, 2009:4)

ERM is therefore an integrated risk management framework; it expands the focus of risk management from traditional risk practices (i.e. financial) towards a breadth of risks (O'Donnell, 2005). It is a standardised process, usually managed from a central team within the organization. ERM adoption promises mistakes of the past will be mitigated (Power, 2009), and that all risks are owned (Nocco & Stulz, 2006). The appointment of Chief Risk Officers (CRO) is closely associated to the development of an ERM approach (Kaplan et al., 2009). A CRO is required to communicate the management of risks to external stakeholders (Liebenberg & Hoyt, 2003). Appointment of a CRO is just one of a number of requirements of an ERM implementation. This journey of implementation may be lengthy (Beasley et al., 2010). Beasley et al. (2010) suggest that an organization's adoption of ERM will be a progressive journey, and that both a decision to implement and the implementation itself are as much concerns for practice as the theoretical basis of holistic risk management, and the classification of risk itself.

In direct contrast to the earlier ontological discussion, the review of risk management standards reflects the practical nature of risk management: What is the terminology being promoted? What components form the prescribed standard? What is the overall objective of the standard? Three of these different standards (the three most commonly observed standards in use within the European Energy Industry, (cf. Beasley et al., 2008; Voronca,

2012) are reviewed in turn, in order to expose the similarities and differences. Although showing commonality, there are subtle differences in the focus and order of the process, and the language used.

2.2.1 British Standard (BS ISO31000)

BS ISO31000 (BSI, 2009) is the British Standard of the ISO31000 implementation; this document is used as basis of review. The British Standard emphasises that it intends to provide *principles and guidelines*, rather than advocating a set of specific processes. It is, and states to be, a *generic approach* to risk management. The emphasis is on providing a common language, a set of terms and objectives in effective risk management processes. Purdy (2010) summarises the objectives of ISO31000 as providing: one vocabulary, a set of performance criteria, standardised process and integrated decision-making. There are several features of BS ISO31000:

- The standard separates risk management into *principles, framework* and *processes*.
- *Principles* are applicable regardless of context. These *principles* include creation and protection of value, integrating with organisational processes, that it is part of decision-making (this infers taking reasoned decision strategies).
- The process should be systematic, structured, timely and requires a consistent and reliable approach.
- Decisions are founded on the best information available and tailored to the environment, taking into account human and cultural factors, transparency and inclusivity and that it is dynamic and responsive to change (BS ISO31000, 2009:7-8).

These are generic principles that could be applied to any organisational context, and would serve to be logically good principles for any risk management implementation.

The standard requires that the risk management process is continuously improved and checked for organizational alignment, so that it will evolve and maintain relevance to the organization. The *management* sub-processes (figure 2.3) indicate a continuous loop of design, implement, review and improvement; whilst referring back to the principles. Seemingly the *framework* acts as a continual check, balance and iteration of the *principles* with the risk *processes*.

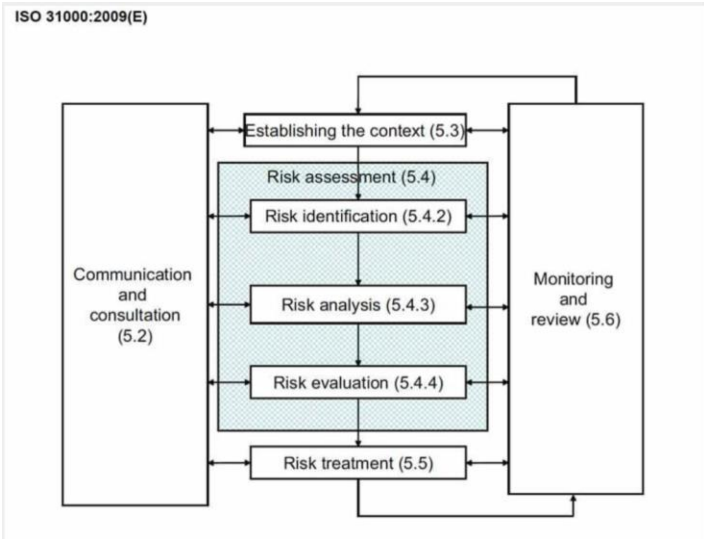

Figure 2.3 ISO 31000 Processes (adapted from BS ISO31000)

The outline of the different terms in ISO31000 is extensive, including:

> *"2.15 risk identification, process of finding, recognizing and describing risks (2.1)"* (BSI, 2009:4);

> *"2.14 risk assessment, overall process of risk identification (2.15), risk analysis (2.21) and risk evaluation (2.24)"* (BSI, 2009:4);

> *"2.21 risk analysis, process to comprehend the nature of risk (2.1) and to determine the level of risk (2.23)"* (BSI, 2009:5);

> *"2.25 risk treatment, process to modify risk (2.1…) Note 2 Risk treatments that deal with negative consequences are sometimes referred to as risk mitigation, risk elimination, risk prevention and risk reduction"* (BSI, 2009:6).

Within the standard these definitions provide a common language. They are linked in hierarchy and order, (e.g. risk identification precedes risk analysis). The description of *risk treatment* identifies possible approaches to managing risk: avoidance, taking risk, removing source, changing likelihood, changing consequence, sharing, contracting and retaining (BSI, 2009:6). This is an outline of potential treatments available to practitioners.

There are two supporting functions:

- *Communication and consultation*;
- *Monitoring and review*.

These are intended to be applicable at all stages of the risk management process. For *communication and consultation*, the standard makes reference to internal and external stakeholders (BSI, 2009:14). This reflects an underlying theme that risks may have a variety of stakeholders and each might have different subjective appreciation of the causes and consequences. *Monitoring and review*, suggests that treatment plans provide performance measures for risk management and that they are accommodated back into the framework enabling improvement.

The standard may appear bureaucratic and labour intensive. It suggests a creation of a *"comprehensive list of risks based on those events that might create, enhance, prevent, degrade, accelerate or delay the achievement of objectives"* (BSI, 2009:17). This aim limits the lower threshold for risks being managed under the framework, and in contradiction to the principle of *"risk management being an integral part of all organizational processes"* (BSI, 2009:7), as it would not be practical to manage all organizational risks in this manner.

However ISO31000 is not without its limitations. Although seen as a pragmatic approach to designing risk process (Purdy, 2010), it is criticised for its vagueness in terminology (Leitch, 2010). So in pursuit of being generalizable has taken some of the potency and preciseness away from the definition. Further that the aggregation of risks advocated by the standard, is dependent on the perspective being taken. There are many ways of categorising risk (Leitch, 2010) and ISO31000 leaves this poorly defined. This leads to imprecision and illogical decisions being made (Leitch, 2010).

In risk treatment, although the standard is clear about the need for a continual process of monitoring and review (BS ISO31000, 2009), it is not stated at which point treatment is terminated, (i.e. where a criteria is reached or a cost/benefit breakpoint is breached, Purdy, 2010).

ISO31000 is therefore seen as a generalizable standard, independent of sector or industry. It provides a clear series of iterative steps in managing and controlling risk, although criticised for its lack of precision; its use is widespread, and referred to by other standards, for example: AIRMIC/ALARM (section 2.2.3).

2.2.2 Committee of Sponsoring Organizations of the Treadway Commission (COSO)

The COSO framework was sponsored by the Treadway Commission for purposes of evaluating internal control systems in a unified manner. COSO (2004) is a requirement of companies listed on the French stock exchange and recognised by the Sarbanes-Oxley Act[3]. COSO is described as *"world level template for best practice"* (Power, 2009:849). It identifies *risk assessment* and *risk response* as risk management phases. *Event identification* is similar to early assessment stages in other standards. Lam (2003), breaks these stages into awareness, measure and control. Lam's *awareness* and *measure* fall into the assessment phase, and *control* into the analysis phase. These two contributors demonstrate the limited consistency in the terms being applied.

COSO does not differentiate in the same way as ISO31000 between the framework being applied and the risk management process. ISO31000 is clearer in distinction between the two. COSO provides a cube model (figure 2.4), inferring that rather than a serial process of risk management it is an iterative and multidirectional process (Chapman, 2006). The activities of identification, assessment, response and control are consistent with other ERM definitions. In the COSO cube, different phases of risk management do not transfer between different levels within the organization (i.e. treatment of strategic risk at the business unit level and control of this risk at the entity level). Instead each process phase occurs at all

[3] *1992 version rather than 2004 for purposes of the New York Stock Exchange*

levels of the organization. The third dimension incorporated in the COSO cube provides different risk categories (strategic, operations, reporting, compliance). These risk categories exist both at different organizational levels, and at every stage of the risk management process. This is a comprehensive appraisal of risk categories, risk management stages and mapping of organizational responsibility.

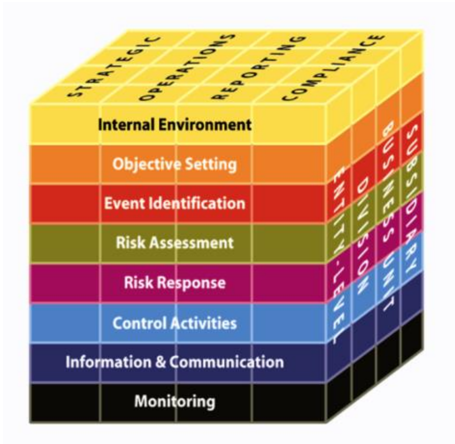

Figure 2.4 The COSO Cube for Risk Management (COSO, 2004)

COSO requires that in identifying of risk a firm should seek an exhaustive list of potential events and causes of risk to and in the firm, and that event interdependencies should be recognised and that events should be grouped into categories (O'Donnell, 2005). This approach should develop an integrated and portfolio view.

In literature the criticisms of COSO appear more distinct than ISO31000. The production of exhaustive risk lists, is a major drawback of the guidance provided, as it is clearly a substantial undertaking (Barton et al., 2002; Samad-Khan, 2005). This issue is pronounced as although felt to be useful guidance at a macro level, it is flawed because of the inconsistency in definition at the risk assessment phase (Samad-Khan, 2005). The issues are not contained to the onerous requirements for identification and the inconsistency in assessment, as the definitions for risk appetite and risk tolerance are confused (Purdy, 2010).

Therefore, COSO ERM is a well-known ERM framework, it is seen as theoretically strong (reflecting on the positive views in macro-level application), and is positively reflected on as using common language (Beasley et al., 2010). But similar to ISO31000, the inherent issues in COSO are deemed to lead to weaknesses in assessment, an onerous organizational overhead.

2.2.3 AIRMIC (2002), A Risk Management Standard

A three-way consortium, comprising The Association of Insurance and Risk Managers (AIRMIC), The Institute of Risk Management (IRM) and The National Forum for Risk Management in the Public Sector (ALARM) formed a team to define a standard for risk management. This is the AIRMIC/ALARM standard.

The standard states that where possible it is consistent with the international risk management standard (ISO31000) to the extent that it defers its whole section of *Risk Assessment* to the ISO standard (AIRMIC, 2002:5). It recognises risk has conditions of both *upside* and *downside*, and that risk management is the management of imprecision.

The risk management process has similarity to ISO31000, however there are differences:

a. Risk Analysis is seen as a sub-process to Risk Assessment;
b. Risk Reporting occurs before Treatment;
c. Reaching a decision on treatment is explicit and not assumed as an inherent part of the treatment phase;
d. The definition of residual risk is explicit and it creates a trigger for reporting;
e. Review of the process is done through *formal audit*, rather than just monitoring and control.

Figure 2.5 is the risk management process from AIRMIC (2002).

Figure 2.5 The Risk Management Process (AIRMIC, 2002:4)

The task of risk estimation is prescriptive (AIRMIC, 2002:6-7), recognising it will be formed from both quantitative and qualitative measures. The standard advocates the use of simple matrices to document risks based on an evaluation of *probability* by *consequence*. It provides examples of qualitative descriptions for these different components of risk.

This standard appears efficient in its statement and objectives. It is highly practical, with very little discussion of how the standard is formed. It attempts to be consistent with other standards, to the extreme point of deferring the discussion and outlining of specific sub-processes to ISO31000. In this way it avoids potential conflict. These three standards are contrasted in the next section.

2.2.4 Comparison of Risk Management Standards

Risk management standards appear to be either prescribed approaches (i.e. COSO, 2004), ISO31000 (2009) or frameworks for risk management (i.e. ERM).

Risk management may be considered as the end-to-end process of handling risk, from identification through to the review of actions and controls. In ISO31000, AIRMIC and COSO ERM there are different risk management phases. They are largely consistent in their main stages (see table 2.1). ISO31000 emphasises the iterative nature of the process more explicitly than COSO, whereas COSO reflects the different organizational levels the process operates across. Where an organization adheres to ISO31000 it promotes an iterative function of reviewing the risks and returning to the start of the cycle. Incident response is a separate function and not included in the ISO31000 model. This is because where a risk is realized, this becomes incident or accident management. In incident response, the probability of risk is removed (it becomes certainty as probability is removed and the impact remains), with the risk becoming realised it becomes a matter of controlling the impact (Perrow, 1984; Reason, 1997).

ISO31000 provides a language for risk management; it provides a generic consistency across a wide range of potential uses (i.e. Health or Energy sectors). It is seen that ISO31000 terminology is used outside of adherence to the ISO certification, it is a common language in risk management. Provision of a precise language in ISO31000 is arguably greater than in COSO, although there are criticisms of both (Leitch, 2010; Samad-Khan, 2005). The focus for COSO is different, with a greater genealogy in finance, and increased focus on control frameworks (Chapman, 2006). Table 2.1 compares the focus and stages of the three standards reviewed:

Table 2.1 Summary of Risk Management Standards

	COSO ERM	**ISO/BS31000**	**AIRMIC/ALARM**
Focus of standard	An enterprise level standard, based in finance principles. Focuses on control frameworks	An industry/sector independent definition of risk and the phases of management of risk	Practical implementation of a risk management approach, refers some sections to ISO31000
Stages (in order)	Event Identification Risk Assessment Risk Response Control Monitoring (figure 5)	Risk Identification Risk Analysis Risk Evaluation Risk Treatment Monitoring (figure 4)	Risk Analysis Risk Identification Risk Evaluation Risk Reporting Decision Risk Treatment Reporting Monitoring (figure 6)
Risk is:	Possibility of an event that will have an adverse effect on achieving business objectives. Acknowledges positive events as having positive outcome on objectives.	An obstacle in achieving the organizations objectives.	Upside (positive) and downside (negative) outcomes of uncertainty

To summarise the similarities across these three standards, and identify the points of general agreement, four stages of risk management are observed[4]:

a. Risk identification;
b. Risk analysis; (called assessment in COSO)
c. Risk treatment; (called response in COSO)
d. Risk control/monitoring.

Risk identification: the identification of potential risks (cf. Dey et al., 2013). Returning to the concept of *exposure* (Holton, 2004), risks are identified that the organization may be exposed toward.

Risk assessment: is the quantification or qualification of a series of latent events as being potential for loss or imprecision and in mature models as a classification of the risk in either means of impact or situation. Risk analysis follows risk assessment (in COSO these two processes are combined into the assessment phase). The assessed risk is taken and

[4] *Business continuity management (BCM) resides across all of these phases. Incident management is the management of an existing event, already likely to have resulted in some loss.*

considered for pre-emptive treatment, this results in one of several risk treatments (section 2.5). Risk assessment includes a number of sub-processes, for example cost-benefit analysis, selection of defences and resource allocation.

Risk treatment: COSO (2009) calls *risk treatment* risk response (although this can be confused with Incident or Accident Management). *Risk treatment* is the selection of a course of action in response to the identified and assessed risk. There are several treatments available.

The review of the risk standards provides a framework for understanding the risk management process. It has identified that the standards have developed from a range of context, but all seek a level of generalizability in their application. The literature review progresses to consider the different categories and disciplines within risk management, with a focus on risk that is described as operational or a risk in operations. *Operational risk* is discussed first.

2.3 Operational Risk

Due to both rapid evolution (Power, 2005: 581) and because it initially came about as a catch-all category for *other* risks (Lopez, 2002), *Operational risk* has a pluralistic translation in application causing the term either to be over generalised *"it is a label for a diverse range of practices"* (Power, 2005:579), or de-scoped to have a meaning closer to *"Operations Risk"* (Loader, 2007). *Operations* in this context describe the function in an organization, whereas *Operational* is the activity being undertaken. *Concept stretch* (Hines et al., 2004), damages efforts for precise transfer into a non-finance context, because as a definition *"it is not global enough"* for transfer into other industries (Kalhoff & Haas, 2004:5). Seeking precision in the definition has more than a semantic resolution, there is benefit through precise definition as a concept being operationalized, it: *"re-positions their location and status for managerial and regulatory purposes"* (Power, 2005:578).

Power (2005; 2009) considers the extension of the concept of *Operational risk*, based on a historical analysis of the term. Critical differences are exposed. Operational risk is discussed in depth within the finance literature (i.e. the Basel definition). There are many different foci of this literature, most relating to the financial discipline of the firm, for example: requirements for disclosure (Brown et al., 2008; Ozbilgin & Penno, 2005), reputational impacts of disclosure (Gillet et al., 2010), impacts on the financial structure of the firm (Ross, 1985), identification of risks (Trkman & McCormack, 2009) and quantitative models for assessing and measuring Operational risk (Allen & Bali, 2007; Chavez-Demoulin et al., 2006; Ebnother et al., 2003; Jarrow & Yu, 2001; Tang, 2006). The discussion of *Operational risk* has developed to include: related assessment of financial systemic stability (Elsinger et al., 2006), the process of Operational risk hedging (Takezawa et al., 2007) the impact on capacity decision, similar to those seen in supply-demand risk (Hasija et al., 2008; Chod et al., 2010), the application of Basel Accord AMA approaches (Chapelle et al., 2008) and the challenge of differentiating between operational losses and reputational damage (Gillet at al., 2010).

A financial orientation of risk analysis has been spurred on by the Basel Committee (section 2.3.1), which codified both the definition and valuation of different risks. However risk measurement in the finance sector is still considered dysfunctional (Power, 2009; Mikes, 2011), because many Operational risks are assumed to be non-financial (Mikes, 2011:231), but measured and analysed from a financial perspective. Aside from the organizational impact that performance management of risk is understood to have, in Mikes' (2011) study it was found that top management's (e.g. Chief Risk Officers) performance management of risk had less diagnostic purpose (i.e. finding and correcting specific risks) but an interactive learning purpose (self-reflecting and self-improving).

From this literature it is understood that:

- Operational risk is perceived to be a finance sector based definition (Basel Committee, 2006; Mikes, 2011; Power, 2005);

- Transfer of the term outside of the finance community has become synonymous and perhaps confused with the idea of risk in operations (cf. Lewis, 2003).

The use of the term Operational risk and the Basel Accord are intrinsically linked (cf. Basel Committee, 2006).

2.3.1 Basel Committee Definitions

The Basel Committee and its 1990s and 2000s directives/frameworks form a critical body of text. To the Basel Committee *Operational risk* is:

> *"The risk of loss resulting from inadequate or failed internal processes, people and systems or from external events. This definition includes legal risk, but excludes strategic and reputational risk"* (Basel Committee, 2006: para644)

It is an established standard for banking supervision (the purpose of the Basel Accord). It refers to risk as loss (Basel Committee, 2006:644); it identifies the causes as those that stem from the operation: *Processes* (referring to the transformation process), *people* (transforming resources) and *systems* (referring to information systems). These causes are all consistent with the Operations Management paradigm, where there exists transforming resources (staff and equipment) and transformed resources (materials and information) (cf. Mooney et al., 1996).

The literature on *Operational risk* is seen to contribute to the understanding of *pure risk* (Colquitt et al., 1999), because operational and hazard risks are seen as the historical focus of the enterprise risk manager. *Operational risk* in the Basel definition is considered a category of residual risks[5] (Currie, 2004:70) making the understanding of its boundary terms: *market* and *credit* risks relevant. *Market* and *credit* risk are closely associated terms, seemingly considered boundary terms of Operational risk.

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[5] *This is different to residual risks defined by Bell et al. (2001), rather a default category for risks not defined as Market or Credit risks.*

Credit risk is:

> *"the risk of economic loss, from the default before final settlement of a cash flow with a third party. This may either be counterparty credit risk or sovereign credit risk"* (Basel Committee, 2006: para49i & 52).

There is difficulty in separating *credit risk* from *Operational risk*. This can be explained using an example of a defaulting client. This is where a manager has allowed, against a company credit policy, to extend credit to his client creating, an *Operational risk*. This is different to loss in default where a company has legitimately accepted a *risky* customer for potentially higher returns. This differentiation offers a vision of process and control as being central to the Operational risk classification. Therefore *Operational risk* is best bounded by a failure of a process or control (Crouhy et al., 2006).

Non-finance sectors may exhibit credit risk as *"counterparty credit risk"* (Jarrow & Yu, 2001:1766). Extending the finance definition may include the ability to secure and maintain credit lines from banks and therefore also considered *credit risk*. This is the influence of the term *counterparty*. Counterparties are companies the organization trades with (Crouhy et al., 2006). The dispute on delineation from process or system-based *Operational* risk is challenging whether counterparty risk is a risk associated to the billing and collections process or the credit checking and monitoring process? Credit risk adopts new characteristics, or at least different priorities, as it is extended. This conflict is in the Basel definition. When is a failure in transaction (one with consideration of cash payment), a credit risk realised, or a failure in billing, collections or even credit checking – an Operational risk? Credit risk stems from the performance of the customer and their ability to pay. *Operational risk* is the process of credit checking which has an embedded risk appetite/tolerance built into the decision process. Crouhy et al. (2006) acknowledge the contention residing in the overlap between different risk classifications.

Market risk is:

> *"risk of losses in on and off-balance-sheet positions arising from movement in market prices"* (Basel Committee, 2006: para 683i).

Market risk is understood to include movement of price for stocks and commodities and changes in interest and exchange rates. It is through the definition of market risk that the plasticity of the term *risk* between *pure* and *speculative* risk can be observed.

Conceptually, Market risk overlaps Operational risk. As part of the definition of Market risk, the importance of uncertainty (volatility) in the price of commodities is exposed (Crouhy et al., 2001:179). Market risk is reserved for the price of commodities; it also affects the availability of commodities. A *pure* risk consequence of market risk is that not all firms have elasticity in their ability to purchase commodities. Therefore volatility in commodity price transfer is volatility in availability. This definition in practice means *Market risk* has risk of loss and potential for gain, this is *speculative risk* (Banks, 2004).

This definition is clear in the context of finance, but there seems to be some uncertainty when extended into non-financial contexts. Market risk in a non-finance context (i.e. not equity price risk, exchange risk or interest rate risk), is *commodity risk* (Crouhy et al., 2001:179), which is part of the internal or external supply chain. It is considered the most advanced segment of risk in terms of modelling techniques in the banking industry (Power, 2005:582). *Market risk* has a meaning different to that implied in the Basel Accord when extended into new sectors, (i.e. in the energy sector, *market* risk can describe the volatility in the cost of coal; this becomes commodity risk). Therefore application and knowledge of *market risk* practices has some limited transferability outside of the finance sector (cf. Denton et al., 2003; Foxon et al., 2005).

Operational risk is unique from *credit* and *market* risk, because of the difficult nature of quantifying expected losses (Crouhy et al., 2001). Potentially these Operational risk losses may be vast; in some estimation these potential losses may exceed the aggregate of *credit* and *market* risk (Power, 2005). Kuritzkes explains Operational risk as *"non-financial"* risks (2002:47). Differentiation from *market* and *credit* risk serves to isolate it as a category of risk, which is orientated to loss-based events, and not imprecision. Management of Operational risk has a much broader objective, and is strategically important (cf. Crouhy et al., 2001). However, senior risk managers view Operational risk as a line management problem (Mikes, 2009).

The Basel Accord and its definitions of risk should represent a complete description of risk with no overlaps or gaps, in order to provide a precise and un-contentious categorisation of risks. However the boundaries are not well defined. Examples have been discussed that exist within more than one category of risk, (e.g. a failure in a cash payment transaction). The terms do have meaning outside the financial sector, but this requires development beyond the specific definitions provided within the Basel Accord. It offers some level of transferability into the energy sector, but this must be done with understanding of the limitations this brings.

2.3.2 Transferability of Operational Risk

The previous sections have suggested that Operational risk is a finance term and that there are issues in generalisation outside of the financial context. However financial risk management approaches are a mature discipline, and provides opportunity for development.

As a matter of unity in literature and practice, Operational risk is commonly understood to reference only *pure risk* (Crouhy et al., 2001; Institute of Operational Risk, 2009; Lewis; 2003; Lam, 2003; Power, 2005). This is largely regardless of whether it is being applied to financial or non-financial contexts. This view is supported through best practice guidelines (Institute of Operational Risk, 2009), case studies into operations failures and successes (Abkowitz, 2008), Nicholas Leeson's *"rogue trader"* (Loader, 2007) which is situated as the origin of *Operational risk* (Power, 2005:579), failure-centric definitions in Basel II (2006) and wider presentation as *loss-making* events (Engemann & Miller, 1992:141; Power, 2005:584). As a direct comparison between financial and non-financial communities, *Operational risk* outside of the finance sector may be considered to be more aligned to *"risk management control and practices"* (Power, 2005:582), than the objective of capital adequacy.

Operational risk is used as a generalizable definition of risk, both as a specific term and the supporting frameworks it infers. Financial institutions may be focused toward management of financial portfolios but they are not uniquely privileged to losses caused through operations or the performance of their systems and processes. Controls placed on *rogue traders* (Greener, 2006), may be equally applicable to controls placed on retailers in the energy industry. It is because of its industrial application (Aven et al., 2006; Denton et al., 2003; Gouveia & Matos, 2009; Panjer, 2006; Sadeghi & Shavvalpour, 2006), that the description and associated concepts must be clearly defined.

The existing *Operational risk* literature has a bias towards discussion of high-impact low-probability events (Christopher, 2011; Power, 2005). This is to be expected, as High-Impact events are probably the only events worth documenting as an organization, either for legislative or reporting requirements. Information on low impact events and their frequency is limited.

Power (2005) makes a demand for greater data and research on high-impact and low-probability (HI-LP) events. Current case studies and their regularity of appearance in papers show that HI-LP events are well documented, for example: The Macondo Well Incident (Skogdalen & Vinnem, 2012), Three Mile Island (Hill & Schneeweis, 1983) and Fukushima Disaster (Visschers & Siegrist, 2013). Instead it is the HP-LI events that seemingly go unchartered. Power is in agreement that these high regularity loss-events in aggregate do contribute significantly to organisational failures. To focus on HI-LP events may be seen as an extension of Power's view that historical data is not necessarily valid to predict future failure. This is in contrast to Crouhy et al. (2001) that historical data is the bedrock of objective probability assessment. This is a view formed because failure is often followed by correction and that the initiating causal force is often not recorded. Power's proposition is one of industrial risk data pooling can be used to overcome this limited understanding. There are concerns however that this could reduce competitive advantage of the participating organisations.

Attributing failures to single *blame* events is inaccurate (Perrow, 1984). Failure is brought about by a complex series of overlapping causal events; so HP-LI events can stack (cf. Ackermann et al., 2007). It is this complexity that Lewis (2003) sees as challenging if not impossible for the corporate machine to control from above.

Learning from *Operational risk,* beyond the financial and banking context (i.e. into service industries) is subject to concept stretch. It exposes that there has been a bias toward HI-LP events in its development; which may be a product of information availability. The focus of research in this area is still a matter of contention, between the need for greater focus on HI-LP events or the LI-HP events.

This understanding exposes two models. The first reflects how the organization approaches the use of risk and event data, and the associated perceptions of quantitative assessment (Calculative Cultures). The second is the organizational approach to managing risk, reflecting four different designs (ERM Ideal Types). These are now discussed in turn:

2.3.3 Power (2005) Calculative Cultures:

Calculative Cultures is where organizations confronted by the requirement to assess and analyse risk fall into one of two categories: *idealists* or *pragmatists* (Mikes, 2009; Power, 2005). *Pragmatists* use risk numbers to direct their understanding. So risk measures become attention-directing devices, and *pragmatists* do not use them in isolation to select a treatment: *"Risk scoring systems make risk capital visible for management purposes and help steer behaviour in the right direction"* (Power, 2005:592).

Idealists assume risk numbers are a reflection of a complete truth: *"they [the manager] have a reductionist, non-pluralist view of Operational risk management and worry constantly about* *the robust and hard nature of Operational risk analysis"* (Power, 2005:593). For *idealists* the focus moves the use of risk numbers to a definitive activity. This has been further elaborated as the difference between soft risk management, "*pragmatism"* (Power, 2005:592) and a more quantitative risk management approach, *"idealism"* (Power, 2005:593).

The *idealist* seeks to treat *Operational risk* no differently from *market* or *credit* risk (Power, 2005). The *pragmatists* acknowledge learning from *credit* and *market* risk approaches, but instead the emphasis is on the practices.

This research involves an understanding of both performance systems and the risk management process, including the part that management personality and individual behaviour have on this relationship (cf. de Waal, 2003). *Calculative Cultures* provides a simple dichotomy of the organizational and individual approach to risk data and the impact this has on the risk assessment process. However as seen in the next section (section 2.6), this relationship may be more complex (cf. Slovic, 1964), for example the differences brought through gender (Byrnes et al., 1999:367).

An extension to *Calculative Cultures*, considers the philosophy and organizational approach to the risk management framework, this is Mikes' *ERM Ideal Types* (2009; 2011).

2.3.4 Mikes (2009) ERM Ideal Types:

Mikes (2009), similar to Power (2005), refers to the management styles of risk in context of *Operational risk*, and that *Operational risk* is an inherent part of Enterprise Risk Management (ERM). This links the two bodies of work: Risk Management Standards and the Basel Accord's definition of risk. There is recognition that risk management is not a pure issue of financial outcome, and that there are non-financial impacts on performance (cf. Leibenberg & Hoyt, 2003); the inference being that this is increasingly important as Operational risk understanding develops. There are four types of risk management discussed by Mikes (2009):

*Type 1: Risk Silo Manage*ment (RSM), with a focus on quantification (particularly Value at Risk [VaR]) and control. Risks are tasked within their specific categories. RSM embodies the quantification of Operational risk. Crouhy et al. (2001) deal with the application of VaR in some depth. VaR is a statistical measure of anticipated loss (Mikes, 2009); it requires an understanding of the different loss distributions. The impact is that risk categorisation has an influence on organizational practices. This is characteristic of first-order risks (Mikes, 2011) where measurements are collected into ordered groups.

Type 2: Integrated Risk Management, recognises relationships between different risk silos, and uses a common denominator of risk measurement to assess risk. Risk aggregation is characteristic of second-order risks (Mikes, 2011), where units of measurements serve as the backbone of performance management. Mikes suggests there is a tendency toward using economic capital as the single metric of risk. Arising from the Basel Accord, use of economic capital as the common denominator is given legitimacy (cf. Mikes, 2011).

Type 3: Risk Based Management, this reverses the association. Risk valuation is used to inform the organization of expected value from parts of the business or its processes. Risk valuation feeds back into the operation, using calculations such as Risk Adjusted Return on Capital (RAROC).

Type 4: Holistic Risk Management, the difference in this risk type is the recognition of non-quantifiable risks. This challenges established definitions of risk. The aim is to turn non-quantifiable into quantifiable risks as experience and knowledge progresses. This approach reduces the reliance on quantitative measurement, and use of single metrics. The impact is formal recognition of a broader consideration to consequences in risk management. However there is little understanding between the various types of risk (Mikes, 2011) for example political, people, reputation, market or finance (Ackermann el al., 2007).

Mikes' four risk management types (2009) recognise that measurement devices provide a link back to the finance community's quantification approaches. Specifically VaR, which is located in *Type 1: risk-silo* management. Although a recognised approach across many communities its applicability is challenged when centred on statistical measures of Operational risk. There is a limitation of these tools for calculating catastrophic risk (Crouhy et al., 2001: 507). Liebenberg and Hoyt (2003) suggest that risk silo approaches are the opposite of ERM practices.

The *risk-silo* approach is a line-management responsibility (Mikes, 2009). Whereas Power's (2005) view that *Operational risk* is a broad and strategic concern that should attract management by senior executives. A senior management body, having oversight of all inter-dependencies, should become involved in risk management (Perrow, 1984). However little has been developed in terms of our understanding of the consequences of ownership of the Operational risk management process.

Quantitative assessment can have distinct benefits (Mikes, 2009), because risk management cascades into the organisation and may result in a granularity of risk pricing or risk portfolio management. It provides a scientific and structured approach to resource management throughout the organisation. Mikes (2011) describes those who are dedicated to risk measurement as *quantitative enthusiasts*. *Quantitative enthusiasts* are similar to Power's (2005) calculative idealists. The link between *Calculative Cultures* and *Risk Management Types* is discussed further in the next sub-section.

The Link between Calculative Cultures and ERM Ideal Types

Bringing the two concepts together: *Calculative Cultures* (Power, 2005; Mikes, 2009, 2011) and *ERM Ideal types*; ERM by the numbers, *quantitative enthusiasm* (type 3) and Holistic ERM, *quantitative scepticism* (type 4), seem to have a direct relation to *idealist* and *pragmatist* cultures (respectively).

Further that "Thermostatic conception" (Power, 2009:851), the singular thermostatic control of risk management, similar to the *Integrated Risk Management Type*, is in contrast to understanding of risk taking behaviour by Slovic (1964), that risk-taking propensity is in its own right multidimensional and subjective. Even where a systems view is adopted, decision-making is understood to be largely individualistic (Lewis, 2003; Slovic, 1964). Power's contribution is that organizational understanding of risk performance may exist in both tangible and intangible formats of a control system. That precise rules (advocated by idealist cultures) may be "*institutionally attractive, and persists because it offers a regulated transparency to the risk management process*" (Power, 2009:852). This requirement to embed internal control systems seems now to be accepted practice within the ERM community.

The approach to the singular thermostatic control of risk, and the understanding that a single measure of risk in the Integrated Risk Management Type exposes the question of risk valuation, is covered in the next sub-section.

Risk Valuation:

The practice of *Operational risk* management appears to be based on risk quantification (Mikes, 2009; 2011), and principally quantification in monetary terms. There are a number of valuation approaches that are considered for use with *Operational risk*, for example Value at Risk (VaR). These approaches have not significantly progressed outside of finance and insurance literature and continue to be immature in their implementation outside of finance (Power, 2005). Valuation approaches have been adopted from the more mature practices for *market* and *credit* risk management i.e. VaR. They may be considered as retrofitted concepts, when applied to *Operational risk*. However Operational risk valuation using VaR is criticised for being inappropriate because of the shape of the distribution curve of this type of risk (Nocco & Stulz, 2006), because Operational risks have a long probability tails and are not evenly distributed. This is contrary to the assumption of normal distribution being an underlying principle of calculating VaR.

Much of the critical analysis discusses the financial as well as the non-financial consequences of *Operational risk* (cf. Kuritzkes, 2002; cf. Kaplan & Mikes, 2012), and may in different contexts be considered a non-financial category of risk. This makes a single measurement of risk challenging and imprecise. Further quantitative valuation approaches of Operational risk are confused, because of the relationship and genealogy to credit risk, where financial measurement of risk is considered appropriate. Therefore financial measurement of Operational risk appears to be only one approach to analysis of risk.

2.3.5 Summary of Operational Risk Literature

Positive *imprecision* in an Operational risk context does not lead to *loss-making events*, as such effort is usually understood to focus on downward mitigation (Institute of Operational Risk, 2009). This has the consequence that the risk-reward dynamic is rarely central to the discussion of Operational risk, unlike its more financially orientated boundary terms (*market* and *credit* risk). These are theoretically termed *speculative* risk are risks associated to the financial dealings of the firm. There is limited discussion of Operational risk treatments, but it is felt that *it* cannot be hedged (Nocco & Stulz, 2006).

Operational risk as a concept is both over generalised and has been used outside of the original context it was defined to operate within (Power, 2005). In the Basel Accord it is a complementary risk type, alongside *market* and *credit* risk, which are financially aggregated types of risk. However in extension it is also a category of non-financial risk types. There is a certain unity in literature that Operational risk is a description of *pure* risk (Lewis, 2003; Power, 2005).

Operational risk continues in the third Basel Accord (Basel Committee, 2006) to exist within these constraints. Its definition is in the medium term unchanged. Operational risk as an issue for capital adequacy is increasingly important. The portability of this term seems limited when technically applied outside of the finance domain.

There is an understanding of the inter-relationship between risk and its use in performance management. The simple dichotomy of Calculative Cultures expresses this as a choice between calculative idealism or calculative pragmatism (Power, 2005). This is extended in the understanding of the different risk management types observed in Mikes' research

(2009; 2011). These four risk management types are generalisations of the approaches to risk management, ranging from the silo approach to the holistic approach.

How does the extension of *Operational risk* affect understanding of risk in an Energy context? There is clear contention in the definition of Operational risk, which seemingly has not been resolved. The contention is symptomatic of a lack of reconciliation with non-finance descriptions of risk. There is an outstanding question as to whether classification of risks is best made through a causal description, as made by the Basel Accord.

While the limitations of Operational risk as a specific definition are exposed, the next reference point is operations risk. *Operations risk* is a closely related term (Loader, 2007). Crouhy et al. (2001) suggest a view later reflected Lewis (2003) that *Operational risks* are not the same as *operations risks.*

2.4 Risk in Operations

The distinction between risk categories is based on the understanding that seeking a definition is more than a pure semantic exercise; it provides "*delimitations of potential jurisdictions*" (Power, 2005). It appears these jurisdictions have multiple meanings, including the organizational structure, reporting of risk and the tools used in managing and treating the different risk types.

Operations risk is considered (in financial institutions) as failure in operations or back office functions. *Operational risk* is understood to span the whole supply chain and the organisation's external environment. In the search for causal forces generating Operational risks, a broader approach is required (Lewis, 2003), beyond that of the traditional operation.

The different definitions of risk have occurred through breadth of terms being employed and different contexts, not least different organisational interpretations being used. These contingent and paradigmatically specific definitions, i.e. *supply chain risk* (Kleindorfer et al., 2003:53), *disruption risk* (Kleindorfer et al., 2003:54), *project risk* (Dey, et al., 1994; Dey, 2002), *legal risk* (Basel Committee, 2006), *people risk*, *political risk* (Jensen, 2005), *culture risk* (Securities Institute, 2004:1-8) are a mixture of outcome orientated classifications (i.e. financial loss), procedural (i.e. transportation risk) as well as technical descriptions (i.e. counterparty risk).

The bridge between Operational risk and risk in operations (operations management and supply chain literature) is limited. Examples include the discussion of the framework of *cause, consequence and control* (Lewis, 2003), assessment of Operational risks by professionals and the role of experience in making decisions (Tazelaar & Snijders, 2013) and the ignoring of Operational risks and the reoccurrence of loss events, based on limited knowledge acquisition (Hora & Klassen, 2013).

The extant literature has several notable features: that a distinction is regularly made between modelling of risk assessment (Cohen & Kunreuther, 2007), decisions in risk analysis (cf. Dey, 2004) and management of realised risks (i.e. response to incidents). There is a clear separation of the literature in operations focusing either on demand and capacity risk management, *supply-demand coordination risks (*Kleindorfer & Saad, 2005); and management of operations or *disruption risks* (Kleindorfer & Saad, 2005). These are reviewed in turn.

2.4.1 Supply-Demand Coordination Risk

Supply-Demand Coordination Risk (SDCR) is *"risks arising from the problems of coordinating supply and demand"* (Kleindorfer & Saad, 2005:531). The risk-reward relationship can occur in supply chain risk: *"Such coordination [of supply and demand coordination] requires both optimization of specific risk-reward tradeoffs associated with each player's environment as well appropriate design of the customer-supplier relationships that link each player in the supply chain."* (2007:531).

SDCR utilise quantitative modelling methods, they provide tools to achieve optimal configuration of demand and capacity decisions within the firm (Cohen & Kunreuther, 2007). SDCR refers to a potential for loss as well as gain in configuration decisions. This is *speculative* risk (Banks, 2004).

Risk taking or making decisions when seeking optimal configuration is still highly subject to risk propensity of the organisation and its managers (Gan et al., 2004). Gan et al. (2011) extend this understanding between agents in a supply chain relationship; where there often exists non-parity in risk propensity between firms and the impact this can have on equality of profit and risk sharing. It seems that the limitation of this concept (particularly when viewing operational failure) is that the Pareto-optimal solutions discussed assume transferability of risk between agents. The transferability of risk between agents is a concept framed by Principle-Agent Theory (Eisenhardt, 1989). In understanding the transfer of risk between agents, this is understood for financial transactions, but the transferability of non-financial risks: reputation, health and safety and regulation are not clear.

Further*, Options contracts* may be used to benefit in SDCR (Fang & Whinston, 2007), seen also in Cohen and Kunreuther's *SC risk management framework* (2007). These are in addition to treatments of mitigation (Kliendorfer & Saad, 2005:59).

SDCR frameworks provide an alternative means of strategic choice valuation (Kulkarni et al., 2004). They consider whether economies of scale have a fundamental impact of the risk accepted by the firm. These are limitations of Kulkarni et al.'s findings when directly applied to managing the risk of failure. By deriving the optimal configuration it seems their model overlooks consideration for threats from introduction of single points of failure. These process configuration decisions (typical of existing operations management) have significant impact on risk propensity (Kulkarni et al., 2004) and risk management principles developed in alternate communities may offer valuable insight (Fang & Whinston, 2007; Sodhi, 2005).

So, contrasting with the Basel definition, there is a relationship between market risk and the propensity for operational failures, for example: *"Network Traffic Options Pricing"* (Fang & Whinston, 2007). It demonstrates how firms may take *options* to secure bandwidth. It shows how failure to secure capacity will quickly lead to communication failures (a *pure risk* of communication capability). It is a criticism of this literature that it independently discusses the problem of *supply-demand coordination risks* without tackling the related disruption risk. The two risk categories can be inseparable.

Finance principles in assessment and valuation may be transferred into the SDCR problem (Seshadri & Subrahmanyam, 2005). This includes a sharper focus on the learning already undertaken in industry by developing links to the finance discipline (Peck, 2006; Sodhi, 2005) and economic evaluation of scale dependent investments (Lederer & Mehta, 2005).

The second risk type discussed by Kliendorfer and Saad (2005) is disruption risk.

2.4.2 Disruption Risk

The work of Kleindorfer (Kleindorfer & Saad, 2005; Klieindorfer & Wu, 2003) and a testimonial paper for his work by Cohen and Kunreuther (2007) are central to this body of knowledge. A limitation of this work is the focus on low probability high impact risks (LP-HI).

Disruption risk is *"risk arising from disruptions to normal activities"* (Kleindorfer & Saad, 2005:53), it is closely associated to risk in operations. Disruption risks are understood as events that reduce effectiveness or efficiency (or total failure of) a supply chain leading to damage in profits, competitive ability and more recently concerns relating to sustainable practices i.e. environment and social perception (Kleindorfer et al. 2003).

Disruption risk is a risk associated to operational failure, it is a risk in operational capability. There is little distinction between the financial definition of Operational risk *"failure in people, processes and systems"* (Basel Committee, 2006) and SCRM's definition of disruption risk: *"equipment malfunctions, unforeseen discontinuities in supply, human centered issues* *from strikes to fraud, and risks arising from natural hazards, terrorism and political instability"* (Kleindorfer & Saad, 2005:53). Other than its specific context and the difference in exclusion of political risk there is little practical difference; Kliendorfer and Saad refer to *Disruption Risk* as *Operational risk*.

There are several observations in disruption risk that contribute to understanding risk in operations:

a. Risk measurement is key (Kleindorfer & Saad, 2005);
b. Supply relationships increase and decrease risk (Ireland & Webb, 2007);
c. Context is important in understanding risk (Gan et al., 2004);
d. There are a variety of risk treatments advocated (Kleindorfer et al., 2003));
e. Learning increases the risk management potential; and
f. Individual behaviours, perceptions and experience (cf. Dey, 2004) influence risk management (Gan et al., 2004).

These are now reviewed in turn.

Risk measurement is key:

Risk measurement has a fundamental role in risk management process (cf. Dey et al., 2013; Kleindorfer & Saad, 2005). Both quantitative measurement (cf. Dey, 2004; Dey et al., 1994) and subjective assessment are intrinsic aspects of the risk management suite (Cohen & Kunreuther, 2007; Dey, 2004; Kleindorfer & Saad, 2005).

Supply Relationships Increase and Decrease Risk:

Supply chain relationships increase risks by introducing uncertainty in relationships or decreases risk by increasing the access to information across the whole supply chain (Ireland & Webb, 2007). This is based upon the balance of power between agents as well as the levels of trust in place. *Power*, is risk reducing and trust, risk-increasing (Mayer et al., 1995). *Power*, a relationship of control or influence (Mayes & Allen, 1977), and *trust*, *"the* *willingness of a party to be vulnerable to the actions of another"* (Mayer et al., 1995:712), are different means of managing uncertainty (and therefore risk) within the supply chain.

Different agents in a relationship infer, transfer and incur risk between partners (Kleindorfer & Saad, 2005). Systems and tools used to formerly or informally manage this process of risk between partners are not developed. Risk is contingent, so different agents will have a different understanding of what risk means. Risk definition does not fall within a consistent framework, even within a single supply chain (Kleindorfer & Saad, 2005). So, there is a lack of industry attention to managing interdependencies of risk between internal and external supply chains (Cohen & Kunreuther, 2007). Therefore, risk management becomes a *"divide and conquer"* approach (a reductionist approach), and ignores the inter-related, system perspective (Peck, 2006).

Information sharing is a theme within the SCRM literature (Ireland & Webb, 2007; Kleindorfer & Saad, 2005; Neiger et al., 2009). Knowledge sharing may both increase risk awareness across the supply chain, but that parity of information may also expose firms to risks of loss of competitive advantage (especially in knowledge intensive markets). Inevitably this becomes a debate on the dynamics of power within the supply chain and the balance between information sharing to increase risk assessment, and valuable knowledge that becomes commercially threatened (Ireland & Webb, 2007).

***Context is important in understanding risk**:*

National context (Makhija & Stewart, 2002), environment (Dey, 2002) and even improvement programmes are known to affect perceptions of risk (cf. Ellis et al., 2010), the inherent risks and the risk management approach taken. For example:

- Where an organization adopts Lean practices it can increase the level of vulnerability of the firm, because of a removal of redundancy, contingency and diversification, (Kleindorfer & Saad, 2005:55; Faisal et al., 2006);

- Different national contexts drive diverse approaches to risk assessment. As seen in Nuclear Power Plant's (NPP) safety assessment (Cepin, 2007), where there are different standards applied between nations.
- There are different representations of risk are influenced by the environment's configuration, e.g. technology, market and importance of product (Ellis et al., 2010).

There are a variety of treatments advocated:

Real options approach, which is the purchase of a right to buy an asset or service at a future time of the organization's choosing, can be used to manage disruption risks (Fang & Whinston, 2007), and Operational risks (Kleindorfer & Saad, 2005). *Insurance*, which at the most basic level is the financial reimbursement of a failure from a third party against a specified event, is an approach to reduce the variation in short term financial losses, and to spread the cost of financial loss over a longer period. However there are limitations to insurance principally that *catastrophic risk* cannot be insured (Vaughan, 1997).

Risk mitigation is the reduction of risk to a lower level. Mitigation approaches can consider the use of multiple sourcing partners, development of the supplier relationships, the implementation of quality initiatives (Spekman & Davis, 2004), increasing flexibility of relationships to respond to events (Ritchie & Brindley, 2004) and redesign of processes to remove sources of risk (Christopher et al., 2011). Further redundancy can provide slack in the system (Grabowski & Roberts, 1999), as it offers a buffer from variance in the environment.

Learning increases risk management potential:

Learning capability, learning culture, system design and managerial risk perception influence the management of risk (Braunscheidel & Suresh, 2009; Peck, 2006; Perrow, 1984). Learning increases the risk management potential of the firm (Braunscheidel & Suresh, 2009), this can be developed through observational learning both within and between sectors, (i.e. learning from understanding of other's successes and failures, Hora &

Klassen, 2013). However it is felt that firms often fail to learn from observing losses occurring in their own industry, which could help develop their practice (cf. Hora & Klassen, 2013).

The development of expertise within the firm may appear an alternative or complementary approach to learning where observational intra-organizational learning is not available. However, the *process-performance paradox* suggests that although experts have different mental models (from the lay-person), it does not lead to better assessments of risk (Glaser & Chi, 1988). It puts into question, whether the development of expertise improves risk assessment as experts neither use less data nor are they faster in their assessments (Tazelaar & Snijders, 2013). There are some influences that experts are known to have, e.g. experienced professionals (in the case of banking auditors) have a lower perception of risk than non-specialist auditors (Taylor, 2000).

Individual behaviours and perceptions influence risk management:

The limited improvement in decision-making that experts provide (Glaser & Chi, 1988), exposes the role of the individual in an organization's risk management. It is found that risk assessments are based on subjective managerial judgement (Ellis et al., 2010; Gan et al., 2004). Therefore, informing this decision, representation of risk is fundamental in risk assessment. It is known that an individual's risk perception is influenced by quantitative assessment and the analysis approach (Knemeyer et al., 2009).

So where consistency is a desirable quality in decision-making (Dilla & Stone, 1997) it is a further challenge that managers are known to perceive the same risk differently if presented in alternative constructions (Kahneman & Tversky, 1984; Slovic, 1964). This area of understanding is covered in greater detail in Section 2.6, however even within this domain of knowledge there is disagreement, for example Ellis et al.'s (2010) findings are in direct contradiction to March and Shapira (1987), that probability assessments have little influence on managerial judgement, rather probability has almost double the impact on risk assessments.

2.4.3 Summary of Risk in Operations Literature

Supply demand coordination risk and disruption risk literature provides knowledge on several points:

The manager and their perceptions and judgement are central to the management of risk. Contentions between Ellis et al. (2010) and March and Shapira (1987) identify a difference in understanding. This includes whether probability assessments are formative on the decisions. Where *Supply-demand* coordination *risk* is heavily based in numerical analysis and optimisation, *disruption risk* is much more aware of subjectivity as a legitimate part of valuation.

Different types of risk infer different practices. The focus of SDCR is quantitative and conforms to Power's (2005) *Calculative Idealists*. Disruption risk literature does not make any great distinction from the discussion of Operational risk in finance.

There are different approaches to valuation driven by financial and non-financial measures. There is less demand for quantitative valuation approaches to be used in disruption risk. However much of the analysis of disruption risks is focused on high impact low probability events, with the limitations this incurs.

There are different types of treatment to consider. SDCR literature identified options contracts and mitigation; whereas disruption risk literature was inclusive of real options, insurance and mitigation treatments. Risk treatments are discussed further in the next section.

2.5 Risk Treatment

A risk treatment is: *"the process by which existing controls are improved or new controls are developed and implemented."* (Purdy, 2010:883). It is also used to refer to the specific description of the controls, which in ISO31000 includes: avoiding, taking, removing, changing likelihood or consequence, sharing and retaining (BS ISO31000, 2009).

The presumption is that the (risk) decision-making process takes inputs (from a range of sources, not excluding the management belief set) and disposes of the risk through a number of treatments accessible to the organization. This application of the treatment is then scrutinised in the control phase. The selection of risk treatment should be based on organizational objectives (O'Donnell, 2005). There are two ways firms manage risk, and the selection of treatment: a) each risk on its own, b) as a portfolio of risks (Nocco & Stulz, 2006).

One of the limitations in the extant literature is the lack of explanation between treatments that are employed primarily to affect the occurrence (the probability) of an event, or those, which principally are employed to manage the impact of an event. This difference is identified in ISO31000 as changing likelihood or consequence (Purdy, 2010), and by Gan et al. (2009) it is the difference between defensive or controlling strategies.

An example of available risk treatments is seen in Crouhy et al. (2001): investment, avoidance, acceptance and transfer. A common management mantra is the *"4Ts of risk treatment: Tolerate, treat, transfer and terminate"* (Hopkin, 2012), this typology seems an over generalization and hides the subtlety in choice.

Risk treatment is discussed by Slack et al. (2010) in an operationalized manner, for example: *Designing out failure* (2010:467-9) through *"redundancy"*, *"maintenance"* and *"fail-safeing"*, aligned to probability reduction. Fail-safeing has roots in quality management techniques (i.e. Lean's Poka-Yoke, Slack et al., 2010). Whereas, *failure mitigation* is closer to impact reduction approaches (2010:473): *"mitigation-planning"*, *"containment"*, *"reduction"* and *"substitution"*. *Substitution* has similarities to redundancy *"but does not imply excess resources"* (Slack et al., 2010:473).

There is further diversity of terminology used to describe treatments: *Avoidance, Reduction, Retention, Transfer, Sharing* (Vaughan, 1997), *Reduction, Protection, Transfer, Financing* (Crockford, 1980), *Loss control, Loss financing, and Risk reduction* (Banks 2004). Although there is a wealth of research on each of these individual strategies, there is a limited and imprecise literature discussing or presenting risk management as a cohesive set of approaches. Much of the extant literature is industry specific or presented as part of a wider risk management process (i.e. Failure Modes and Effects Analysis).

The treatments considered in the following review are reflective of Crockford (1980), Hopkin (2012), Slack et al. (2010) and what is felt to be the most exhaustive of consideration relevant to operations, Vaughan (1997).

The risk treatments reviewed are:

a) Accept or take risk (includes retaining, Vaughan, 1997);
b) Transfer/Sharing (Insurance and Outsource);
c) Avoid/Withdraw;
d) Mitigate (probability and impact) and reflects Vaughan's reduction and protection;
e) Option taking;

These different treatments are reviewed in turn. However returning to the earlier review of Holton (2004) which requires an individual's self-awareness as a component of risk, the review begins by covering the issue of consciousness and the ignoring of risks and how this may also be differentiated from risk acceptance.

2.5.1 Ignorance and Consciousness

The difference between ignoring a risk and accepting it is whether there is a conscious treatment. Differentiation between unconscious and conscious management is a demarcation separating decision-making from omission of decision. Consciousness affects accountability, the learning process and measurement. From an applied perspective *ignored risk* can be difficult to separate from *accepted risk*. Categorisation challenges the meaning of *ignored risk* or the activity of *ignorance of risk.* The meaning of ignored for the purpose of this paper is defined through its omission of *consciousness* (cf. Farthing, 1992)*;* more precisely the lack of a decision process when confronted a risk.

Discussion of consciousness has deeply philosophical roots, as well as psychological and ethical backgrounds. Using James' 1910 definition and the modern application in Farthing's *The Psychology of Consciousness* (1992), there are four requirements for consciousness:

1) Consciousness is *subjective* (Farthing, 1992:25; James, 1910 in Coren et al., 2004). The subjective nature of *'consciousness'* means it must be understood in context with an organisation's risk decision-makers;
2) Consciousness is not a passing activity, it is a process *constantly going through change* (Farthing, 1992:26; James, 1910 in Coren et al., 2004), it supports consciousness as being an evolving thought process, addressing new knowledge and changes in environment;
3) Because it is subjective, changes being addressed will be personal to the individual. Consciousness will also exhibit *continuity* (Farthing, 1992:27; James, 1910 in Coren et al., 2004);
4) *Selectivity*, is the personal attribute of choice (Farthing, 1992:28), this is the influence of both voluntary and non-voluntary factors. This is critical as organisations look to control the level of consciousness of risk. But debate whether a reflex decision is a conscious decision is raised. If a manager routinely responds to a risk having made an initial consideration (by doing nothing), is this ignorance or acceptance? The same debate has raged within the psychology field, as the *volitional/reflexive* debate (Farthing, 1992:39). Reflex action is understood as taught, inherent or *a priori* conditioned decision. Reflex may be considered a level of physical consciousness. As a decision-making process, reflex decision is included in the consciousness of risk management. This is separable from a risk being identified and no act or thought process being applied, i.e. dismissed without analysis. Farthing's description of a *volitional act* may be taken to describe this process, one which creates *"overt behaviours or further cognitive acts"* (1992:38).

A distinction that this definition creates is the organisational inability to be *conscious,* it is reliant on the existence of decision makers in the firm to act as the subjective and selective body for handling risk. Holton's (2004) need for individual's self-awareness in risk definition would seem to support this point.

So with this understanding, deciding on a risk treatment even where there is inaction (i.e. risk acceptance) is differentiated by the consciousness of the decision-maker, even where this has become a reflex action.

2.5.2 Accept

With both *accepted and ignored* risk there is no noticeable change in the activity (or lack of) employed by the organisation in handling the risk. It is the conscious (Farthing, 1992) lack of activity that separates the two paths. Acceptance is a conscious activity.

Several characteristics influence this understanding:

- That the managerial characteristic of optimism, is commonly adopted (March & Shapira, 1987);
- Optimism means managers will positively skew predictions of probability and impact (Schwenk, 1995);
- Illusions of control encourage managers to think that they influence positively the outcomes of a process (Schwenk, 1995);
- Mangers attribute visions of failures of to *"external factors"* (Bowman, 1984; Clapham & Schwenk, 1991), this discourages personal responsibility from being taken in loss-situations.

Using a figure plotting impact and probability, these different influences are understood in the perceived changes to a risk.

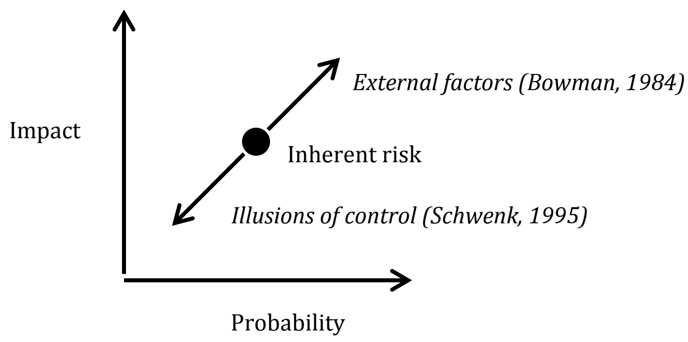

Figure 2.6 Accepting Risk

The implication of accepting risk is that neither probability of occurrence nor impacts are altered in any way.

The acceptable risk in the organization may be a subjective valuation (an order of magnitude, rather than as a specific valuation). This may be described as the risk profile of the firm, and sometimes described as the *risk appetite* of the firm (Kaplan et al., 2009). It is the role of the CRO (where appointed) to align this understanding of current and expected risk (cf. Liebenberg & Hoyt, 2003). Some risk management approaches (e.g. COSO ERM), as adoption of ERM approaches (or processes), are expected to move the organization away from acceptance of risk toward forward proactive management of risk (O'Donnell, 2005).

2.5.3 Transfer (Financial)

An organisation may *transfer* its risks or specifically *transfer the economic cost of a risk being realised*. This involves the operating party (the insured) to identify a specific risk, and contractually transfer the impact (or part) of the risk to a 3rd party (the insurer). This is commonly undertaken as *insurance*. Examples of insurance in operations and maintenance used as a risk treatment evident in Dey (2004): Pipeline Insurance Plan.

Insurance as a discipline is not an appropriate replacement for risk management (Crockford, 1980:44; Engemann & Miller, 1992:143), rather it should be one of a number of tools encompassed within risk management. This confusion is rooted in the relationship between pioneers of risk management and their heritage in insurance practices.

Commercial insurance is understood as a move of variable costs relating to failure to a predictable fixed cost (Knight, 1921: 213). Smaller (e.g. domestic) types of insurance collects: *"from many to pay for the losses of the few that suffer them"* (Crockford, 1980:45). However, there is limited permanent transfer of loss costs to the insurer in commercial markets. Insurers for other than catastrophic losses, will recover the cost of losses either in increased premiums, or will have done so prior (Crockford, 1980). Operational failures when transferred to the insured are the cost of impact plus the administration costs and normal profits of the Insurers. Consideration of political risk (Dey, 2004), socioeconomic and cultural matters are essential in the consideration of transfer (Vaughan, 1997; Jensen, 2005).

Not all events and their impacts are commonly insurable. Vaughan (1997) proposes four principles for an insurable risk:

1) *"There must be a sufficiently large number of homogeneous exposure units to make the losses reasonably predictable"* (Vaughan, 1997:210)

   Where there is a refusal of insurance or unacceptable premiums being offered can lead to formation and use of *Mutuals* or *Captives* (Crockford, 1980:51).

2) *"The loss produced by the risk must be definite and measurable"* (Vaughan, 1997:211)

   Measurability presents significant obstacles for insurance for anything other than direct financial loss. Indirect loss, reputational loss and strategic loss become difficult to conceive in an insurance agreement. Even where an organisation manages to purchase insurance on social matters (i.e. insurance against the cost of planning application being refused), the premiums may be higher (the specifics covered by the insurance limited to directly attributable losses). There are three categories of insurable political risk: *expropriation risk* (confiscation of assets), *transfer risk* (limitation of repatriation of profits) and *violence risk* (war or civil disturbance) (Jensen, 2005). It is seen that the economic consequence of political risk is currently the only insurable aspect of political risk.

3) *"The loss must be fortuitous or accidental"* (Vaughan, 1997:211)

   Where probability is *subjective uncertainty*; for a mutually acceptable and beneficial premium this presupposes that the insurer and insured exist in a market with uniform and available knowledge. Experience may create imbalance in the insurance market. An organisation with strong risk management processes may be disadvantaged by proportionally weaker risk management across an industry, upon the acceptance of the insurance approach to law of large numbers (Vaughan 1997:211).

4) *"The loss must not be catastrophic"* (Vaughan 1997:211)

   Following catastrophic failure, for example: The Chernobyl Disaster (1986), Exxon Valdez Oil Spill (1989), The Attack on The World Trade Centre (2001), and The Macondo Well Incident (2009), insurance can be enforced by regulation (i.e. Nuclear Risk Insurers Limited). As these catastrophic events occur there is pressure on the ability of insurance companies to cover the costs, and places the insurance companies under significant strain (e.g. AES, 2008 and Lloyd's of London, 2001). The insurance against catastrophic loss is vital to firms as it not only stands to damage earnings and value of the firm but also the potential for its very existence.

There are *two common mistakes of buying insurance*, too much and too little (Vaughan, 1997). The costs of these common mistakes can be significant, with the former it can be existence threatening and the latter can damage any economic advantage, through operational cost inefficiency. *"Insurance always costs more than the expected value of the loss"* (Vaughan, 1997:69).

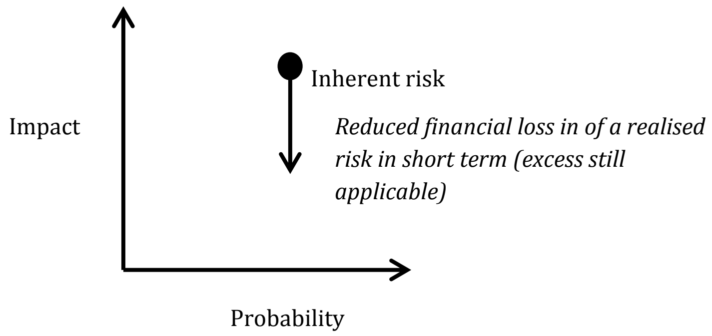

Figure 2.7 Transfer Risk (Insurance)

Figure 2.7 demonstrates a reduction in the impact of an event when insured. It does not influence the probability of the event. The impact is not reduced to zero because the insured needs to recognise the cost of insurance and the excess being. This is therefore a limited transfer of impact to the insurer.

2.5.4 Risk Transfer (Outsource)

Outsourcing is the turning over of an organization's functions to an external service provider (Teng et al., 1995) or *"turning over to a supplier those activities outside the organization's chosen core competencies"* (Sharpe, 1997:538). This is a strategic decision to be made by the organization (Teng et al., 1995). The nature of outsourcing has led to the discussion of the relationship between outsourcing and risk (cf. Kaplan et al., 2009), as the outsourcing decision to be the causal influence on risk being incurred (Adeleye et al., 2004; Aubert et al., 2001; Lonsdale, 1999). Outsource may be used as a risk treatment, in response to projects or operations considered too great or complex for the organization to manage (Cucchiella & Gastaldi, 2006; Richmond & Seidmann, 1993), this is a potential to *"transfer the risk of emergency costs or the costs due to an incapability to realise the investment in-house"* (Cucchiella & Gastaldi, 2006:708). However, outsourcing also incurs increased risk (cf. Kaplan et al., 2009), for example *knowledge leakage*, where valuable information or know-how is shared outside of the organization (Narasimhan & Talluri, 2009). Contracting out services can result in moving risks away from the operating party into a 3rd party. This is under a different and more specific relationship than insured-insurer. It may include legally, economically, socially and morally binding features (Vares, 2004:25). This includes reputation, staff and motivation that would not be managed within the insurance relationship.

The benefits of outsourcing can provide access to *"best in class skills and capabilities"* and *"improvement of products and services"* (Harland et al., 2005:841), this can reduce the probability of the loss event or at least a better prediction of the loss event (cf. Kaplan et al., 2009). But there are still divisions in the views of the role of outsourcing. The mantra of *"don't outsource a problem"* is still topical (Ishizaka & Blakiston, 2012; Soderberg & Bengtsson, 2013). Whether it should be used as a risk treatment (because it can reduce the inherent risk), it can solve problems (Mazzawi, 2002) or whether it increases the level of inherent risk in an operation or function, as the risks in outsourcing are large (Murthy et al., 2002). Combined with the application of partnering contracts (Levery, 1998) or service Level Agreements (SLA) which may have limited damage clauses, this may insulate the organization from limited short-term financial losses, much in the same way as commercial insurance. Away from the valuation of risk as a financial measure, reputational risk is understood to be difficult to protect against in an outsource relationship (Ang & Inkpen, 2008; Christopher & Gaudenzi, 2009; Hoetcht & Trott, 2006).

Figure 2.8, represents these different influences on the risk position. That financial loss can be reduced through contract (Murthy et al., 2002), but that non-financial risks (i.e. reputation) may be increased through the relationship; these affect the potential impact axis of the inherent risk. Further the probability of risks may be reduced through the increased skills being bought through the contract (cf. Harland et al., 2005).

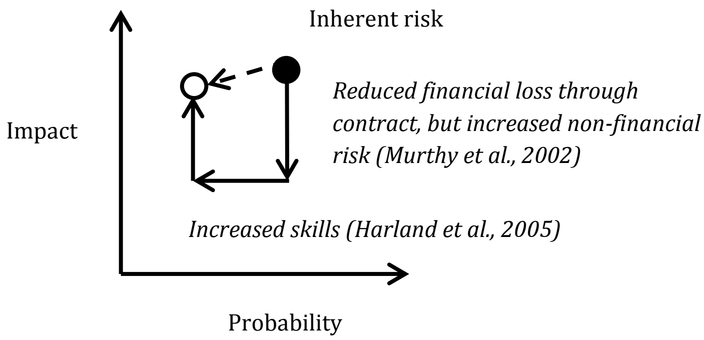

Figure 2.8 Outsource Risk

Treating risk through outsourcing needs to understand this relationship between the offset of financial risks being transferred to the 3rd party, and the increase in the non-financial risks (e.g. reputation). Further, that the change in risk may be materially influenced by the reduction in probability by engaging increased skills.

2.5.5 Avoid or Withdraw

Withdrawal (when in a path of a risk) or avoidance (when decision to enter a path of a risk) requires total removal of any probability of occurrence or any impact of occurrence (or both). Any interim position is considered as a mitigation strategy, and as a typology, mitigation is assumed a more moderate response to risk.

There is limited theory developing the concept of risk management as a process of withdrawal or avoidance. The notable exception is Pauwels and Matthyssens (1999). Avoidance requires an organisation's total removal from an environment, or to make event consequences within that environment totally valueless. The reasons for adopting such avoidance are considered where the costs of impact are significantly greater than any expected returns; or where probability of impact is so high as to move negative outcome into a description of near certainty. Where withdrawal is based upon the possibility of *threat-rigidity* this is termed as *tactical withdrawal* (Pauwels & Matthyssens, 1999:4).

Withdrawal is the selection of a course of treatment that results in a different economic and social position, and avoidance of the specified market. The practical effect of whether avoidance treatment was chosen based upon direct threat or strategic alternative is a result of the decision-making process. Response to a direct threat has increased stigma attached to the decision (Pauwels & Matthyssens, 1999:21)[6] perceived as moving away rather than moving-toward a market. Figure 2.9 represents a withdrawal treatment.

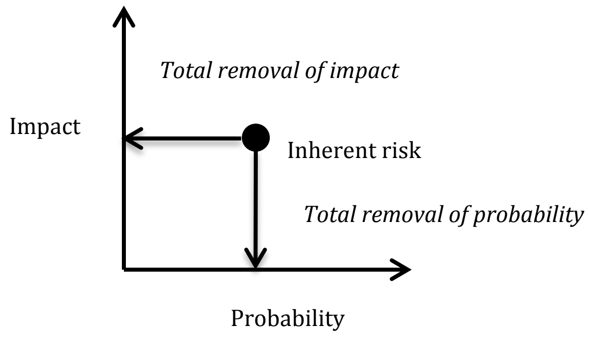

Figure 2.9 Risk Avoidance

2.5.6 Mitigate

Mitigation is an active and conscious risk management treatment. There is a difference between mitigating the probability or mitigating the impact (sometimes called resilience) (Gao, 2009).

Mitigation covers recognised and actively managed risks, where either the impact of risk has been altered or there has been a change in the likelihood of occurrence; this is where *"one variable helps to ameliorate another variable"* (Faisal et al., 2006:5).

With mitigated impact the probability is unchanged but the scale of impact has been reduced. Mitigation impact may be considered a *defensive strategy* whereas mitigation probability may be considered a *controlling strategy* (Gao, 2009).

The concept of *hedging*, is discussed as a mitigation technique in a non-financial context, as a *"portfolio of ventures"* (Oren, 2001:4) or *"as investment of backup systems"* (Crouhy et al.,

[6] *although limited by their convenience sample frame in analysing international market withdrawals*

2001:476). This is a bridge between the financial and non-financial discussion of risk management. The impact consequence of hedging is understood as the offsetting of an outcome through adoption of a negatively correlated process (cf. Kaplan et al., 2009); it becomes a specific sub-category of a mitigate impact strategy.

The two different approaches of probability and impact mitigation are discussed separately.

Mitigate probability

Treating a risk through mitigating the probability leaves the impact of the risk unaffected, whilst affecting the likelihood of the risk occurring. This may include the implementation of quality control processes, and failsafe devices (for example Poka-Yoke in Lean). In literature examples of mitigation-probability are seen in integration of suppliers in supply chains to reduce potential for coordination failures (Faisal et al., 2006:3) or insourcing of IT department to avoid divisions between business and IT strategy (i.e. RBS who insourced IT staff against a sector trend of outsourcing to manage large projects; Currie & Willcocks, 1998:125).

An example of two naval risk management treatments: radar and lifeboats are used to exemplify the difference between probability and impact mitigation. Radar has no value where a collision has already occurred, but will aid the avoidance of obstacles, reducing the probability of a crash. Whilst lifeboats has no impact on reducing the probability of a collision, but where a collision has occurred is used to reduce the loss to life, and is an impact mitigation approach.

Figure 2.10 demonstrates how an approach to probability mitigation only affects the probability axis and leaves the impact unchanged.

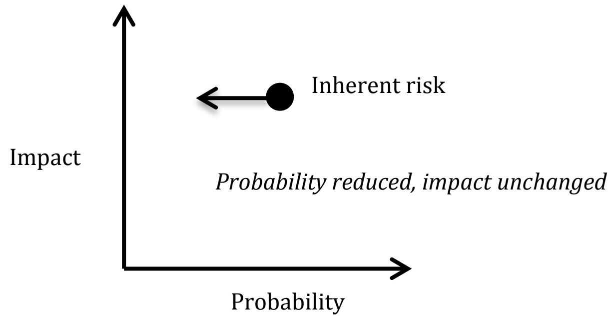

Figure 2.10 Probability Mitigation

In operations, mitigation of probability is seen in the carrying of buffer stocks, using alternative sources of supply (Spekman & Davis, 2004), developing multiple sourcing partners (Ritchie & Brindley, 2004), *"safety"*, implementation of preventative measures (Davies & Walters, 1998:2), *"buffers"*, (ibid, 1998:3), *"reserve"* (Oren, 2001:4) These are tactics (Spekman & Davis, 2004) in reducing disruption occurring in the supply chain. These are *controlling strategies* (Gao, 2009).

Mitigate impact

Application of impact mitigation strategies is better evidenced in literature and practice than probability mitigation, these include: joint ventures (Currie & Willcocks, 1998:124), and multiple-supplier sourcing (e.g. ICI in Currie & Willcocks, 1998:123). Joint ventures were intended to share both risk and reward and the latter to reduce the impact of a single supplier failure. These decisions to outsource may exhibit characteristics of both mitigate probability and mitigate impact as it could be inferred that outsourcing approaches (a route of impact mitigation) increased the capability of the operation and shared the discomfort of failure.

Figure 2.11 demonstrates how mitigation of the impact leaves the probability of the inherent risk unchanged.

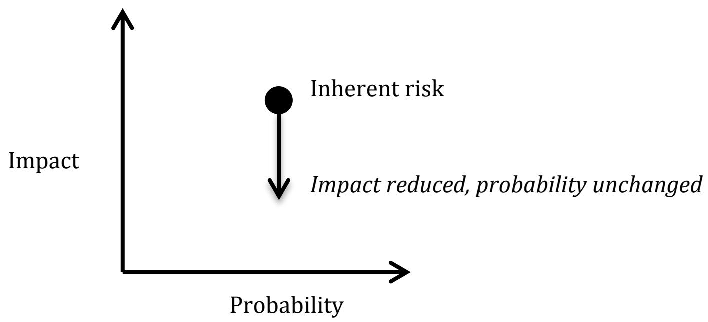

Figure 2.11 Impact Mitigation

There is close association of specific characteristics that identify impact mitigation being adopted: *"contingency"* (Davis & Walters, 1998:4; Engemann & Miller, 1992:146), *"backup"* (Currie & Willcocks, 1998:129), *"sharing"* (Currie & Willcocks, 1998; Oren, 2001:1), *"limitation & preparation"* (Davis & Walters, 1998:1; Faisal et al., 2006:1), *"flexibility",* the creation of capacity or operating flexibility (Grabowski & Roberts, 1999:707), *"redundancy"*, holding of reserve resources (ibid, 1999:707) and *"agility"* (Faisal et al., 2006:2), which provides for responsive actions to be taken on failure. These are *defensive strategies* (Gao, 2009).

Impact mitigation in supply operations are seen in increasing flexibility of suppliers (Christopher et al., 2011), and creating redundancy in the system by developing slack (Grabowski & Roberts, 1999). Figure 2.12 demonstrates how combined impact and probability mitigation approaches can be used to reduce the overall risk affecting an operation.

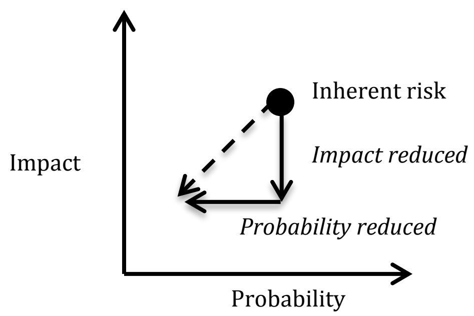

Figure 2.12 Combined Mitigation Strategies

The reality is that organizations use a mixture of mitigation approaches, treating both the impact of the event and the probability of the event occurring, (e.g. the development from simple arm's length relationship to long-term partnerships in Miller et al., 2008).

2.5.7 Defer (Options Approaches)

An area not often exposed in operations risk management, are *options approaches*. An *options approach* is the delay of a decision to a point where there is a change in knowledge regarding probability or impact expectation. It can suit situations where complexity is high. An *options approach* may be useful in explanation for many social or noneconomic activities, for example marriage and suicide (Dixit & Pindyke, 1994:23). This is a challenge for those that believe *real options* are the territory of pricing based decisions (Amram & Kulatilaka, 2000:17). Gopal et al. (2005) consider attractiveness of options in risk treatment. *Options* can be used in situations where economic values of an impact are not easily calculated, perhaps because the costs are largely indirect. These are effective in situations where there is significant influence from social forces in addition to the more empirically observable and predictable forces (e.g. plant and equipment). It provides the organization the option to take action at a future point in time, whilst not committing high levels of capital or resources to the treatment.

The *option approach* in operations risk management is borrowed from the finance community, *"analogous to a financial call option – it has the right but not the obligation to buy an asset at some future time of its choosing"* (Dixit & Pindyke, 1994:6). This extension of financial options pricing models to the discipline of *"real options"* approaches (Amram & Kulatilaka, 2000:15) may be applied to the concept of suspending or decommissioning assets. Suspension or decommission is only a subset of the *real options approach*, which is technically considered in the domain of a company's strategic options (Amram & Kulatilaka, 2000:17). Use of *suspension options* means that an avoidance strategy does not become irreversible, i.e. commitment of sunk costs (Huisman, 2001:4). Mothballing (suspension) a factory or power station or purchase of land for future development would be classical examples of an option approach in a noneconomic context. An example of this was E.ON's mothballing of Grain A Power Station in 2008 with the plan to close in 2012 (Schaps, 2012).

An *option* has a cost. It is a concept embedded in English Case Law: Mountford v Scott [1975] 1 All ER 822, it has a value and when exercised the investment is irreversible. When it is exercised it is expected to *"yield a positive net payoff"* (Dixit & Pindyke, 1994:30). Under an investment or abandonment decision, an increase in the uncertainty (probability) of *"payoff"* or rather cost of a decision should increase a firm's effort in seeking to delay social, political or financial commitment (Huchermeier & Loch, 2001:86), this is the *options approach*.

This section has analysed the operations risk treatments exposed in extant literature. It has focused upon the effect of each treatment type against the influence on the impact of the risk and the probability of the risk. The next section summarises the risk literature.

2.5.8 Summary of Risk Literature

Figure 2.13 provides a summary of the different concepts in the risk literature. It differentiates between: a) Definitions of risk; b) The process of risk management; c) Risk treatments. It can be seen where the concept is understood as a generic consideration (i.e. it is not specifically aligned to a sector or an organization) or where it is a specific concept, situated in an identified sector.

The links represent a relationship between concepts, without inferring causal direction. It identifies that definitions of risk have separation between the generic and specific contexts. However the process of risk management and the different risk treatments are not shown to be specific to any sector or company.

A point of contention is identified in the link between Operational risk, situated as a specific definition arising from the Basel Accord (Basel Committee, 2006), used within the banking and finance sectors. Risk in operations is situated in the generic category. It is found that the difference is more than a semantic issue.

VaR, a risk valuation tool (section 2.3.2) is specific to monetary valuations seen in the finance community, but it is also viewed as a technique to be transferred across disciplines.

There is a detailed discussion of the different risk treatments, combining knowledge from a broad range of sources. This enables representation based on impact and probability (derived from the ontology of risk) for each treatment. This literature provides a description and influence of the different goals of the risk management process entering into the analysis.

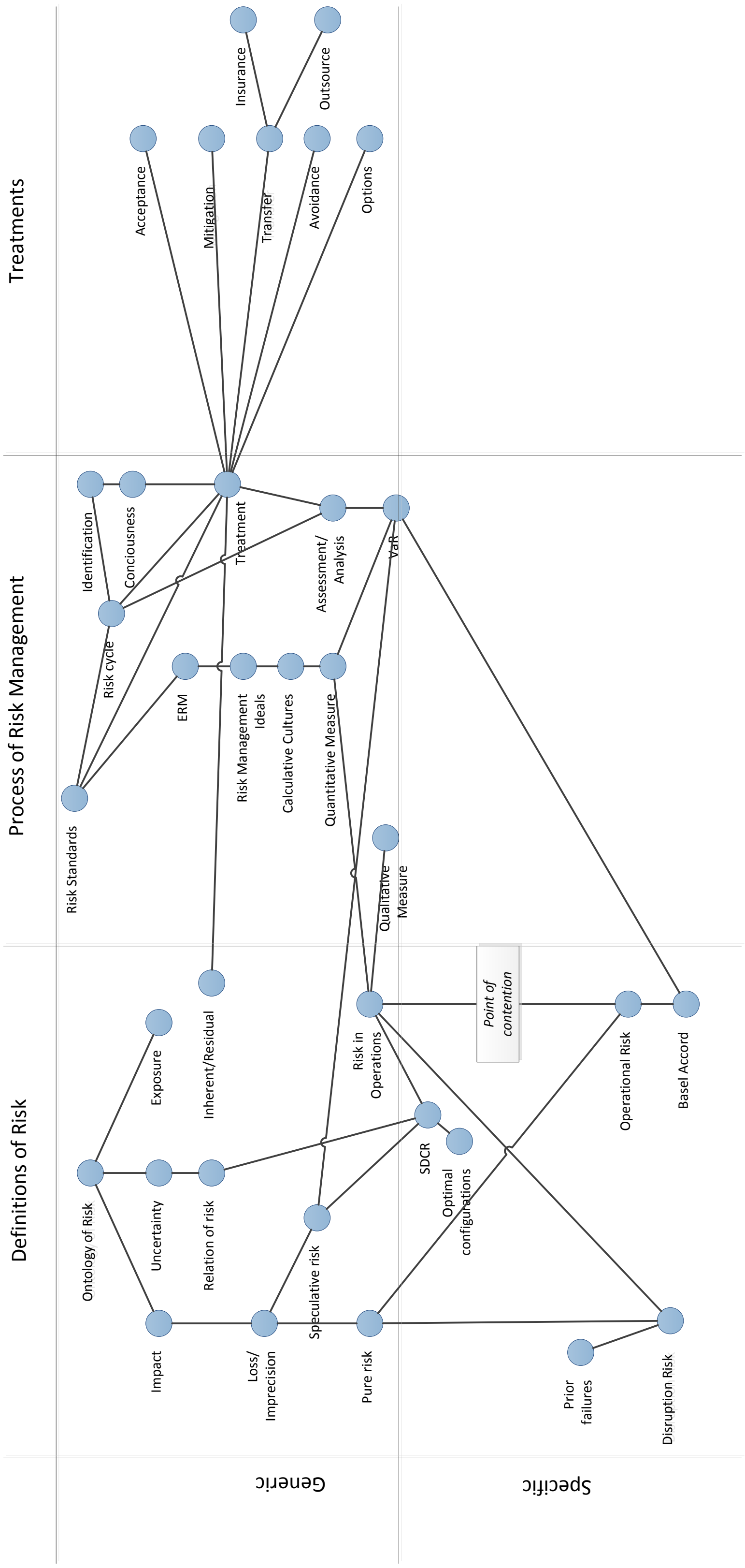

Figure 2.13 Summary of Links in Risk Literature

The review moves onto Decisions under Uncertainty. This changes the point of reference from the organization and its risk management approaches and descriptions to an understanding of the individual and their behaviour. Section 2.4.2 identified a strong link between understanding the risk management decisions being made by managers and their perceptions of risk. This is the humanistic link between the presentation and understanding of risk, which later is analysed for the impact of performance management.

2.6 Decisions under Uncertainty

This section looks at existing theories and models relating to decision making under uncertainty, based heavily in the decision sciences and psychology literature.

The review begins with the long-established Prospect Theory (Kahneman & Tversky, 1984; Tversky & Kahneman, 1981), a representation of individual's choices when faced with uncertainty. From Prospect Theory we understand that the decision maker's interests are known to affect outcomes of decision-making and the process of decision-making (Dutton & Webster, 1988), and that these influences on the decision-maker can be both conscious and unconscious (Dutton & Webster, 1988). This means that representations of risk play a dominant role in the decision-making process (Ellis et al., 2010). This is the basis for undertaking a review of the *decisions under uncertainty* literature.

2.6.1 Prospect Theory

> *"people systematically violate the requirements of consistency and coherence, and we trace these violations to the psychological principles that govern the perception of decision problems and evaluation of options"* (Tversky & Kahneman, 1981:453), supported by Fischhoff (2009) and Hsee and Hastie (2006).

In 1981 there was a move away from an *Expected Utility Model* (a theory supposing people make rational choices based on the highest expected utility) toward *Prospect Theory*. *Prospect Theory* comprises a two stage process of framing and evaluation. It proposes that people are risk averse for gain and risk seeking in loss, and therefore explains the non-rational choice behaviour observed in their research (Hertwig et al., 2004; Tversky & Kahneman, 1981). Prospect Theory describes that losses loom larger than gains (Tversky & Kahneman, 1992), extended by Bilgin (2012) that losses also seem more likely.

Choosing a decision frame can be an *ethically significant act*. It means that an individual's framing of a problem is contingent, and that human perception of risk is imperfect. This can be through the adoption of minimal accounts (a simplified and reduced statement of the choices) when framing problems. Minimal accounts are adopted because it assists simplification and therefore cognitive strain and that it reflects intuition that consequences are related to acts (Tversky & Kahneman, 1981).

Figure 2.14 shows that the utility (the value associated) of an outcome is not defined by the weight of its probability; it is defined by a multiplication of the decision weight associated to the value. So that high gains have a decreasing weight associated to the value, and high losses have an increasing weight associated to the value (i.e. losses loom larger than gains). The curve is therefore depicted as a S-shape curve, this is different to the expected utility value which would be linear in depiction.

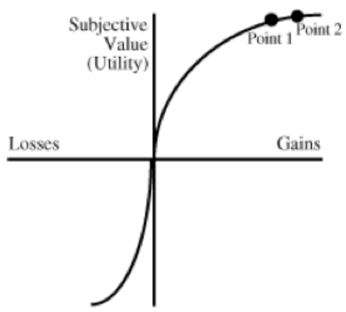

Figure 2.14 Prospect Theory (Kahneman & Tversky, 1984)

Utility Value expressed in Prospect Theory does not differentiate or distinguish the unit of measure; it is assumed as a financial measurement. This infers that non-financial and financial measures of impact will be equivalent in their perception. This is a key limitation of this literature and an area of further study. Prospect Theory opens up consideration of several concepts:

1) Intuition and Reasoning (Hodgkinson et al., 2008; Kahneman, 2003);
2) Framing (Marteau, 1989; Tversky & Kahneman, 1981);
3) Decision Strategies (Payne et al., 1988);
4) Time pressure (Pennington & Tuttle, 2007; Wedell & Senter, 1997);
5) Information load (Chewning & Harrell, 1990);
6) Rationality (Chater & Oaksford, 2000);
7) Informational attributes (Edworthy & Adams, 1996; Leonard, 1999);
8) Weighting (Bleichrodt, 2001; Tversky & Kahneman, 1981);
9) Risk and Imprecision aversion (Wiseman & Gomez-Meija, 1998);
10) Bias (Hsee & Hastie, 2006);
11) Personal contingencies (Sullivan-Taylor & Wilson, 2009).

These concepts are integrated, creating a link between the different subjects:

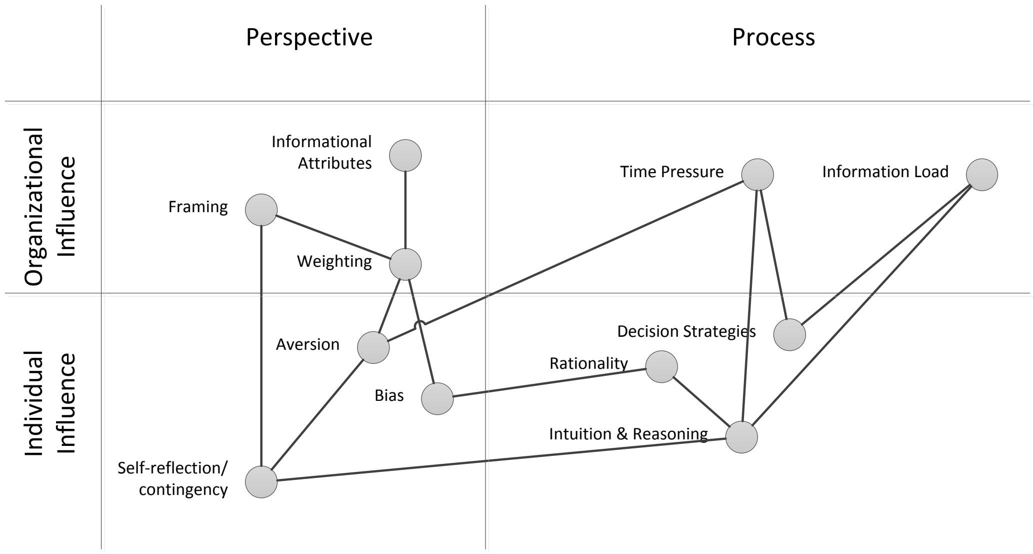

Figure 2.15 Decisions Under Uncertainty Concept Links

The figure is developed from the discussion in literature, where concepts refer to supporting concepts in their understanding or in their mitigation, a link is established[7].

Later it is discussed whether the performance system has direct control (i.e. maintains the organizational influence). However, decision-making under uncertainty means managers will fall back onto judgement heuristics (Lewis, 2003). The different concepts are taken in turn.

2.6.2 Intuition and Reasoning

There are two types of decision-making: intuition and reasoning (Kahneman, 2003). Intuition is *"thoughts and preferences that come into mind quickly and without much reflection"* (2003:697), intuition occurs almost instantly (Hodgkinson et al., 2008). Reasoning is a calculated and deliberate process that occurs when intuition is not forthcoming. Kahneman does not relegate intuition to a lower order of decision making quality; rather acknowledges that intuition can be a more powerful analysis tool when used by the skilled decision maker, and a skill acquired by prolonged practice (Kahneman, 2003:699). Intuiting (using intuition) is *"a complex set of inter-related cognitive, affective and somatic processes, in which there is no apparent intrusion of deliberate, rational thought"* (Hodgkinson, 2008:4). Intuition is influenced by habit, and therefore more difficult to control or modify, it involves concepts evolved through language. Intuition is used in identifying patterns with minimal information and guides problem solving in complex environments. Intuition can provide an advantage in complex situations (cf. Eubanks et al., 2010; Hodgkinson et al., 2008).

The relationship between intuition and reasoning appears to be ordered; reasoning is a control or test of intuition, therefore reasoning endorses intuition through application of valid rules, correction of known biases and adjusted by anchors (Kahneman, 2003:711), the concept of doubt is more closely aligned to the application of reasoning.

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[7] *The length of links has no meaning. The position on the x-axis is decided with sympathy to a readable format, position on the y-axis infers increasing levels of organizational influence.*

Intuition has a lack of sensitivity to sample size (Kahneman, 2003:698). Accessibility (which is the ease of availability of a mental model) increases with skill and therefore practice (2003:702). Where probability estimates are being made under intuition, this analysis is *"mediated by attributes such as similarity and associative fluency"* (Kahneman, 2003:704), but intuition is understood to yield more conservative estimates (Peterson & Beach, 1967). Reasoning dominates where there is the ability to yield relationships between versions; this is where intelligence and statistical thinking become apparent. Reasoning tools, such as decision trees are deemed inappropriate for complex decision problems (North, 1968). However reasoning is impaired by time pressure, the logical deduction being intuition is a quicker process. *Time impairment* (Pennington and Tuttle, 2007) affects the impact of *information overload* (section 2.6.5), although the association with intuition or reasoning is not made explicit.

Descriptive statistics underlie intuitive inferences (Peterson & Beach, 1967). This is consistent with the concept that mental models are formed by previous experience (Kahneman, 2003), and those mental models are used in intuition. Intuition and reasoning are therefore seen as two related but independent approaches to decision-making, affected by experience, time pressure and the complexity of the decision. Both of the approaches have their limitations, for example intuition's lack of sensitivity to sample size.

The forming of reasoned decisions is influenced by the quantity, perceived quality and presentation of data. These are discussed in the concepts of framing and weighting.

2.6.3 Framing

Framing is the manner in which probabilities are presented (Marteau, 1989). Framing has an influence on an individual's risk preferences. It is closely associated to the concepts of weighing which is an individual's sensitivity to probabilities. Framing is influenced by *accessibility* and *awareness*.

Accessibility and an increase in multiple dimension *awareness* are seen in *framing*. They are closely related to reasoning (Tversky & Kahneman, 1981). A*ccessibility* is determined by human cognition, changes in attributes are more accessible than absolute numbers, further that presentation of data as average results are more accessible than data as sum of results (Kahneman, 2003:702). When people are confronted with a difficult decision sometimes they answer an easier question instead (Kahneman, 2003). In complement to the concept of framing, Peterson and Beach (1967) analysed the statistical capabilities of the individual, including: accuracy of estimation, confidence in estimation and sample size utilisation. Therefore framing describes the effect of the measure. For example, where a manager is faced with performance reports for their operation, the effect of having multiple metrics covering different dimensions of the operation may be used as a relative change in performance rather than assessment of absolute numbers.

2.6.4 Decision Strategies

There are nine different decision strategies that can be used in making a discrete decision; these are outlined in the highly cited paper by Payne et al. (1988):

- Weighted additive (WADD) (multiple attributes with different weights);
- Equal weight (EW) (multiple attributes, same weight);
- Satisficing (alternatives one at a time, first required value wins);
- Majority of confirming dimensions (MCD) (pairs of alternatives compared, all considered, best wins);
- Lexicographic (LEX) (primary attribute compared, best option wins);
- Lexicographic semi-order (LEX on primary attribute and progresses onto other attributes where primary close);
- Elimination by aspects (EBA) (cut-off value for primary attribute, then progress onto secondary attribute);
- EBA +WADD (EBA for three choices and then WADD);
- EBA + MCD (EBA for small range and then MCD).

There are differences between those decisions that contain either high or low dispersion dimensional attributes (e.g. are the number of attributes informing the decision minimal and similar - low dispersion, or high and covering many different aspects of the operation - high dispersion?). Further these decision strategies can be subdivided into *compensatory* and *non-compensatory* decision strategies. WADD, EW, MCD are *compensatory* strategies (they are decisions made on appreciation of multiple attributes), the remaining are *non-compensatory* (where single attributes are compared).

The suggestion is that a move toward *non-compensatory* models is a less cognitively demanding approach, as it considers attributes independently. It supports that where information overload is experienced, less information is utilised; supportive of the move toward single attribute processing (Wedell & Senter, 1997). Wedell and Senter (1997) remark on the evidence that shows *strategic sampling* occurs in complex choice tasks, reflective of a *non-compensatory* coping strategy being employed. Chewning and Harrell (1990) and Pennington and Tuttle's (2007:518) view that *"the use of coping strategies reduced decision quality"* then seems at odds with Payne et al.'s (1988) findings, where lexicographic or semi-lexicographic deliver relatively high levels of accuracy. This is unless the presumption that all decision-making starts with a weighted additive approach. The view that time pressure (a decision characteristic) reduces quality of decision-making that is also reflected by Maule and Edland (1997), adding weight to the findings of Pennington and Tuttle (2007). The relationship between intuitive decision-making and the specific strategies employed in the decision making process seem to have little empirical basis.

2.6.5 Time Pressure

Where there is an impact of time pressure, people are shown to be highly adaptive in their decision making capability. Decision making skill reduces the need for coping strategy adoption (Pennington & Tuttle, 2007) and that relevant information attracts greater attention (Wedell & Senter, 1997). There are three approaches to handling decisions under time pressure: acceleration, filtration and a change in the choice heuristic (Payne et al., 1988). This is in compliment to the effects of information overload as found by Pennington and Tuttle (2007) whom acknowledge acceleration (for short periods), filtering and then change of the decision model as coping strategies. This change is the move from a *compensatory* to *non-compensatory* strategy (section 2.6.4). This three step model for coping strategies is extended by Maule and Edland (1997): acceleration, filtration, change and also *do nothing* (in order). People weight importance they increasingly look at the information (Wedell & Senter, 1997), although this has not been proved in reverse (this misunderstanding is seen in Pennington & Tuttle 2007:493), this is supportive of *filtration*.

The three coping strategies outlined by Payne et al. are valid approaches to coping with decisions under time pressure (Pennington & Tuttle, 2007). However, Pennington and Tuttle's research state that acceleration and then change in decision strategy were observed coping strategies in their study, but there was no proof of filtration approaches found in their sample. This discrepancy was attributed to their use of *"experienced professional subjects"* (Pennington & Tuttle, 2007:518), and exposes the potential for a contingent relationship between experience and coping strategy.

Confidence can be reduced under the pressure of time (Maule & Edland, 1997). There is an expectation that simpler strategies are used but also that strategies are used in incomplete formats. The impact on risk propensity in decision-making is more pronounced under Maule and Edland's work; that in low dispersion environments (where there are low numbers or similar attributes in decision) risk taking in decisions is not subject to a material difference, whereas in high dispersion environments there was a significant impact. The impact in high expected value environments increased risk taking, and in low expected value environments there was a decrease in risk taking (Maule & Edland, 1997:192), and that time pressured choices were largely less extreme in difference. Where time pressured decisions are required, *non-compensatory* strategies are utilised (Maule & Edland, 1997). Time pressure does change the individual nature of judgement and decision making, and that this can be categorised into seven areas, it:

a. Reduces quality;

b. Changes propensities;

c. Increases importance of internal sources;

d. Affects use of coping mechanisms;

e. Changes weights;

f. Changes weights assigned to sources;

g. Changes perceptions of alternative choices. (Maule & Edland, 1997)

2.6.6 Information Load

Information load is understood as volume of dimensions rather than amounts of information on a single dimension. *Load* and a threshold for *manageable load* is dependent on the individual (Chewning & Harrell, 1990; Pennington & Tuttle, 1997). Information load causes less consistent decisions (Pennington & Tuttle, 1997); this is supported by the concept of *compensatory* versus *non-compensatory* decision-making (Pennington & Tuttle, 2007; Maule & Edland, 1997; Wedell & Senter, 1997).

Larger samples will incur greater processing, but they may offer more accurate inferences. Larger samples are subject to the issues of information load on the decision maker (Maule and Edland, 1997; Chewning & Harrell, 1990). Sample size can be controlled by either *pre-selection* of sample size in advance of decisions or through *optional stopping* (Peterson & Beach, 1967). *Optional stopping* is where the individual can decide to stop accessing the sample data at the point they are content with their decision. This reflects a *satisficing strategy* (cf. Payne et al., 1988). However confidence increases with sample size (Peterson & Beach, 1967:114).

2.6.7 Rationality

F*ormal rationality*, is rationality that uses mathematical theories of good reasoning (Chater & Oaksford, 2000:65). This supports Kahneman and Tversky's differentiation between reasoning and intuition (1984); that reasoning is a check on intuitive decisions (it is a higher order cognitive process). It reflects the need to underpin intuition with rational models, even if this is not done consciously at the time. To define rationality, it should be viewed as a decision leading to the achievement of goals relating to the agent (Chater & Oaksford, 2000). Rationality is instead replaced by managerial perceptions, what is termed the effect of *ludic* fallacy (Sullivan-Taylor & Wilson, 2009). This achievement of goals when seen through formal rationality, leads to the selection of optimal solutions. It infers subjectivity in defining the optimal solution, and therefore rationality itself becomes subjective.

Another form of rationality is *Lay rationalism* (Hsee & Hastie, 2006:37). *Lay rationalism* proposes an irony that in chasing a desire to be rational, people often make less rational decisions. This can be seen in a bias for economism, functionalism (similar to attribute possessing) and important to management science. *Lay scientism* is understood where decision makers revert to using only objective information, to the ignorance of subjective information (e.g. the differentiation between financial measures seen as objective versus and non-financial measures which are seen as subjective valuations).

Rationality is associated to consistency in decision-making, where *consistency* (ability to evaluate information consistently) is perceived as a desirable quality (Dilla & Stone, 1997; Pennington & Tuttle, 1988:498). The desirable quality comes from the ability to be consistent and rational (Chater & Oaksford, 2000). It would appear that irrationality would be a negative characteristic in decision-making. This relationship exposes the link to bias in decision making (Chater & Oaksford, 2000; Hsee & Hastie, 2006).

2.6.8 Informational Attributes

Risk perceptions are themselves influenced by both *informational* and *iconic* factors contained within risk information (Edworthy & Adams, 1996). Colour, font-size, shape comprise the critical elements of *iconic* factors (Edworthy & Adams, 1996) but also contribute to the informational factors.

Colour and colour words have equal significance in evaluation by individuals (Leonard, 1999). Colour is known to influence cognitive processes (Mehta & Zhu, 2009), although colours are not shown to affect relative assessment as often indicated by common standards (Leonard, 1999). Colour influences are thought to be learned associations (Elliot et al., 2007). Leonard (1999) tested these associations using colours and signal words. This demonstrated a valid association between colours and predefined warning words. Colours were also shown to have a defined order of severity perception (Severtson & Henriques, 2009). Confusion of order in low threat colour usage, notably confusion on green and blue usage, is demonstrated in a study of Homeland Security Advisory System warnings (Mayhorn et al., 2004). The use of colour coding, typically red, amber, green in performance systems are documented in Caramona and Gronlund (2003).

Perceptions of risk are affected by a number of factors including both colour and framing effect (Williams & Noyes, 2007). Colour may contribute to the attention grabbing features, which includes font-size and accompanying shape of the signal (Edworthy & Adams, 1996). Colour signals influence perceptions of urgency, and can be interpreted as a guide to priority, whereby red is the highest level of risk, followed by orange, black, green and blue respectively (Lehto, 1992). The use of red signals has a further effect, that compliance is increased, this is relative to the use of green or black signals (Edworthy & Adams, 1996). This is extended in understanding by Severtson and Henriques (2009) and Cleveland and McGill (1984), who's study of format modification on warning labels, demonstrated that colour grading was the least responsive element in their study of ten visual features.

These studies have shown that beyond the information being conveyed to the decision-maker, what is described as the *informational* content, the format of the information and the accompanying shape and colour also has an impact on the perceptions of risk and the priority assessment, this is the *iconic* factor in the communication.

2.6.9 Weighting

Weighting is *"the non-linear sensitivity of people towards probability"* (Bleichrodt, 2001:185). Weighting of information and framing of decisions affects choice (Tversky & Kahneman, 1981; Wedell & Senter, 1997; Wiseman & Gomez-Meija, 1998). The weighting function is described through *discriminability* and *attractiveness*. *Discriminability* describes how people discriminate probabilities. This is developed from Prospect Theory, that diminishing sensitivity is that people become less sensitive to changes in probability as they move away from the reference point (Tversky & Kahneman, 1992). *Attractiveness* recognises that some people find speculative uncertainty more attractive than others (i.e. under or overweighting of the same probability in Gonzalez & Wu, 1999). However, weighting of losses is elevated over weighting of gains (Abdellaoui, 2000).

Accuracy of estimation increases with observation time (Peterson & Beach, 1967), but increased data weighting increases data access time (Wedell & Senter, 1997). Weighting of attributes is seen in the *Weighted Additive* decision strategy, but multiple attributes increase the cognitive demand (Payne et al., 1988). It is understood therefore that weighting of attributes increases accuracy but has two negative implications: it increases processing time and increases cognitive load on the decision maker (Payne et al., 1988).

The medium of choice description can have an impact of the weighting assigned by the decision maker. Hertwig et al. (2004) found that *rare events* have less subjective weight assigned when based on *experience*, and greater weighting when *described* by a third party. Their findings suggested that expectation of *rare event* probability reduction is based on the idea that many people will not experience the rare event; this does not mean that the event will be underestimated, just that the expectation is lower. However an individual that does experience the *rare event* is far more likely to produce a better assessment of the likelihood of the event (Hertwig et al., 2004). Wiseman and Gomez-Meija state that prior success in selecting risky choices is also understood to positively skew evaluation (1998). This is consistent with Kahneman's (2003) view that decision making can be improved with practice.

Weighting is therefore understood as both a product of the decision strategy being used *compensatory* (weighted) or *non-compensatory* (un-weighted) and the experience of the decision-maker; whereby experience results in less subjective weighting of rare events and previous success increases risky choice. The reverse of this influence where risky choices are avoided is discussed in the next section as *risk aversion*.

2.6.10 Aversion

Risk Aversion is the desire to avoid risks. There are two types of risk aversion discussed in the literature: *risk aversion* and *loss aversion* (Wiseman & Gomez-Meija, 1998). This seems to have particular importance in the difference between risk as imprecision (*speculative risk*) and risk of loss (*pure risk*).

Risk aversion is where aversion is based on a dislike of the unknown, and a desire to control the outcome. *Loss aversion* is where the aversion is dominant in the dislike of loss; the individual's attention is driven by the concern over losing wealth more than the desire to gain it (Wiseman & Gomez-Meija, 1998). *Loss aversion* arises because individuals imagine what they will lose; it is the individual's imagination that increases this evaluation of subjective probability (Bilgin, 2012). Aversion can relate to both the individual and a collection (Abdellaoui et al., 2011).

Therefore *aversion* is the dislike of uncertainty and/or loss, they are separate considerations. Aversion is a subjective and personal consideration. In the case of *pure risk* management it may be deduced that both *loss aversion* and risk aversion will influence the decision-maker. *Aversion* therefore affects the decision-makers choices and their attention.

2.6.11 Bias

Biases are *"deviations from logical or statistical principle"* (Gigerenzer & Gaissmaier, 2011:451). This may be understood to be an explanation for why decision-makers ignore part of the information in their decision process. Biases affect perception and the stability of preferences (Lai, 2001). Biases exist in several formats. Hsee and Hastie (2006) identify four types of bias:

i) *Projection;*

ii) *Distinction;*

iii) *Memory;*

iv) *Belief*. (Hsee & Hastie, 2006)

Projection bias is based on the situation of the decision maker. *Distinction bias* is based on the existence of different evaluation modes (i.e. single-evaluation mode or multiple comparison models). *Memory bias* is affected by past events. *Belief bias* is influenced by held individual assumptions (Hsee & Hastie, 2006). The last two suppositions are based on the understanding that people reconstruct the past, even if this is inaccurate, because they may reformat random events into logical and causal relationships (Kemdal & Montgomery, 1999). People demonstrate a bias towards inaction rather than intervention (Baron, 1994); however this does not reflect obligation on the individual (e.g. holding a managerial office).

With underlying biases, there are two approaches to judgement of risk (Fischhoff, 2009):

1. *Absolute*, judgement based on anchors;
2. *Relative,* comparison between choices.

The concept of *absolute* judgement and its relationship to *anchors* has an impact on risk perception, and therefore the systems controlling risk. People generally overestimate small frequencies and underestimate large frequencies, this judgement is changed with supply of *anchors* (Kaplan & Mikes, 2012). Anchors are reference points, by which the individual makes judgement. A low *anchor* was shown to reduce over-estimation of small frequencies (Fischhoff, 2009).

Previous loss or failure events are known to influence not only the way in which organizations but whole industries operate, e.g. Nick Leeson, Rogue Trader (Harland et al., 2003) and the Macondo Well Incident (Bea, 2011; Brewer & Mckeeman, 2011, Rathnayaka et al., 2013; Skogdalen & Vinnem, 2012). These cases form an understanding of previous losses, or memorable events; this is the influence of *weighting* (cf. Tversky & Kahneman, 1981) and *bias* (Hsee & Hastie, 2006).

2.6.12 Personal Contingencies

There are a number of contingencies in risk perception, brought by the individual and their role. They influence the individual's decision making (Pablo et al., 1996). These are described as personal contingencies effecting risk perception.

Environment and context can affect managerial decision making under uncertainty (Villena et al., 2009). Analysis of executive decision making showed that loss of executive control due to external environment, increases risk aversion (Villena et al., 2009). Executives may avoid taking choices beneficial to the organisation, if this could have a personal potential for loss. More difficult targets increase risk taking and that when individual's remuneration is attached to firm wealth, riskier choices are made; and that when agents bear too much risk they become risk averse (Wiseman & Gomez-Meija, 1998). Rewarding results rather than behaviour may *privatise* the risk choices being made and that *private* security of the executive actually increases the risk seeking in decisions (Villena et al., 2009). This has implications on the affect that individual risk has on the decisions they are making for the organization. These relationships are a product of risk transfer between agent and organization, a concept discussed in *Agency Theory*.

Being explicit about targets and statement of magnitude of outcome has an impact on driving risk aversion within the manager (March & Shapira, 1987). Individual managers adopt an overly optimistic view of risk (Kaplan & Mikes, 2012; Sullivan-Taylor & Wilson, 2009). However, decision makers may base their choices on *rules* rather than predictions (Hsee & Hastie, 2006:36). These can be rules of *good behaviour* that are contrary to their own predicted experience. This suggests organizational rules take primacy over individual knowledge.

Where decision-making can be understood to be the *formalisation of common sense*, it includes both a numerical calculation and a subjective expression of preference (Warner North, 1968). These two stages of risk determination, demonstrate that it is difficult to separate a decision from the amalgamation of both objective information and the subjective interpretation of the decision maker. The subjective interpretation therefore becomes a product of both the environment and individual (Looney et al., 2008).

Reflection on the risk taker influences managerial judgment (cf. Gardner & Steinberg, 2005). Specifically, Zuckerman and Kuhlman (2000) identify that personality, sensation seeking and attention gathering effect risk taking in individuals, therefore suggesting that the reflections on the individual decision-maker are important forces. This is seen in organizations that rely upon incentive payment which perform more poorly than their competitors (cf. Bloom & Milkovich, 1998:284).

For the individual, financial measures are prioritized in allocation of bonuses and incentives (Ittner et al., 2003). This does not suggest that non-financial measures do not form part of the evaluation criteria, just that the financial measures have greater *weighting* in decision-making (Baddeley, 1994; Cardinaels & Veen-Dirks, 2010; Lipe & Salterio, 2002). This is explained by the *Outcome Effect* (Mitchell & Kalb, 1981), where evaluators weight measures of outcome over behaviours (Dilla & Steinbart, 2005; cf. Ittner et al., 2003). Individual therefore respond differently according to their evaluation criteria. So, reward systems that favour individual unit thinking, are difficult for individual managers to overcome (Spekman & Davis, 2004). This exposes the role of personal risk bearing on the individual.

The relationship between risk management as a set of disciplines and practices and individual decision-making is understood further in a deconstruction of the different components influencing managerial risk judgements. This is explained in Principle-Agent Theory (cf. Eisenhardt, 1989). Principle Agent Theory develops an understanding of the relationship between the organization and the individual.

2.6.13 Principle Agent Theory (Eisenhardt, 1989)

Principle-Agent Theory is a perspective developed from Agency Theory (Principle-Agent Stream). There are two actors in the relationship, the *Principle* and the *Agent*, this relationship is held together by a form of *contract*.

> *"Given that the principle is buying the agent's behaviour, then a contract that is based on behaviour is most efficient. An outcome-based contract would needlessly transfer risk to the agent…"* (Eisenhardt, 1989:61).

The Principle's measures may include more than pure financial outcomes (Eisenhardt, 1989:71), for example it recognizes that self-interest as well as risk aversion can be understood through this transfer of responsibility*:*

> *"according to agency theory we would predict that such managers [of the operation] will be very sensitive to outcome uncertainty"* (Eisenhardt, 1989:65).

Principle-Agent theory, has a perspective that the performance system is operating as contract between Principle and Agent (Eisenhardt, 1989); *control systems* are a contract (Anderson & Oliver, 1987). The performance measurement system is proxy for a contract: *"the unit of analysis [performance measure] is the contract between Principle and Agent…",* (Melnyk et al., 2004). Celly and Frazier (1996) outline this role as a matter of co-ordination and McMillan (1990) as a matter of control.

There are different options for *contract construction*: contract with the individual or with a collective. However, groups (collectives) are riskier than individuals in their choices (Dorwin, 1971).

Agency Theory suggests that there is *a "pursuit of self-interest at the individual level and goal conflict at the organizational level"* (Eisenhardt, 1989:63). It informs how the difference between managerial levels might be displayed. *"Risk Bearing plays an important role in agency models of executive behaviour"* (Wiseman & Gomez-Mejia, 1998:136), this is the *"Perceived risk to an agents wealth that can result from employment risk or other threats to agent wealth"* (Wiseman & Gomez-Mejia, 1998:136). Taking this view, managers' rewards might become an influence in both the sensitivity to different risk assessment metrics but also the decision-making processes. The impact on group *risk bearing* is harder to establish.

Agency theory provides an understanding that risk as a latent concern can be transferred. It supports the concept of exposure to risk (Holton, 2004). The transfer being described by agency theory is from the principal (the firm) to the agent (the employee). In understanding that risk can be transferred to the agent, and that the approach to transfer can have a material effect on the agent. This highlights the potential for personal contingencies (the context of the agent, their beliefs and emotions, see section 2.6.12) to have a bearing on the subjective valuation of the risk. Further, agency theory suggests that in transferring the risk to the agent through outcome measures that this becomes an inefficient process for managing risk (Eisenhardt, 1989). Therefore risk is determined both at an individual and organizational level (Spekman & Davis, 2004:417).

2.6.14 Decisions Under Uncertainty Summary

The role of weighting (Wedell & Senter, 1997), framing (Looney et al., 2008; Tversky & Kahneman, 1981; Fischhoff, 2009; North, 1968), information load (Chewning & Harrell, 1990; Maule & Edland, 1997; Pennington & Tuttle, 2007), aversion and rationality (Gomez-Majia & Revilla, 2009; Hertwig et al., 2009; Peterson & Beach, 1967; Villena, 2009) and risk preferences (Kemdal & Montgomery, 1999; Lai, 2001; Wiseman, 1982) explain some of the influences on decisions (under uncertainty). It extends Slovic's (1964) suggestion that risk taking and individual behaviour has a complex relationship. This section has reviewed the knowledge on how risk decisions are affected by different influences, it has shown:

- There are two types of decision-making: intuition and reasoning (Kahneman, 2003);
- Accessibility and reasoning are closely related, however accessibility relates to the individual, whereby changes in attribute are more accessible than sums (Kahneman, 2003);
- Mental models are formed by previous experience (Kahneman, 2003), and those models are used in intuition;
- The use of mental models, the derivation of estimates from experience, is associated with intuition (Fischhoff, 2009);
- There are nine types of decision-making; these can be grouped as either *compensatory* or *non-compensatory*. The difference is based on the attention to the inclusion of all attributes in the decision. This is affected by the different coping strategies under time pressure;
- Time pressure in decision-making is managed through an order coping response: acceleration, filtration and moving to a non-compensatory decision strategy (Maule & Edland, 1997);
- People are generally overconfident with their choices, where overconfidence is more typical of difficult choices and under-confidence with easy ones (Fischhoff et al., 1997; Tversky & Kahneman, 1981);
- There are distinct gaps in risk judgement between lay people and experts (Fischhoff, 2009);
- That when communicating information on which to make risk decisions it is important to supply the information in order of expected impact on decisions (Fischhoff, 2009), as larger samples increase the information load (Chewning & Harrell, 1990);

- Managers have a tendency to use rational decision-making when confronted with uncertainty (Knight, 1921);
- Information communicated includes both informational and iconic information (Edworthy & Adams, 1996), colour use is iconic (Leonard, 1999);
- Format and use of words and phrases influences judgement (Dilla & Stone, 1997);
- Increased *weighting* increases data access time (Wedell & Senter, 1997), although weighting increases accuracy it increases cognitive load and processing time;
- Risk aversion is comprised of two different influences: loss aversion and imprecision aversion (Wiseman & Gomez-Meija, 1998);

These different influences on risk judgement may be configured through the medium of communication (Erev & Cohen, 1990), the types and format of measurement (Edworthy & Adams, 1996) and the purpose (cf. Kahneman, 2003) of the information provided. The performance measurement and management systems used in organizations are considered as a framework for this communication (cf. Otley, 2008). The next section reviews the performance management literature, to understand the role of the performance system.

2.7 Performance Management

The body of Performance Management knowledge is described by Franco-Santos et al. (2007), as distributed and diverse ranging from *"strategy management, operations management, human resources, organisational behaviour, information systems, marketing"* (2007:784) through to management accounting and control. Authors in the performance management field are from diverse backgrounds, from accounting through to information systems (cf. Neely, 2005). The lack of consensus of definition is therefore an issue (Franco-Santos et al., 2007). The link between performance management, performance measurement and management control systems is explained by Otley:

> *"Performance management therefore provides an important integrating framework, both academically and practically. It goes well beyond the traditional*

boundaries of management accounting… The use of management accounting and control systems can be fruitfully analysed from the framework of performance measurement and performance management." (Otley, 1999:381)

These three schools of understanding: Performance Measurement, Performance Management and Management Control Systems (MCS) have a long lineage[8]. This body of work seems more mature and integrated than the risk management literature. There are a number of codified approaches to implementing performance systems, these include: The Balanced Scorecard, Performance Prism and MCS, amongst others.

The Balanced Scorecard has been extensively academically and commercially analysed over the past 15 years, contexts are broad including: supply chain performance (Brewer & Speh, 2000), Information Systems management (Martinsons et al., 1999), a strategic management system (Atkinson, 2006; Kaplan & Norton, 2000, 2006, 2008; Malina & Selto, 2001), research and development (Bremsner & Barsky, 2004; Eilat et al., 2008), process improvement (Amaratunga et al., 2001), financial performance (Davis & Albright, 2004) and even as far as predictive use of risks becoming realised, i.e. terrorist attacks (Beitel et al., 2004). The contexts are as far ranging from healthcare (Radnor & Lovell, 2003), to education (Karathanos & Karathanos, 2005; Kim & Davidson, 2004).

MCS, based in the management accounting community have historically discussed the use of financial measures; only recently expanded this discussion to include non-financial measures. They have been used predominantly as systems to control the organization, with limited feedback loops and generative learning mechanisms. Anthony's (1965) focus on operational attributes of control systems has attracted some criticism, that it separated itself from strategic concerns. It was a criticism that is addressed in Kaplan and Norton (2008) and Otley (1999; 2008)

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[8] *The term "performance system" is used throughout as a collective term for performance management systems, performance measurement systems and management control systems.*

The MCS is one which is *"the mediating activity between strategic planning (objective setting) and task control (the carrying out of specific tasks)."* (Otley, 2008:25). This identifies two control system attributes:

- *Alignment* of objectives from *strategy;*
- *Implementation* into specific tasks.

The Performance Prism focuses on data retrieval processes: acquisition, collation and sorting and the learning processes: analysis and interpretation (Neely et al., 2002:3). However this is not only an operational reporting tool.

So the body of performance knowledge has two perspectives:

- Discussion of named techniques e.g. Balanced Scorecard (Kaplan & Norton, 1996; 2000; 2008), Performance Prism (Neely & Adams, 2002) and Management Control Systems (Anthony, 1965; Otley, 1999);
- A theoretical discussion of roles and functions of the performance system/control system e.g. Franco-Santos et al. (2007) and Dresner (2010).

The latter approach is favoured in developing the research, as it avoids issues in controlling specific implementation of a technique, and whether it has been correctly interpreted by the organizations studied. However, learning from both bodies of work aids an understanding of theoretical and practitioner perspectives. This idea of a theoretical perspective is borrowed from Broadbent and Laughlin (2009), which itself developed from Otley's work (1999).

Reviewing the literature it appears that the three schools of work can be compared through understanding: the breadth of metrics employed and the feedback mechanism they imply. Figure 2.16 outlines the relationship between the different concepts as understood from the literature. Specifically how the performance management and measurement fields have taken greater consideration of a breadth of financial and non-financial metrics in discussion.

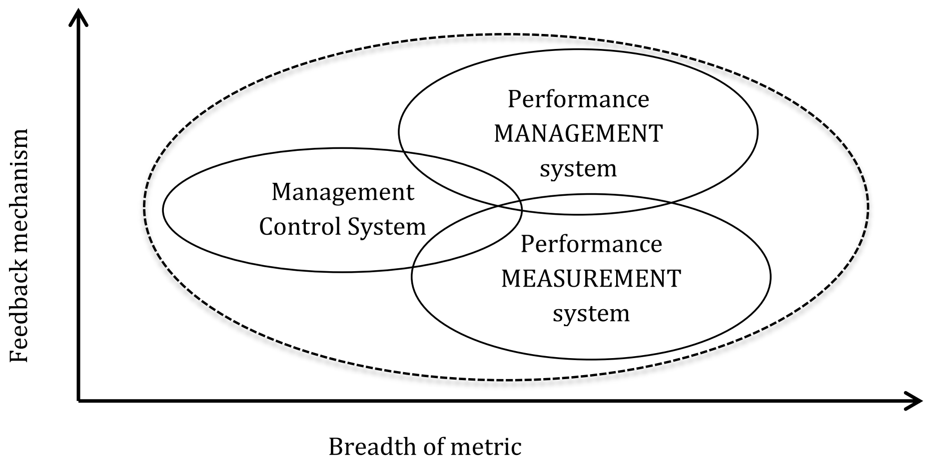

Figure 2.16 Overview of Performance Systems

The difference between the three schools presents semantic issues between definitions of measurement and management. Much of what is written differentiates only subtly between the two. Theoretically the difference may exist between their use of feedback loops into the operation and with the development of strategy.

It is not always clear of the distinction between *performance management* and *performance measurement*. This is a consistent issue between authors, for example the Balanced Scorecard is referred to as a *measurement system* (Neely & Austin, 2002:42), and as a *management system* (Barnes & Radnor, 2008:98; Radnor & Lovell, 2003; Lawrie & Cobbold, 2004:611). Even within individual texts both terms are used interchangeably (Neely & Austin, 2002:44)[9]. The *performance measurement system* is a backward looking *"of past action"* (Neely et al., 2002:2). The *performance management system* is a system that incorporates enablement of action: *"[The performance management system] enables informed decisions to be made and actions to be taken"* (Neely et al., 2002:2). The *measurement* system is an input into the *management system* (Kagioglou et al., 2001); and as a function conceptually separable from it. The measurement system is a constituent and wholly encompassed facet of the management system (Bititci et al., 1997).

[9] *It is considered that at the point of writing or the context, the differentiation is insignificant and therefore no criticism should be levelled. Rather it opens up the discussion to be inclusive of both.*

The development from *performance measurement system* to *performance management system* is considered in the influence it has on decision-making. Otley suggests a move in the frame of reference for performance measurement research: *"we shall broaden this perspective by looking beyond the measurement of performance to the management of performance."* (Otley, 2008:24). This move from a passive system of measurement toward an active system of management: *"Management of"* as defined is "*to administer and regulate resources" (Simpson, 2006:762),* includes control and direction and *resources* includes (e.g. people, systems, knowledge and capital within the firm).

Therefore it is appropriate to consider the three schools of literature in a review of performance systems. The next section reviews the different functions of the performance system from these three bodies of literature, both in terms of codified approaches and theoretical discussion of the performance system.

2.8 Performance System Functions

Analysis of the literature adopts an approach to illicit the different functions of the performance system. The control system *"consists of several interrelated but often loosely coupled parts."* (Otley, 2008:24). These parts may be separate (but sometimes causally related), therefore defining choices or configurations of a system (cf. Ferreira & Otley, 2009). By deconstructing the performance system into the different functions, this supports the first step in Bhaskar's (1989) approach, which is *"Resolution of the complex event into components"* (Collier, 1994:162), discussed in the research strategy (chapter 3).

In reviewing the Balanced Scorecard (BSC) and Performance Prism (PP), the nature and application of the performance system is dependent on the component configuration and priorities, reflecting the different functions. They appear to be different configurations, rather than fundamentally different concepts. The BSC is dominated by the transfer of strategy into objectives and measures. The Performance Prism focuses more on understanding the different stakeholder contributions. It is apparent that definitions used in the literature (on performance systems) are contingent (cf. Holloway & Thorpe, 2008:3; Broadbent & Laughlin, 2009). By approaching through a lens that looks at the various functions of the systems, it mitigates much of the contingency effect on this definition.

System *functions* are in complement to *features* and *process*. *Functions* include: *measurement, strategy measurement, communication, influence behaviour and learning and improvement* (Franco-Santos et al., 2007:797).

Table 2.2 Summary of Performance System Functions from Literature

Role	**Ferreira & Otley (1999)**	**Franco-Santos et al. (2007)**	**Kaplan & Norton (2008) Balanced Scorecard**	**Kennerley & Neely (2002) Performance measurement system**	**Neely & Adams (2000) Performance Prism**
Communication	■	■	■	■	■
Measurement	■	■	■	■	■
Learning	■	■	■		■
Strategic Alignment	■	■	■	■	■
Evolution & Influence	■				

The review exposes the some of the considerations performance systems may have on risk management decision-making. Broadly these functions of the performance system are summarised as:

1. *as a* Measurement System;
2. *as a* Communication Function;
3. *as a* Strategy Tool;
4. *its impact on* Learning.

These are discussed in turn.

2.8.1 Performance System as a Measurement System

A performance system includes a measurement function: *"The process of quantifying the efficiency and effectiveness of action"* (Neely et al., 2002:1). The measurement function is discussed in Melnyk et al. (2004), Otley (2008) and Pinheiro de Lima et al. (2009).

The measurement system includes:

a) Data acquisition;
b) Data collection;
c) Construction of measures.

There are a number of dimensions affecting measures:

- *Tense* (Melnyk et al., 2004);
- *Lag-lead balance* (Evans, 2004:222; Kaplan & Norton, 1993);
- Balance of finance and non-finance orientated measures (Clarke, 1995; Drucker, 1990; Evans, 2004; Gomez et al., 2004; Kaplan & Norton, 1993, 1996; Manoochehri, 1999;Melnyk et al., 2004; Schneiderman, 1999), also advocated by the management accounting community (Bhimani, 1993:21; Ferreira & Otley, 2009:269; Mikes, 2009:22); and
- *Stakeholder representation* (Neely & Adams, 2002; Schneiderman, 1999).

The approach advocated by Schneiderman would have a ratio of non-financial to financial measures at 6:1 (1999:7); although this is largely in the context of the BSC. Melnyk et al. (2004:212) encourage selection of financial and non-financial measures as a recipient consideration. Whereby, top managers focused on financial metrics, they are *outcome orientated* and focus on operational measures, and are *predictive orientated* (Melynk et al., 2004). It shows that there must be a blend of to provide measures for both groups within an organization.

Stakeholder representation in measures is closely related to financial/non-financial consideration of measure usage. The common stakeholder groups considered are: *customer*, *financial and market*, *human resources*, *supplier and partner* (Evans, 2004:221). Stakeholder presentation in the metrics should be a reflection of stakeholder value in the process, and directly related to promotion of this value (Mikes, 2009:22).

There is pressure on maintaining a manageable set of measures, this seems to agree with Pennington and Tuttle (1997). Measures must be understandable (Melnyk et al., 2004). The managerially effective number may be as low as 10 to 30 measures (Kaplan & Norton, 1993; Schniederman, 1999). There may be a distinct difference between the strategic measurement systems as opposed to operational measurement systems. An aspect is *understandability* as the benchmark by which to gauge how many measures. In Schniederman's vision this is an *"8½ x 11 sheet of paper, 18 pica or larger font size…"* (1999:7). This relates to the discussion of informational and iconic factors (Edworthy & Adams, 1996), which defines the different properties of measure communication.

Strategic intent, learning and system capability should inform selection of measure (Malina & Selto, 2004). So, firms operating in risky environments may select qualitative and non-financial performance measures, as a response to their environment (Malina & Selto, 2004). The banking sector have developed financial measurement of potential loss in the same way as market or capital risk, using VaR, although this is widely understood to be an ineffective approach for Operational risk (Matz, 2005:3).

Decoupling measurement and communication can be challenging. However, not all measures need to be or are communicated, so the representation of measures, directly considers this function of communication.

2.8.2 The Communication Function

The communication function can be understood as the method (the channel and target) and the protocol (the format), for representing measures and targets. There are several different considerations in the communication function of the performance system.

The method of communication:

Performance system communication can be as diverse as internal and external channels (i.e. shareholder reports), for example environmental disclosures (Wiseman, 1982). Public disclosures from control systems have the consequence of broadening the range of stakeholders involved in the performance management of the organization (Wiseman, 1982).

There are different targets (stakeholders) for the communication. *Best-fit stakeholder balancing* supported by Stakeholder Theory (Donaldson & Preston, 1995; Freeman, 1984) is that no single stakeholder has primacy over the others and is likely to have conflicts in demands. This suggests that different types and delivery of communication are needed to reflect individual stakeholder demands.

The protocol of communication:

The considerations of communication protocol are intrinsically linked to the perceptions and judgements of managers *(*Lowrie & Cobbold, 2004); this is discussed in section 2.6, for example *framing* (Marteau, 1989), *informational attributes* (Edworthy & Adams, 1996) and *information load* (Pennington & Tuttle, 1997). The performance system becomes the vehicle for communication to an organization of both explicit and implicit risk measures and targets.

There should be a move toward more *eye appealing* presentation of information, so as to decrease the complexity of the decision-making process (Speier, 2006; Vessey, 1991), this links to the discussion of increased informational *attributes* (Payne et al., 1988).

Measures may be provided as a list or as a matrix. A matrix presentation is more cognitively demanding (Hong et al., 2004). Presentation and use of tables, graphics and matrix are contingent on the individual and decision-making being required (Yigibasioglu & Velcu, 2012). Purpose, task requirement, individual knowledge and user personality should be considered in design of the communication protocol (Yigibasioglu & Velcu, 2012). The latter consideration, *user personality* is related to: *aversion* (Wiseman & Gomez-Meija, 1998), *bias* (Hsee & Hastie, 2006), *and informational attributes* (section 2.6.12). In responding to the issues of data load and resulting cognitive strain not all measures need to be published to be effective (Malina & Selto, 2004).

The considerations in communication protocol include choices on:

- Volume of measures (Hong et al., 2004);
- Financial or non-Financial Measures (Schneiderman, 1999);
- Breadth of stakeholder representation (Freeman, 1984);
- Balance between internal and external measures (Keegan et al., 1989);
- Measures for early indication, and past performance (Bourne et al., 2000).

The performance system is therefore understood to contain different choices in communication method and protocol. Further it is the mechanism by which to influence management behaviour *(*Lowrie & Cobbold, 2004:615). The organization must establish channels of communication to feedback the delivery against objectives (O'Donnell, 2005).

The knowledge of performance system communication is the link to influences on risk judgement (section 2.6), and operationalizes these choices, for the purpose of influencing managerial behaviour *(*cf. Lowrie & Cobbold, 2004).

2.8.3 The Performance System as a Strategy Tool

Performance systems are the tool by which strategies are implemented into an organisation (Bititci et al., 1997; Kloot & Martin, 2000; Malina & Selto, 2004; Otley, 1999). It is the articulation and transfer of strategic ambition into objectives, measures and hence targets, and to assess the implementation of strategy (Bourne et al., 2000). The other components of the performance system appear to be supporting functions to this requirement. Performance systems are used both as strategy implementation tools and as an influence on the formation of strategy (Langfield-Smith, 1997). The BSC literature is central to understanding the link between performance systems and strategy.

BSC literature comprehensively covers the process of *strategy mapping,* this is the dissemination of strategy into objectives (Kaplan & Norton, 2000), and it is the cornerstone of the BSC framework (Kloot & Martin, 2000; Pun & White, 2005). The BSC encourages use of financial/non-financial measures and lag/lead measures (Kaplan & Norton, 2003). This is reflective of choices exposed in the discussion of measurement (section 2.8.1) and communication (section 2.8.2). The BSC literature infers a top-down approach to creation of objectives.

However in reverse, *measurement* should be used to challenge strategic assumptions (Bourne et al., 2000), it requires constant revision to ensure that the measurement of the organization is still aligned to the strategic intentions. In doing so managers should become the mediators between strategy and the performance system, not just recipients of the objectives, especially where there are discrepancies (Langfield-Smith, 1997). This dual role of a performance system therefore both challenge the strategic assumptions and also measure the performance against strategic objectives (Bourne et al., 2000). This reflects a change in focus from the backward looking accounting based control system apparent in Anthony's MCS, toward a system that assists organizational change (Langfield-Smith, 1997). There is an alternate perspective as to whether measures should be derived from strategy (Neely et al., 2002). This is seen in the *Performance Prism*, it is an understanding that strategy is the route rather than destination of the organisation (Neely et al., 2002:164).

This link between the performance measurement system and strategy implementation extends to the individual's objectives (Kaplan & Norton, 1992), and this influence extends into individual decision-making (Micheli et al., 2011; cf. Merchant & Van der Stede, 2007).

This links to performance measure design (section 2.8.2) for example, the use of non-financial measures (Ittner & Larker, 2003).

It is therefore understood that the link between strategy and performance management is both a top-down influence (i.e. strategy mapping) and also a check and balance to the strategy (Bourne et al., 2000). This link between strategy and performance management influences managerial decision-making (Lowrie & Cobbold, 2004; Micheli et al., 2011), it is integral to the considerations of performance measurement and communications.

2.8.4 Learning in the Performance System

Learning within the performance system has several considerations: development of feedback loops (Bititci et al., 1997; Otley, 1999), to enhance strategic development (Kaplan & Norton, 2000; Kloot & Martin, 2000), influence organisational design and change (Bourne et al., 2000; Busco et al., 2006) and develop mature learning practices (Argyris & Schon, 1978) (i.e. a move from single-loop, corrective learning to double-loop, generative learning).

The development of a *generative learning* approach is highlighted as a desirable attribute (Anand et al., 2009) it enhances the impact a performance system may have on an organization (Otley, 1999), and is indication of an evolved or mature system (Ballentine et al., 1998). *Generative learning* drives continuous improvement and improvement in supply chain risk practices (Braunscheidel & Suresh, 2009). It helps challenge past action and decisions evident in individual's choice and judgement (Slovic, 2000). The requirement for driving learning in the performance system is reflected in the BSC literature, as implementation of a BSC aids organisational planning. It integrates long-term planning with performance measures, it should *"foster a kind of learning often missing in companies"* (Kaplan & Norton, 1996:36). It is understood therefore that learning is a desirable component in the performance system (Anand et al., 2009), and it affects managerial decision-making.

These are the four main functions of the performance system (measurement, communication, strategy alignment and learning). Deconstructed in this way identifies the core attributes of the system. Next, the evolution and influence of the system is explored, this is separate to the functions of the performance system and describes the evolution of the performance system itself.

2.8.5 Performance System Evolution and Organizational Influence

Not described as a function of a performance system, but a description of how a performance system evolves and its organizational influence, for example: *centralization* versus *decentralization* of power (Chenhall, 2003).

Performance systems can be *organic* and *mechanistic* models of structure (Chenhall, 2003). It is a description for the system's evolution (Davenport, 1998). *Organic* system evolution describes a Darwinian effect, as the system develops and responds to its environment. *Mechanistic* evolution is planned, a deliberate development of the system against a number of pre-defined criteria. Bourne et al. (2000) provide examples of when performance measurement system should be developed or reviewed:

- Periodic review and revision of targets and standards;
- Contextual changes that require a development of individual measures;
- Changes in the competitive environment or strategic direction, may drive a comprehensive review of all measures;
- In challenging the strategic assumptions.

These examples suggest that there may be revisions both to the individual measures and targets and the complete set of measures. This check and balance of the measures should respond to internal and external changes, and as a development activity. In challenging the strategic assumptions, it highlights the need for the measures to feed back into the activity of development and review of strategy, and not just as an output of the process.

The performance system also reflects a broader organizational development. It reflects allocation of power and autonomy (Busco et al., 2008). The performance system is used to manage different organizational relationships: *centralization* versus *decentralization, lateral* versus *vertical relations* and *convergence* versus *differentiation*. It reflects a growing move to disseminate power and greater autonomy to the operating units (cf. Busco et al., 2008).

2.8.6 Performance System and Risk

This section, reviews what is known about the relationship between performance systems and risk. There is an expectation that risk management is embedded within the organizational objectives:

> *"Risk management and mitigation processes should be explicitly related to organizational and sub-organizational objectives"* (Power, 2009:849).

This understanding is supported by the limited discussion in extant literature on: Enterprise Risk Scorecards (ERS) and Key Risk Indicators (KRI). Secondly there is direct mention of risk measurement in the Balanced Scorecard and Performance Prism literature, although this is not well developed. Finally, the Levers of Control (Simons, 1995) is reviewed to the understanding this provides on the control of risk.

Risk Management in Performance Prism and Balanced Scorecard:

Inclusion of risk measures is more inferred than explicit in Performance Prism literature (Neely & Adams 2002). The discussion of risk is focused upon using a failure mode and effect analysis (FMEA), to identify strategic destinations, and scenarios an organization wishes to avoid (Neely & Adams 2002:61).

In the Balanced Scorecard (Kaplan & Norton, 2004) risk management is stated as worthy of attention in performance measurement. Contained largely within their *"internal perspective"* these included measures of *"Leverage leadership in risk intelligence. Comply with risk management processes. Manage our books of risk"* (2004:73). The discussion in this literature does not progress to critically assess how this is achieved or the limitations of the exercise, beyond these limited examples. An exception is the Bank of Tokyo-Mitsubishi case (Kaplan & Norton, 2006), where risk was considered as an influence in BSC design. This supplements the measures of risk to *"growing revenues"* and *"enhancing productivity"* (Kaplan & Norton, 2006).

The literature appears reasonably underdeveloped in the application of risk in performance management, leaving a gap in understanding as to the interplay between financial and non-financial measurement and whether risk is implicit or explicit within the broader performance metrics. The suggestion of development of an ERS (Calandro & Lane, 2006) has had little development in literature, but advocates a separate scorecard for risk measurement. The same distinction seems to occur in the isolation of key risk indicators as a subset of key performance indicators (Proctor et al., 2009).

Enterprise Risk Scorecards:

A link between *measurement* of risk, *communication* of risk and the performance system is provided by Calandro and Lane (2006). They advocate inclusion of risk measures as a separate *balanced enterprise risk scorecard* (ERS), rather than embedding risk measures in the BSC. It is understood the ERS can be developed in the same manner as the BSC:

> *"1. If all of the measures required to comprehensively measure risk are inserted into a performance scorecard the resulting complexity could dramatically decrease the scorecard's usefulness;*
>
> *2. Frequently, the people and departments that measure risk are different from the people and departments that measure performance;*
>
> *3. Having two separate scorecards for performance and risk can balance managerial time and attention between performance and risk; and*

4. Risk measures and performance measures can resemble one another…" (Calandro & Lane, 2006:38)

This approach assumes that ERS and BSC are consistent, that managers look to the ERS in the management of risk only and that decision makers respond consistently and appropriately to the quantitative directions of the ERS. This important relationship does not suggest whether tools (i.e. BSC) impact the management of risk in operations. Little is still understood about this relationship *"the subject of risk comprises very little of the hundreds of pages written on the BSC…"* (Calandro & Lane, 2006:32).

Key Risk Indicators:

Key Risk Indicators (KRI) (Proctor et al., 2009; Witty et al., 2009), are a subset of Key Performance Indicators. A KRI has a distinct attribute of being a leading indicator (Proctor et al., 2009:2), however history is seen as a poor predicator of future risk (Matz, 2005). This is in direct conflict with the suggestions made by Power (2005), for increased industry data pooling (section 2.3.2).

Risk Measurement:

There are limitations on risk management when using capital investment appraisal techniques, such as IRR and NPV (Milis & Mercken, 2004), as risks are sometimes not accounted for (Martinsons et al., 1999). A purist quantitative approach to performance management of risk has well documented failures *"There are many other examples of firm failures in which quantitative analyses either failed to identify increasing risk levels and/or failed to convince executives of the need for dramatic risk management changes , e.g. Enron, Adelphia, Parmalat, etc."* (Calandro & Lane, 2006:31).

There is a perceived disconnect between the actual business activity and its quantitative modelling, which is where implementations of performance systems and specifically the BSC is meant to correct (Calandro & Lane, 2006). With these limitations this would seem still not to alleviate the issue of risk management through these tools (Milis & Mercken, 2004; Wu & Olson, 2009, 2010).

Kaplan and Mikes (2012), discuss VW's *Risk Event Card*, which identified a range of risk measures (e.g. outcomes, indicators and controls). It demonstrated different (and bespoke) approaches for representing and managing risk data, although none have appeared as generically adopted across sectors.

Non-financial Risk Measurement

The impact of a risk can be deconstructed into financial and non-financial impacts (Arena & Arnaboldi, 2014; cf. Cardinaels & Veen-Dirks, 2010; Eccles, 1991; Kaplan & Mikes, 2012; Khandwalla, 1972; Lipe & Salterio, 2002; Mitchell & Kalb, 1981). Example of a non-financial risk is *Reputational* or *reputation risks* (cf. Kaplan & Mikes, 2012). These are difficult to measure (Eccles et al., 2007); however quantitative measures are desirable, and should be pursued, but in doing so it must be recognised that qualitative measures also exist and have a role (Eccles et al., 2007). Mikes observed:

> *"an alternative style of risk management which resists the urge to push metrics into carefully protected areas of judgement. In this style of risk management, the emphasis is on using 'softer' instrumentation to frame and visualise non-measurable uncertainties"* (Mikes, 2011:227).

The Levers of Control (Simons, 1995) is considered next as a more theoretical perspective of the relationship between performance management and risk.

2.8.7 Simons (1995) Levers of Control:

The *Levers of Control* (Simons, 1995) proposes four theoretical levers in the control system (i.e. Belief, Boundary, Diagnostic and Interactive). The framework offers an understanding of the strategic implications a performance system may have, and that different components of a performance system may have alternative uses (Ferriera & Otley, 1999), for example providing failsafe or developing the creative function of the organization.

There are four levers defined (Simons, 1994; 1995):

- *Belief Systems*: these contain the core value of the firm (Ferreira & Otley, 2009);
- *Boundary Systems*: these specify the *"risk to be avoided"* (Ferreira & Otley, 2009:6);
- *Diagnostic Control Systems*: these contain the *"critical performance variables"* (Ferreira & Otley, 2009:6);
- *Interactive Control Systems*: these manage the strategic uncertainties (Ferreira & Otley, 2009).

This typology of levers excludes informal control procedures, and explicitly requires that the systems are information systems[10] (Simons, 1995).

There are limitations to *The Levers of Control*. The *diagnostic* and *interactive* functions of the control system are not always possible to separate in implementation (Ferreira & Otley, 1999). Simons suggests a move from *diagnostic* to *interactive* is developed through managerial interaction. Interaction is where top managers become engaged on a regular basis. Therefore this questions whether *interactive* levers are more than a physical embodiment of a system or the behaviour of the managers (cf. Simons, 1994). The development from *diagnostic* to *interactive* also has some reflection of the move from measurement to management systems (see section 2.7). *Diagnostic* levers are used to track deviation from the objectives (Simons, 1994), but this can be challenging to define in terms of risk, and what are the *diagnostic* measures of risk, where risk is a latent force.

The same criticism of separation is levelled in the division between *boundary* and *belief* systems (Ferriera & Otley, 2009:34). *Boundary* and *Belief* systems are opposing forces of control: *"the yin and yang"* (Simons, 1995:84). *Boundary* systems are the outer limits, which operating within is seen as enhancing the creative function in the organization. *Boundary*

[10] *Information systems are data systems using a network of hardware.*

systems are influenced by ethics and morality (Simons, 1994). This causes some confusion in its separation from *belief* systems that may be understood as a closer match to these influences. However, Simons is clear that the implementation of a *boundary* system is strong in response to failure. *Belief* systems are a reflection of the core values of the firm; they provide momentum to develop creative behaviours (Simons, 1994). Ferriera and Otley criticise the applicability of the Levers of Control in structures where the design of the *belief* systems are outside control of the organization, perhaps as a subsidiary of a larger group.

To this point the discussion conducted has been generic in terms of performance management, other than the explicit statement that *boundary* systems specify risk to be avoided. However risk management is at the core of the framework. The four levers control different aspects of risk (cf. Simons, 1999). Reference to *risk control* is deliberate as it is not a system for risk valuation[11]. The different levers are understood to have the following relationship with the control of risk and risk management behaviours:

1. *Belief Systems* are seen as a failsafe/safeguard, which protects against loss in core values of the organization (Simons, 1999:92);
2. *Interactive* systems protect against the evolving and uncertain development *"strategic uncertainties"* (Simons, 1999:94), this is framed as a link into the *learning* capability of the organization;
3. *Boundary systems operate* as a negative control, stopping the organization from breaching critical limits (taking on increased risk); however *Boundary systems* do not map routes of action as seen in positive controls. These are prohibitory controls that contribute to the continuance of the system (cf. Simons, 1999); and
4. *Diagnostic* systems are designed to identify failure or deviation from the objectives, which would infer increased imprecision in the output of the organization.

These four levers operate as a suite of influences on risk taking and risk management within the organization. Linked to the impact this has on managerial action and individual risk

[11] Simons (1999) offers a risk calculator to help identify general movements in risk trends, but this is under-developed in literature.

judgement, the *Levers of Control* begins to explain the influences that the performance system has on the management of risk in the organization.

2.8.8 An Integrative Model of the Performance System

Section 2.8.1 to 2.8.4, identified the core functions of the performance system, and exposed that these functions operate as a collection of inter-related activities. This section of the literature review develops upon these different functions to understand the order of activities, for example the process of mapping strategy into objectives and consequentially measures and targets (cf. Kaplan & Norton, 2008) and the use of measures to challenge the strategic assumptions (Bourne et al., 2000).

This review is developed further, with a specific aim of understanding the flow of events and relationships between the different components and the operation. The establishment of links between functions is subject to interpretation of the literature. Taking in turn the different functions of the performance system, the literature supports the following links:

- The performance measure is mapped from strategy and vision (Kaplan & Norton, 2008; Kloot & Martin, 2000; Langfield-Smith, 1997), this mapping informs the target setting (Otley, 1999), this is the implementation of strategic management (Band, 1990; Globerson, 1985; Henri, 2006);
- The decision-maker is influenced by communications (Chater & Oaksford, 2003; cf. Kahneman 2003; Ranyard et al, 1999; Otley, 1999), including framing, weighting (Lai, 2001), and informational features (Edworthy & Adams, 1996);
- Decisions being made influence the activities in the operation (cf. Nilsson & Darley, 2006);
- Learning influences the Operation (Ballentine et al., 1998; Bititci et al., 1997), for example: learning in *speculative* risk practices (Brennan, 1998; Turner et al., 1989), *pure* risk in Health and Safety (Edmondson, 2002) and disaster management (Kotze & Holloway, 1996);

- Information is retrieved from the operation back into the measurement system; this is the activity of measurement (Otley, 1999; Melnyk et al., 2004; Neely et al., 1995; Schneiderman 1997);
- The operation influences strategy, this is a bottom-up perspective, Slack and Lewis (2011) and, *learning* or *environmental* perspectives (Mintzberg et al., 1998);
- Measurements of performance feed into the learning cycle, both corrective or generative learning (Argyris & Schon, 1978 & 1996), development of continuous learning capability (Ghalayini & Noble, 1996; Johnson & Kaplan, 1991; Medori & Steeple, 2000; Noci, 1995) and learning as a system consideration (Bourne et al., 2005; Flynn & Flynn, 2004);
- Measures are communicated (Kaplan & Norton, 2000; Malind & Selto, 2004; Simons, 1994; Shneiderman, 1999). The COSO cube (2004; 2004b) references this role in ERM;
- The strategy is operationalised and disseminated through measures and targets (Kunc, 2008). Operationalising objectives comes about through the monitoring of performance (Bhimani, 1993; Blenkinsop & Davis, 1991; Gomez et al., 2004; Grady, 1991; Neely et al., 2005) and that control systems focus attention on *strategic uncertainties* (Simons, 1994);
- The measures are used to challenge strategic assumptions, more than just confirming alignment with the strategy (Bourne et al., 2000).

From this understanding a presentation of the performance system, its component parts and influences on the operation is provided in figure 2.17.

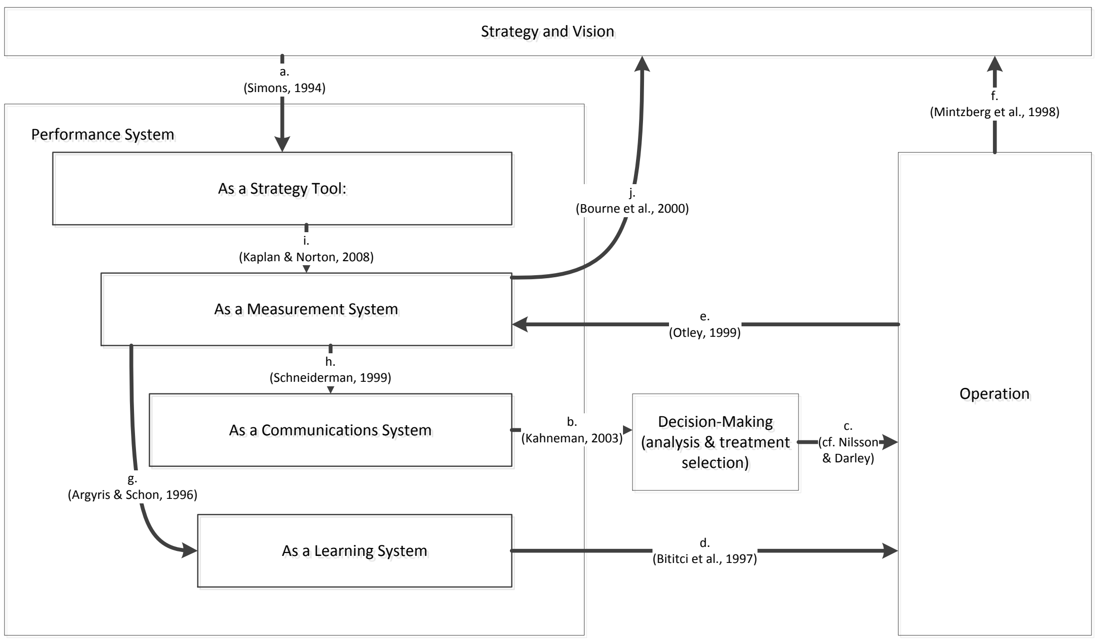

Figure 2.17 Integrated Performance Management System and Risk

Figure 2.17 shows the performance system in operation and exposes the complex relationships between the different performance system components.

2.8.9 Summary of Performance System Literature

The review of performance systems considers literature from the performance management, performance measurement and management accounting disciplines, these were synthesised to identify four core functions of the generic performance system (measurement, communications, strategy alignment and learning). Further the review considered knowledge from specific system implementations (e.g. BSC).

The semantic issue between performance measurement and performance management, did not present a limitation to understanding. Rather it is understood that measurement is a wholly encompassed component of the performance management system. The management control system literature developed an understanding of the use of financial metrics. This refers back to the work of Power (2005) and Mikes (2009), see section 2.4.3.

In summary the literature can be broken down into a relationship between three areas: the codified approaches (i.e. BSC), the four functional lenses (i.e. communications function) and specific considerations (i.e. stakeholders). These areas and their relationships are outlined in figure 2.18.

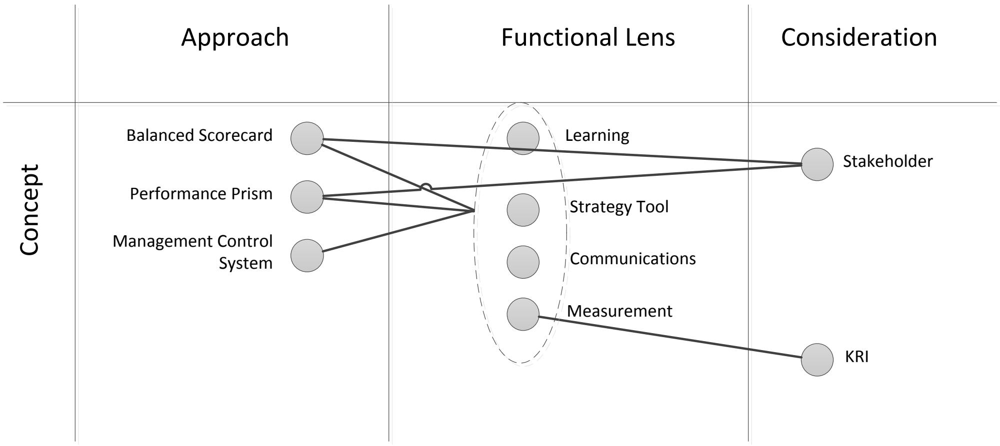

Figure 2.18 Overview of Performance System Concepts

Figure 2.18 identifies that all three approaches reviewed had consideration of the different functions apparent in the review; however the BSC and Performance Prism had greater reflection of stakeholders in the design. It was shown that understanding the influence of the performance system (on decision-makers) benefits from reference to the decisions under uncertainty literature (section 2.6), and that there is a limited link in knowledge with the risk management literature; although it is this latter limitation in literature which this research seeks to develop.

2.9 Synthesis of the Literature

This literature provides an understanding of existing knowledge of performance management, risk management and decisions under uncertainty. The review has established that the shape of the body of knowledge for risk is diverse and is covered in a broad set of communities. The discussion of risk in operations is implied within the supply chain literature, the accounting community and Operational risk (a closely associated concept) is defined within the discussion of financial supervision. However as the level of analysis reduces from organizational risk management and its standards to the individual, understanding of the risk decisions (or decisions under uncertainty) is explained further in the psychology literature. Principle-Agent theory (Eisenhardt, 1989) establishes a link between the organizational structures in risk management and the individual's risk perception and decisions. The framework in understanding this relationship has been further explored in the context of the performance management system; resulting in a logical flow of performance management of risk.

There appears to be no single framework or theory to answer what the treatment strategies for risk in operations are, or what influences the selection of treatment strategy. However there are a number of frameworks and theories that aid an understanding to approach the research aims:

1) *Calculative Cultures* (Power, 2005) is a description of the approach and purpose of valuation in an organization when managing risk. Organizations can be described as calculative *pragmatists* (use the numbers as a guide), or calculative *idealists* (use the numbers as a definitive point of reference);
2) *ERM Ideal Types* (Mikes, 2009; 2011), describes an organization's approach to ERM through four types. This highlights the different focuses of an ERM implementation. This includes: Risk Management Silos, Holistic Risk Management, Integrated Risk Management and Risk Based Management types;
3) *Levers of Control* (Simons, 1994; 1995) defines the control system as having four levers: *boundary*, *belief*, *diagnostic* and *interactive* systems. These four levers may exist within a single system, and range from providing outer limits of the organization's function through to developing interactive engagement between managers and the control system.

There are a number of judgements that can be made in reviewing this literature:

- That the terms *Operational risk* and *risk in operations* are separate terms. Their use has attachment to the context and community. The term Operational risk is developed from the finance community and that generalisation of its usage changes the meaning and purpose of the term. Mikes (2009; 2011) and Power (2005) discuss Operational risk in the context of the performance management system;

- If the decision-maker sits between the performance system and the risk management process (Lowrie & Cobbold, 2004) it infers that the existing frameworks explaining the decision-making process should be understood, and specifically the impact on risk judgement (Ellis et al., 2010). The issue outlined by Slovic (1964) is that risk choices are multidimensional and subjective. Mechanical adjustment of a performance system to affect a decision-maker, infers then that reasoned decision-making is being applied, and there is no mediating influence on the decision-maker;
- From the finance literature we expect there to be financial orientation in risk decisions (cf. Basel Committee, 2006). As this knowledge develops to *risk in operations* non-financial impacts need recognition (Mikes, 2011). This is the issue of multidimensionality. Risks can be defined as more than financial consequence (Mikes, 2011), and this is understood as being relevant. There is not an agreed classification of risks, and this itself leads to confusion in the term;
- An interpretation of Mikes (2009) and Power (2005; 2009) is that financial orientation infers quantitative approaches. This does not hold in reverse; that quantitative approaches are more than financial. The difference in *Calculative Cultures* exposes two approaches to using quantification (i.e. *idealism* and *pragmatism*). There is no understanding of how the adoption of different cultures impacts the selection of risk treatment;
- Performance systems are used to influence decision-makers (Lowrie & Cobbold, 2004; Mikes, 2009);
- Management behaviour should be considered the key recipient of the control system, and that the control system must be considered in both its *formal* and *informal* constructions (Ferreira & Otley, 2009). Performance systems, measures and configurations are contingent on their environment; these differences are reflective of a range of different recipients, and their individual needs and expectations. Differences

between *top managers*, and *operational managers*, featured within existing research as examples of this divide (Melnyk et al., 2004). The literature combining understanding of risk and control of management behaviour is summarised in table 2.3

Table 2.3 Summary of Risk Influences

Concept	**Literature**
Probability and Impact	Banks (2004); Coughy et al. (2001); Craighead et al. (2007); Ellis et al. (2010); Knight (1921); March & Shapira (1989); Mitchell (1995); Mikes (2011); Harland et al. (2003); Lu & Yan (2013); Hallikas et al (2004); Williams (1966); Zsidisin et al. (2004)
Financial and non-financial measures	Crouhy et al. (2001); Eccles (1991); Harland et al. (2003); Matthews et al. (2002); McNamara & Bromiley, (1999); Meulbroek (2002); Mikes (2011); Schwartz & Gibb (1999); Zahra (1991);
Incentives and the risk taker	Carpenter et al. (2003); Dhaliwal (1982); March & Shapira (1987); Gardner and Steinberg (2005); Govindarajan & Gupta (1985); Power (2009); Sjoberg (2000); Wiseman & Gomez-Mejia (1998);
Historical data	Cabedo & Moya (2003); Harland et al. (2003);Hendricks (1996);
Risk management process	Calandro & Lane (2006); O'Donnell (2005); Hallikas et al. (2004);
Risk standards, processes and tools	Harland et al. (2003); Hopkin (2012); Hunter et al. (2004); Mikes (2011); Shaw & Centry (1988); Simon (1999); Yeo et al. (2001); Zwikael & Sadeh (2007)
Alignment with strategy	Daniel & Reitsperger (1991);Eisenhardt & Sull (2001);Hallikas et al. (2004); Langfield-Smith (1997);
Perception of risk	Bansal & Clelland (2004); Eccles (1991); Eccles et al. (2007); Ellis et al. (2010); Harland et al. (1999); Melchers (2001); Mitchell (1995);

- The performance system literature does not resolve which of the function/s become influential in affecting risk decisions. It does not demonstrate how risk objectives or requirements are incorporated (i.e. definition of risk appetite or communication of risk behaviours). The performance system's influence on changing risk decisions is not understood (cf. Arena & Arnaboldi, 2014);
- Nahlik (2008) challenges whether performance measurement is a pure dimension of performance management. The explanation that *"The received wisdom is that to manage performance, you first have to measure it"* (Nahlik, 2008:43). It is a crux of this understanding that knowledge is partial and imperfect, that the use of measurement and associated components is not understood in a realist perspective to offer a simple route to outcome. The influence is more subtle in the response to measures and targets,

indeed some measurements invariably lead to distraction from the core issues and management consideration (cf. Nahlik, 2008:45). This distraction or inconsistency in influence on individual perspectives is partially explained by the knowledge of biases (Hsee & Hastie, 2006), individual risk aversion (Wiseman & Gomez-Meija, 1998), and a range of personal contingencies (i.e. experience, environment and context of decision).

Understanding of whether an organization's knowledge of risk, its risk management practices and its strategies in managing risk are aligned is imprecise. This review demonstrates that the term *risk* has a long history, with a debatable origin. It is not a surprise that there is concept stretch and semantic disagreement or that as different communities have used the term it has developed it in a manner to suit their discipline.

The gap in understanding, which this research seeks to explain, exposes two research questions:

RSQ1: What are the treatment strategies for risk in operations? and

RSQ2: What influences the selection of treatment strategy?

To answer these questions, two cases from the European Energy Industry are analysed. These cases are good examples of multinational, vertically integrated energy companies operating retail, generation and distribution functions within the sector.

This concludes the foundational literature review.

Chapter 3

3. Research Strategy

This chapter outlines the philosophical position, methodology and approach underpinning this thesis. There is a presumption that the applied method is consistent with the philosophical beliefs of the research and researcher, it needs to be consistent with the research topic and availability of data (Collier, 1994; cf. Walsham, 1995). Discussion of the methodology and approach is conducted in reference to the research questions.

3.1 Research Strategy Overview

I adopt the Critical Realist paradigm, acceptant of its limitations. The Critical Realist paradigm is focused upon identifying generative mechanisms (Collier, 1994), by identifying the causal forces in our environment it allows us to develop in-depth knowledge. Critical Realism is sometimes criticised for being an uncommitted research position: acceptant of quantitative testing, whilst also recognising the way in which people socially construct their world (Ackroyd & Fleetwood, 2000; Kwan & Tsang, 2001). However this broad awareness is presented as strength in seeking an understanding of performance managing risk, where theory development is nascent (cf. Edmonson & McManus, 2007).

In combination with an abductive methodology (Easton, 2010), the methods available are varied and their use appropriate for the pursuit of understanding the generative mechanisms held. The abductive methodology (discussed later) is an iterative process moving from the empirical to the theoretical and back (Kovacs & Spens, 2005). It continuously seeks the most appropriate frame of reference by which to answer the question/s.

3.2 Philosophy

There are three principle considerations in setting out on the research process: ontological assumptions, epistemological stance and the impact these have on choice of methodology. These are discussed in turn.

Ontology is the study of being or truth, *"the way we think the world is"* (Fleetwood, 2005:197). Ontological selection is commonly discussed along an axis, the two extremes being objectivism and subjectivism (Morgan & Smircich, 1980, 492). Objectivism is the belief that truth and therefore knowledge is a matter disconnected from the perspective of the individual mind. Therefore that truth is consistent regardless of the standpoint it is seen from: *"reality as a concrete structure"* (Morgan & Smircich, 1980, 492). Subjectivism is the opposite position that truth is a concern of the individual mind, that truth is entirely dependent on the mind that sees it: *"reality as a projection of human imagination"* (Morgan & Smircich, 1980, 492). There is a midpoint on the ontological spectrum. This is ontological realism: *"for realists, patterns of events are explained in terms of certain generative mechanisms…"* (Tsoukas, 1994:290). Realism regards truth as independent of the individual mind and considerate of context where knowledge is a journey rather than a destination reached in a single attempt.

Epistemology is the study of how knowledge or how truth is acquired: *"what we think can be known about it [the world]"* (Fleetwood, 2005:198). Epistemology is axial, where the extremes are *empiricism* and *constructivism*. Empiricism is the belief that truth is discovered through sensory data, and leans toward a grounded ontology (Dooley, 2009:40; Flynn et al., 1990). With a grounded ontology evidence is collected as a route to understanding the truth. This epistemological position is most clearly associated with hypothesis testing (Lee, 1991). Constructivism, the other extreme, is a view that truth is an issue of mental construction. It is a matter of human beliefs and ideas. That regardless of the sensory experience it is the way in which an individual experiences and their interpretation that is important (Mir & Watson, 2000).

In conjoining the ideas of ontology and epistemology there are several commonly accepted paradigms that describe the influence on an individual's research. There are many, including: Positivist (e.g. Spender, 1998), Social Constructivist (e.g. Mir & Watson, 2000), Pragmatist (e.g. Richardson & Kramer, 2006) and Realist (e.g. Bhaskar, 1986). Positivists are empirically-guided objectivists (Spender, 1998). Where truth is independent of the individual and that it can be discovered through sensory observation and recording. It is independent of bias in observation by the researcher: *"the positivist position is that knowledge deals with things 'out there' for which we can gain positive evidence"* (Spender, 1998:234).

The Social Constructivist is ontologically subjectivist and epistemologically constructivist. Truth is dependent on the individual's perspective. Truth is a matter of how people see the world and articulate it, this infers that the research in itself will bring the researcher's heuristics into the data collection process, Mir and Watson state that *"constructivists view the process more as an act of sculpting, where the imagination of the artist interacts with the medium of phenomena to create a model of reality which we call knowledge."* (2000:943).

I acknowledge these different paradigms. My background, the concept under analysis and the community I exist within all influence my position. More appropriately I recognize it is the Critical Realist paradigm that I take the greatest influence and learning from.

3.2 The Influence of Critical Realism

Critical Realism, earlier Transcendental Realism (Bhaskar, 2008), is understood to be ontologically *Realist* and epistemologically *Relativist* (Collier, 1994:90; Johnson & Duberley, 2006:151).

The Realist perspective identifies the importance of *causal mechanisms*, rather than empirical regularities. Realism is understood through a *stratified ontology*, which presents three domains: *the real, the actual and the empirical*. Realism does not reject empirical regularities in the journey to understand and seek the generative mechanisms, it recognises that the third level of a *stratified ontology* is the empirical. This is in contrast to empiricist's flat ontology, which only deals with the empirical.

Bhaskar explains that our experiences are separated from the real structures causing them: "*real structures exist independently of and are often out of phase with actual patterns of events*" (2008:13). The stratified ontology can be applied to the concept of risk management where causal mechanisms such as human, system and external mechanisms exist in the real, loss-events exists in the actual and on occasion realised in the domain of the empirical (cf. Collier, 1994). The same may be true in the analysis of the performance system where components (and sub-components) of the control system exist in the real, influence on risk management outcomes exist in the real, but as events they exist in the actual, they do not need to be observed to be ontologically *true events* (Bhaskar, 2008:179).

A Relativist epistemology influences the approach adopted, through a process of *retroduction* (Bhaskar, 2008). Retroduction is the iterative movement from a description of phenomenon to explanation of cause. Retroduction is a method of maintaining science as a "*process-in-motion*" that may "*sustain the rationality of scientific growth and change*" (Bhaskar, 2008:15). It is a fusion of the *idealist's creative model-building* process and *empiricist's empirical-testing process*. The retroductive process is a movement from *"a description of some phenomenon to a description of something which produces it or is a condition for it"* (Bhashkar, 1986:68). It is the search for underlying causal powers highlighting the "*conditions which activate the structures and the mechanisms which produce events*" (Smith, 2003:319). Collier summarises Bhaskar's decompository-retroductive approach into four steps:

1. Resolution of a complex event into its components (causal analysis);

2. Redescription of component causes;

3. Retrodiction to possible causes of components via independently validated normic statements;

4. Elimination of alternative possible causes of components. (Collier, 1994:162)

The decompository-retroductive approach is distinct from the analogical-retroductive approach, which is best suited to theoretical explanations (Bhaskar, 1986:90). The application of the decompository-retroductive approach can be seen throughout the research beginning with the literature review which breaks down the constituent parts of both performance system and risk management, to a level that is intended to expose the mechanisms and powers (that exist in the domain of the real). These mechanisms are then empirically analysed to identify the critical mechanisms that allow development into the concept of the performance system. This is consistent with Bhaskar's transcendental realist approach:

> "*The 'real entities' the transcendental realist [CR] is concerned with are the objects of scientific discovery and investigation, such as causal laws.*" (Bhaskar, 2008:26).

In Critical Realism it is understood that social entities are conceptually mediated. Intransitive objects and their resulting causal powers may not be directly observed rather they must be theoretically speculated (Johnson & Duberley, 2006:166). Aspects of the performance system are clearly tangible in nature: measurement, communication and targets. These conform to the dominant Operations Management paradigm and growing preference for use of empirical methods (Meridith, 2009; Sanders, 2009; Theoharakis et al., 2007). However the incorporation of risk extends the performance system to include managerial interpretation and subjective description of risk requires acknowledgement of the role of social mediation in the relationship. I believe the world of risk management may not be reduced to such a closed system image. There is greater complexity affecting the world than may be observationally accounted for and perception of empirical regularities. This is not totally sufficient for establishing knowledge in this field – this is the Realist's view.

Finally the term *Critical* in Critical Realism seeks to deliver an understanding that could enable change in the organisational performance management of risk; and the more emancipatory objective of developing risk management practices that offer a safer employment environment and risk management practices that are socially and environmentally sustainable, rather than the monolithic aim of economic enhancement.

Learning from Critical Realism and the process of conducting Relativist research, this research uses an abductive approach. Abduction and retroduction are closely associated terms, and are complimentary approaches (Easton, 2010). Peirce (in Fann, 1970) used the term abduction; abduction is understood to be an aspect of retroduction (Chiasson, 2005). Retroduction highlights the need to test hypothesis as it moves toward a deductive phase (cf. Collier, 1994), whereas abduction focuses more on the discovery of hypotheses to test (cf. Dubois & Gadde, 2002).

The next section discusses the abductive approach and the influence of systematic combining.

3.3 Abductive Development: Systematic Combining

The Critical Realist perspective encourages seeking generative mechanisms underpinning the complex relationship between an organization's control systems and management and treatment of risk. The chosen methodology must support this aim. Methodology is:

> *"The general study of method in particular fields of enquiry…To investigate the methods that are actually adopted at various historical stages of investigation into different areas, with the aim not so much of criticizing, but more of systematizing the pre-suppositions of a particular field at a particular time."* (Blackburn, 2005).

Selection of methodology is therefore contingent both to the subject and the availability of data. The abductive approach is considered fruitful if trying to discover new things. Its emphasis is development of theory rather than generation of new theory (Dubois & Gadde, 2002). Abduction is a process beginning with a real-life observation where either the theories are in contention with observation, or there is an absence of understanding (Kovacs

& Spens, 2005). Abduction is an iterative process, to extend theory or offer new theory, perhaps ending in deductive research (Kovacs & Spens, 2005). It is a cycle of theory matching, observation and suggestion, completing with conclusions (Kovacs & Spens, 2005:139); this is what Dubois and Gadde (2002) term "*Systematic Combining"*.

Abduction is closely associated with the Pragmatist approach to research (e.g. Richardson & Kramer, 2006). However learning from the Critical Realist understanding is also consistent with the abductive approach (Easton, 2010). The link between retroduction, abduction and Cririical Realism already discussed that: *"Retroduction means 'moving backwards' and that is what the process involves."* (Easton, 2010:123). The process of *"systematic combining [is] grounded an abductive logic"* (Dubois & Gadde, 2002:559).

Systematic combining has two distinct elements: matching and redirection. Matching is the *"non-linear, path-dependent process of combining efforts with the ultimate objective of matching theory and reality"* (Dubois & Gadde, 2002:556). Redirection (or direction and redirection), supports the process of matching, involves incorporation of multiple different sources, which allows for broader appreciation of the issues presented. Use of multiple sources can reveal *"sources unknown to the researcher, i.e. to discover new dimensions of the research problem."* (Dubois & Gadde, 2002:556). Therefore in this research multiple iterations of data collection and analysis are required. This is consistent with the abductive approach. Thus, this research is a mixed-method, quantitative and qualitative study. This is done to understand the treatment strategies for risk in operations and what influences their selection.

This cycling between observation and theory considers both inductive and deductive approaches. If quantitative analysis is used to test hypotheses this supports deductive studies (Eisenhardt & Graebner, 2007), some quantitative methods e.g. Exploratory Factor Analysis, can be used in an inductive manner (cf. Hair et al., 2011). Qualitative analysis is expected to yield an insight into the different influences brought on the relationship and supports inductive studies (Eisenhardt & Graebner, 2007). This research uses quantitative and qualitative approaches, to systematically combine understanding in theory and practice. This is the process of matching and redirection.

This research adopts the following approach, based on Bhaskar's decompository-retroductive and the abductive approaches:

1. *Resolution of a complex event into its components*: The terms of Operational risk, risk in operations, performance management and measurement have been deconstructed into their components (chapter 2). The performance management literature was analysed for relationships between components of the system and for theories of interaction with managing risk. This decomposition extends further to deconstruct the different risk management treatments.
2. *Redescription of component causes*: Learning developed during the decomposition is situated in both the context of energy and the inter-relationship that can be described between the performance management theories established for managing risk in operations (e.g. ERM Ideal Types, Mikes, 2009). These re-described components were then taken as basis for understanding the relationship between the two concepts. The performance system at the start is considered the generative mechanism in the relationship with managerial decision-making; although this assumption is challenged as the study progresses. Redescription of the performance system as functions (i.e. as a communications function) is completed in the foundational literature review.
3. *Retrodiction to possible causes of components*: Iterative phases of observation and theory development, including thematic analysis are used to explain the application of performance system components. The frame of reference becomes increasingly granular, from corporate structures to individuals, in its search for revised generative mechanisms. Retroduction is the focus of chapters 4, 5 and 6, as the research cycles between observation and explanation. Each chapter is informed by the previous level of analysis and integrates its understanding in the discussions.

4. *Elimination of alternative causes of components*: Challenges whether there are alternate explanations to the relationship. So at all phases it is questioned as whether this relationship is appropriate to describe the problem. This is the *"direction and redirection"* explained in the process of systematic combining (Dubois and Gabbe, 2002:555).

In summary this thesis adopts a process of systematic combining (Dubois & Gadde, 2002), and learning from the Critical Realist literature. The approach of systematic combining as a method to understand the research question is in response to the *nascent* nature of theory development within the field of risk in operations and performance management.

The next section details how the design of the research conforms to the understanding of abduction and systematic combining. It details the frames of reference and focus of research for each cycle of observation and explanation.

3.4 Research Approach and Methods

The context of this thesis is the European energy sector. Each successive level of analysis considers both its method of data collection, and means of analysis.

Direction and Redirection

Systematic combining involves two aspects: matching and redirection (Dubois & Gadde, 2002). This research followed four phases in the search for the generative mechanisms involved in performance managing risk in operations. Table 3.1 shows the phases of the research:

Table 3.1 Abductive Phases of Research

Phase	Focus	Phenomenon	Frame of Reference	Rationale
Phase 1	Policy & structures	Classifications of risk, structures of risk methodologies	Firm	The firm is the highest level of aggregation, and the unit of investor analysis.
Phase 2	Process	The process of risk management, systems and valuation approaches	Function	A self-contained operating unit. Preparatory discussions identified potential differences between functions because of different motivations and expectations.
Phase 3	Decision Paths	Mental models of selecting treatment as influenced by performance measures	Communities	A distinction between management responsibilities. Preparatory discussions identified potential differences between levels of seniority and that a person's social identities are characterised as a collective identity (Whetton et al., 2009)
Phase 4a	Risk Judgement	Affect of stimuli (performance measures) on risk judgement	Individual	The lowest level of analysis, reflecting Kahneman & Tversky (1981) that decision-making is largely individualistic.
Phase 4b	Treatment selection	Affect of stimuli (performance measures) on treatment selection	Individual	

As the research evolved it not only moved the frame of reference from the *firm* to the decreasing granularity of the *individual*, it also developed from analysing structures towards individual decisions and influences. This representation can be seen in figure 3.1.

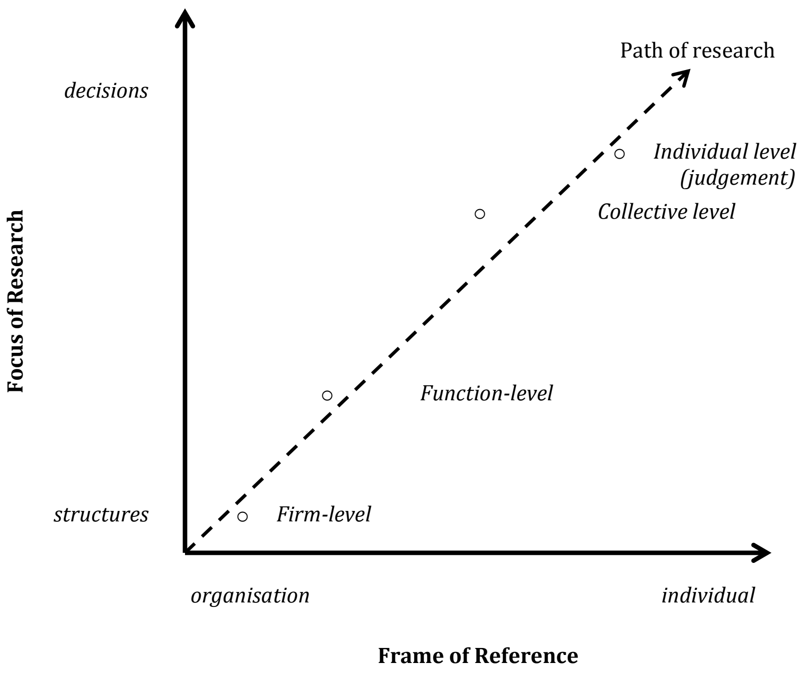

Figure 3.1 Path of Abductive Development

Each frame of reference develops an understanding of the research question, but in doing so opens up a further gap in understanding. It is the combined understanding developed across frames that has provided insight into the risk management process. Different causal influences were seen to dominate, as were the desired outputs from each level.

At each phase, there was consideration to the most appropriate method. This research approaches the question using the levels: firm, function, collective (group) and then individual.

In the first and second phases (firm and function-level) reflecting Dubois and Gadde (2002), a case study method was adopted. This used triangulation of data (cf. Jick, 1979): interviews of key staff and managers, observation of their meetings, inspection of reports and analysis of their communications. This approach enabled an atheoretical[12] analysis to be completed. The results were treated and reported in a thematic style, looking both for commonality and contrast between the firms. The firm-level analysis demonstrated convergence between cases. However within each firm representation at risk oversight meetings demonstrated a difference in perspective between Generation and Retail Business Units (BU), this lead to the second phase using function differences as the frame of reference.

The second phase (function-level analysis) exposed differences between asset and service orientation, the accounts started to show some difference between management levels. This frame of reference was adapted to look at how the different groups made their risk decisions.

In the third phase, (still reflecting back on the incomplete discussion of structure and process) to develop an understanding of the complex order and influence of decisions a method of causal mapping was employed. Rather than triangulation of the data this took the accounts of the individuals and coded results to create causal maps. These causal maps were aggregated into collective groups to identify different perspectives. Only in this way could the generative mechanisms be surfaced that were not apparent when employing only a thematic analysis.

In the fourth phase, the study focused on the individual. It was felt that neither a case study nor causal mapping method could be employed. The causal mapping approach was close to its limitations aggregating seven accounts per sample, and was subject to loss of information in selecting the majority view above this volume of accounts. However from the previous three phases a number of questions could be identified, and although limited in their attachment to literature they gave a basis for developing the data collection. The individual's accounts examined a series of influences (e.g. company strategy or perception of the individual) on risk decision and the selection of treatments being employed (e.g. avoidance

[12] *This is distinct to a grounded approach, as the literature and potential theories had already been exposed. Further as the researcher I already had experience of these organizations and some of the perceptions already held.*

or mitigation). This administered a survey and resulted in an exploratory factor analysis. Table 3.2 summarises the four levels of analysis, the methods of data collection and analysis.

Table 3.2 Levels of Analysis and Methods Employed

Level of analysis	Method	Method of data collection	Means of analysis
Firm	Case Study	Interview, meeting and system observation, document and report review. A-theoretical unstructured interview protocol	Thematically structured analysis
Function			
Group	Case Study/ Causal Mapping	Semi-structured interview	Cognitive mapping and thematic analysis
Individual	Survey	Electronic survey	Exploratory factor analysis, T-tests, Chi-square tests

The methods are outlined in more detail in each of the chapters (representing successive phases). The firm and function-level analysis use the same method so is only outlined at the start of the firm-level analysis (section 4.1).

The research reflecting understanding of systematic combining means that for each phase (frame of reference), there is:

- An introduction to the frame of reference;
- A statement of method (where this is different to the previous phase);
- Outline of data sources;
- Analysis and results;
- Discussion (reflecting on the findings within that frame of reference);

- An integrative discussion (reflecting on developed understanding across previous frames of reference)[13].

The research begins with a firm-level analysis.

[13] There is not an integrative discussion at the end of chapter 4, firm-level analysis as it has no previous reference point.

Chapter 4

4. Firm-Level Analysis

Chapter Four uses a case study method to analyse two different organizations from the European Energy Sector. It used findings developed during exploratory workshops[14] and extant literature to inform the questions and identify respondents for interview. The structure of this chapter is conventional: method, results/analysis and discussion.

A method section provides outline for the justification of the case study approach. Two cases are outlined, including context and explanation of the markets they exist within.

In analysis, the different thematic categories are summarised. In turn these themes are discussed, looking for both convergence and contradiction. The chapter ends with a discussion of the results.

4.1 Case Study

Application of the case study method is a powerful approach in the development of new theory (Boyer & Swink, 2008; Eisenhardt, 1989:532; Eisenhardt & Graebner, 2007; Jaspers, 2007; Voss et al., 2002). It has both inductive (Eisenhardt & Graebner, 2007) and deductive (Dubois & Araujo, 2007) uses, it continues to be favoured for its ability to develop theories (Jaspers, 2007:210), where the existing understanding is nascent in nature. The case study approach is clearly documented by Yin, that case research is appropriate: *"to cover contextual or complex multivariate conditions and not just isolated variables"* (2003:xi). In approaching an exploratory case study[15], the unit of analysis is critical but also challenging.

Case research: *"deals more with direct observations of object reality compared to people's perceptions of object reality"* (Meredith et al., 1989:302), it *"is used to investigate a specific*

[14] *An exploratory workshop was conducted with representatives from 2 companies, and 3 different operational functions.*
[15] *Exploratory case studies are one of six different types of case study approaches outlined by Yin, 2003*

phenomenon through an in-depth limited-scope study" (Steenhuis & Bruijn, 2004:3), case research therefore provide a basis for analytic generalisation. The case method itself allows questions of how, what and why, to be posed and explored (Voss et al., 2002).

In design the sample does not need to be representative of some population (Eisenhardt & Graebner, 2007:27), this is the fallacy drawn across from positivist methods. Instead the cases should be chosen because they are suitable and interesting in their nature. Voss et al. (2002) support this consideration in discussion of the practical barriers and facilitators in gaining access to an organization. Eisenhardt (1989) argues that although single case studies are valid, the opportunity to develop multiple case studies can lead to a stronger foundation for theory building. The ability to explore a wide range of research questions that can emerge from the process should be encouraged (Eisenhardt & Graebner, 2007); this is consistent with the abductive process (Dubois & Gadde, 2002; Ketokivi & Choi, forthcoming).

Opportunity for research access should not be ignored and the *"opportunity for unusual research access"* (Yin, 2003:26) is a valid consideration. The development of *"polar types, in which a researcher samples extreme cases in order to more easily observe contrasting patterns in data"* (Eisenhardt & Graebner, 2007:27) is an important sampling consideration. Voss et al., (2002) and Handfield and Melynk (1998) identify that multi-site case studies are useful in both theory building and theory testing.

Case studies are likely to rely on qualitative data; this can be gained through interview, reports, observations, archival data and surveys amongst other sources (Sanders, 2009). Triangulation of data is advocated by Voss et al., (2002) and Jick (1979) as this increases result validity (i.e. that the test measures what it was designed to measure). Whilst consistent with the Realist aim of seeking generative mechanisms, case study research is capable of eliciting the causal mechanisms in much greater detail (Jaspers, 2007; Yin, 2003). Eisenhardt and Graebner encourage researchers to be explicit about the desire to build theory, and to enrich the accounts by *"liberally use footnotes to sharpen the distinctions…"* (2007:28).

Shah and Corley (2006) encourage the use of multiple methods in the development of theory. In research where complexity is high (e.g. organization studies):

> *"as scholars we should strive to rely on multiple complementary methodologies, and avoid creating and a adopting a dogmatic position which excludes valid empirical methodologies"* (Carter et al., 2008:693)

This understanding provides justification for the development and combining of methods to explore an issue. Voss et al., (2002) identify that in theory testing the combination of case study and survey-based research can be used for triangulation.

There is consideration as to whether a case study selection should be based upon a *retrospective* or *current* case (cf. Voss et al., 2002). Longitudinal case analysis is seen as particularly useful as it provides an increased account as to the relationship between cause and effect (Voss et al., 2002). Retrospective cases however do offer the researcher more control over the selection, as the cases are already likely to be distinguished in their criteria for selection.

A clear warning is common in the literature discussing case research and more generally in theory building research, that being inductive does not give licence to enter into the study without some understanding of *"the general constructs or categories we intend to study"* (Voss et al., 2002:199), this is echoed by Eisenhardt and Graebner (2007). The discussion of Grounded Theory (Glaser & Strauss, 1967 & 2009; Glaser, 1992) cannot be divorced from the discussion of the inductive case method. The extreme of entering into a case with no prior knowledge or attachment to literature is much argued, however taking understanding from Eisenhardt's (1989) case study approach there is a more planned cycle in research design and selection of cases.

Therefore in adopting the case study method, we are left with the following understanding:

- Case study is consistent with the abductive approach (Ketokivi & Choi, forthcoming);
- Case studies explore the how, what and why (Voss et al., 2002);
- Opportunity for interesting and unusual access should be exploited (Yin, 2003) and that extreme cases should be sought (Eisenhardt & Graebner, 2007);
- Triangulation of data increases validity (Jick, 1979) and is capable of eliciting causal mechanisms (Jaspers, 2007);
- However some prior understanding will provide general constructs and categories being studied (Voss et al., 2002).

4.1.1 Approach

The use of the case study method is accepted and prevalent in the operations management community (Boyer & Swink, 2008; Carter et al., 2008). Furthermore, case study approaches are desired where behavioural theory is examined (Boyer & Swink, 2008), behaviour is implicit in this study of individual risk treatment decisions. Specifically the aim of the firm-level analysis is to identify and understand:

- The different influences on the risk management process through the adoption of standards (section 2.2) and use of risk terminology/descriptions and the process being prescribed (cf. Power, 2005);
- The different recipients of risk communication (cf. Donaldson & Preston, 1995; Freeman, 1984);
- The roles associated to the risk management process and their influence;
- How risk decisions are being made at the firm-level.

Table 4.1 summarises the approach taken to case study in chapters four, five and six:

Table 4.1: Adopted approach to case study

Step	Consideration	Sources/ Reference
Data gathering	Using first hand observations, interviews and reports (cf. Meredith et al., 1989; Yin, 2003)	• Operational Risk (section 2.3) • Risk in Operations (section 2.4) • Inherent/residual risk (section 2.1.1) • Risk as loss or imprecision (section 2.1.2) • Use of defined risk management standards (section 2.2) • Recipients of communication, based on stakeholder contribution (Neely and Adams, 2002 and section 2.8.4) • Performance systems, explicitly or implicitly used to manage risk (section 2.8) • The measures used and valuation approaches (section 2.8.1) • The systems used to record and process risk.
Define theory	The understanding from the literature and workshop are used to define the theory base, there are models of character and behaviour (cf. Steenhuis & Bruijn, 2004; Voss et al., 2002)	• Calculative cultures (Power, 2005) • Risk Management Ideal Types (Mikes, 2009)
Design & selection of case analysis	This is an exploratory case study. There is deliberate sampling of risk managers, risk reports and risk oversight meetings as the source of this understanding at firm-level (cf. Eisenhardt & Graebner, 2007; McCutcheon & Meredith, 1993)	
Data analysis	It is qualitative in approach, using verbal and written direction. There is both data reduction and logical analysis through the conjoining of observations, reports and individual accounts. Developing the analysis from case data, requires a systematic approach to coding the data (interview, observation and archival data), reducing this into categories. (cf. Jick, 1979; Eisenhardt, 1989)	

In result, comparison was sought during this abductive process at different levels (e.g. firm and function-levels). In analysis this comparison identified convergence and clarification. These principles (McCutcheon & Meredith, 1993) informed the approach to the case analysis.

4.1.2 Sample Frame

Energy in Europe was the sector being studied. I had unique access to this sector. The Energy sector presented an interesting dynamic, containing a multiplicity of both financial and non-financial risks. Not only were there many different types of risk, but many different causes of risk (e.g. political, consumer and environmental).

The privileged access afforded to me, and a study of what the energy companies reflected as their: *"soft underbelly of risks, risk management and general handling of threats"* (CFO, Energy Company). The cases presented operated in the same markets, with subtly different influences on their culture and standards, these are outlined in section 4.1.3 and 4.1.4. The case organizations (Firm Level: FCORP and GRS) are now described:

4.1.3 Case Organization: GRS

At the time the research was conducted, GRS was a European vertically integrated energy company. Its focus of business was energy, including production, trading, retail and distribution (2010). Originally GRS was a conglomerate that in the 90s saw a major change in strategy, shedding all of its non-energy assets and businesses; it then used its capital to acquire an international (mainly European) portfolio of energy companies. It had shared assets in upstream gas fields and gas transportation. It was an international company, with moderate links to its host country (where the headquarters existed). There was not a strong national identity running through the company, as it valued the local market unit cultures (in 2010). This was specifically valued in the retail business units, where attachment to host nation (and therefore customer market) was seen as a core requirement. In total there were over 100,000 permanent employees, the number of contractors is not reported at a group level.

The UK market was managed by a market unit CEO, and included a CFO and a managing board. This function had diminishing authority within the group structure and was used as a risk management and political alignment structure. The heads of the different business units were members of this managing board. These business units were legally independent from one another, themselves controlled by managing boards and supplying a set of independent accounts.

In the UK market of GRS there was Business Units (BU) for: Retail (ERS), Generation (EGEN), Distribution, Business services and Engineering Development. Two of these subsidiaries ERS and EGEN are described in the function-level analysis (chapter 5).

4.1.4 Case Organization: FCORP

At the time the research was conducted, FCORP was vertically integrated. FCORP had a bias in the structure of its business toward generation activities, and specifically nuclear generation and build. FCORP employed a structure of national market units; although there was indication that economies of scale may be increased by a greater functional alignment. FCORP had market that covered most of Europe, and some non-European investments (specifically south East Asia and Africa). The UK market contained functions of retail, generation (non-nuclear), nuclear, distribution and central services. The trading function was not dedicated to the UK market[16].

FCORP had a very strong national culture, derived by its close links to the government and its investors, of which 85% of investments came from this nation. FCORP encouraged local cultures to be accepted within its national market units. However there was a clear bias in

[16] *Following the study (2012), the Trading function of FCORP was setup as an international trading function, as an equal peer of the market unit structure. The trading function itself then created national trading business units, one of which was based in the UK.*

the top management roles, which were predominantly occupied by nationals of the parent company. FCORP had over 160,000 employees.

Two of the subsidiaries in the UK market were considered in the function-level analysis (chapter 5). FRET was the retail subsidiary and EAM was the generation (non-nuclear) subsidiary.

4.1.5 Case Summary

The two Energy companies, based in the European Energy market were identified as having generally similar objectives and corporate structures, competing within similar (often the same) marketplaces. At firm-level there was no presumption as to the management of risk, or the performance management of risk. However understanding that these corporate bodies were assembled through a wide range of semi-independent BUs, the study was designed to explore an expected difference between those business units that were asset focused, against those that were service focused, because of introductory discussions with energy representatives, who suggested:

> *"we [asset business] are fundamentally different in the way we describe risk, record risk, process risks and the strategies we employ to manage them than our counterparts in retail."* (Asset Manager, GRS).

The data collection periods between firm-level and function-level overlapped for a short period, reflecting that it was difficult to separate between discussions of corporate relevance and BU relevance. This was because managers exist within both structures. However all effort was made to undertaken the analysis sequentially. Table 4.2 summarises the firm-level case organizations.

Table 4.2 Summary of Case Organizations

	GRS	**FCORP**
Business Units Analysed	*UK Market Unit:* ERS (Retail & Services) EGEN (Generation)	*UK Market Unit:* FRET (Retail) EAM (Generation – non-nuclear)
Nature of Business	Vertically integrated	Vertically integrated
National Influence	Host nation in Europe, National influence on retail business. Generation assets legally owned by UK market unit. Multi-national culture	Strong singular national culture. Generation assets based in UK. Operates separate business unit for retail activities in the UK which is independent.
Region of Business	Pan-European, some new ventures in Russia	Pan-European, some minor subsidiaries in Asia and Africa

4.1.6 Firm-Level Data Collection

The case study comprised:

- Inspection of stated risk management policies and processes;
- Observation of risk oversight meetings;
- Discussion and interview of the corporate risk managers.

The *general constructs and categories*[17] sought are outlined in section 4.1.1. This is extended to identify the different questions posed (Appendix A) to interview participants, and the questions being asked during observation and analysis of reports. These questions are referred to in the summary of thematic categories (table 4.4).

In total nine staff were interviewed (covering all roles as identified as formative on the risk process), six risk meetings (these were the total of risk meetings in the research access period) and nine reports (again the total number of reports available in the research access period) were analysed. The following sources were used during the firm-level analysis, summarised in table 4.3:

[17] *This reflects Voss et al.'s (2002:199) statement of entering into Case Study research.*

1) Data were collected over three months (June-September, 2011), it used a semi-structured interview protocol (see Appendix A);
2) Observations from meetings and reports were summarised freehand;
3) Six of the reports were copied, but were prohibited from being reproduced (table 4.3, marked with an *). Where copies of reports could not be taken field notes were made during the meeting describing the results and data published;
4) Critical statements in meetings were transcribed where possible. It was not permitted to take slides or recordings of any of the meetings being attended;
5) Detailed notes were taken during system observation sessions;
6) Draft process flow diagrams were created freehand to identify the order of risk information processing. These were supplied to the hosts to confirm accuracy in understanding;
7) Interviews were recorded where possible, and transcribed (using a professional transcription service). Where it was not possible to take an audio recording, field notes were taken; this included the main points in discussion and a transcription of any key statements made;
8) Following the data collection, notes and transcriptions were coded using NVivo against the main themes. The two cases were thematically analysed.

Table 4.3 Firm-Level Data Collection

	FCORP *12 visits (June-August 2011)*	GRS *14 visits (July-September 2011)*
Interviews	Group Risk Manager, Chief Risk Officer (CFO's dept)[FN] UK Head of Risk, Risk Manager (UK FD's dept) [*TR*] UK Risk Analyst [FN] Head of performance reporting i/c risk reporting [*TR*]	Corporate Risk Manager (Board appointment), *in UK* [*TR*] UK Finance Director (FD) in charge (i/c) of risk management [*TR*] UK Performance analyst (FD's dept) i/c Risk reporting [FN] Head of IT Services (UK), dual role head of risk planning [FN] Internal Auditor (UK) i/c risk control[FN]
Meetings attended	UK Performance review meeting (risk session only) Risk Review: Business Unit Analysts meeting Critical incidents wash-up meeting	Risk Oversight Group (UK) Pre-board risk planning meeting Information Services Monthly Risk Audit
Reports Reviewed	*All with UK Risk Analyst* 2011 Annual risk and mitigation summary, group submission June M[arket] U[nit] risk report * July M[arket] U[nit] risk report * August M[arket] U[nit] risk report *	Quarterly board risk report (Q2, 2011), *with head of UK risk ** UK update report [to group] mid-term 2011, *with head of UK risk ** Risk oversight meeting report (August, 2011), *with UK performance analysts* Risk oversight meeting report (Sept, 2011) *with UK performance analysts* Internal audit report, *with Auditor* IT Services UK report (June)*, *with head of IT Services*
Systems observed	UK Risk Register UK Risk Matrix Risk reporting intranet page	Combined MU UK Risk Register Risk Matrix Risk reporting tool Near hits reporting tool
Documents	Group Risk Policy (English) Communications Policy [Translated] Group website	Group Risk Policy UK Risk Policy Group website

[TR] Recorded and transcribed, [FN] Indicates field notes, * Reports copied

4.2 Firm-Level Results and Analysis

Table 4.4 shows the following themes that appeared during the analysis. These were contrasted between GRS and FCORP.

Table 4.4 Inductively Developed Thematic Categories at Firm Level

Category	Thematic Category	Key Terms	Characteristic Level 3 responses
Questions posed, see Appendix A (Firm-level interview protocol): *What does risk mean to your organization?* *What is the terminology used to describe risks?* *Review documents reporting risk management to shareholders and staff.* Risk Types			
RT1	In Public Communication	Public, consumers, safety	*"An incident occurred at A power plant, no injuries or threat to local environment was reported."* (i/c Risk, FCORP)
RT2	In Investor Communication	Investors, shareholders, financial, credit risks, market risks	*"The company operated in challenging financial times, but had managed to maintain its profits by increasing efficiency in the production process through investing in new technology."* (FD, GRS)
RT3	In Internal Communication	Staff, awareness, updates	*"Risk to safety is not tolerated, it is everyone's responsibility to identify, and communicate safety risks."* (FD, GRS)
What informs the approach adopted to manage risk? *What roles in the organization manage risk?* *Review reports and submissions detailing firm-level risks.* *Observe risk oversight meetings, agreeing corporate reporting submissions.* Risk Governance			
RG1	Policy	ERM, corporate guidelines, marketplace	*"We operate an enterprise risk management approach throughout the company"* (GRM, FCORP)
RG2	Risk Roles	CFO, risk manager	The CFO is the responsible manager for risk in the business unit
RG3	Reporting	Corporate process, reports, feedback	*"Information feeds upwards, but there is little in feedback to us on the process"* (Analyst, FCORP)

Continued…

Category	Thematic Category	Key Terms	Characteristic Level 3 responses
What is the strategy to manage risks? *Review documented corporate risk management process and standards recognised.* Risk Strategy			
RS1	Mapping	Risk management process, stakeholders, strategic impact, alignment	*"The prioritisation of risks reflect the strategic priority of the company"* (IA, GRS)
RS2	Desirable Decision-Making	Optimal solutions, through reasoned and empirically informed decisions	*"The Market Units are expected to demonstrate diligence in their decisions and provide optimal solutions in the management of risk in their operations"* (IA, GRS)

As the different themes are discussed, both convergence and contradiction are sought. This happens at two different levels, 1) within case, and 2) between cases (cf. Huberman & Miles, 2002). For brevity, these are combined in the results. Having triangulated the data for the case analysis (using reports, observations and interviews), it is apparent where there was internal contradiction or where there was convergence. These are analysed in turn:

4.2.1 Risk Types: Public Communication (RT1)

FCORP used the terms: Safety, Sustainability, Legal and Political risk in public communications. The discussion of Safety made clear both their legal and moral requirements, and that this was their risk management priority:

> *"When it comes to risk, what I think is a largely negative term, we know, or we think we know, what our customers and the public want to hear. This requirement doesn't seem to differ between different market unit], as the people, the public and the regulators are largely consistent in their concerns… when we talk about nuclear, they think Chernobyl, they don't think about low cost and reliable energy, when we talk about oil they think about the thick sticky stuff that floats on water and kills wildlife, they don't think about a proven technology where we are sweating the asset"* (Risk Officer, FCORP).

GRS used the terms Operational, Environmental, Regulation and Political risk in the communications. The term Operational risk[18] was closely associated to Safety, and the terms were interchanged. The communications were supplemented with a corporate responsibility of workforce safety. GRS understood this focus of their communications:

> *"Risk is something they [the public] want to manage away, if it doesn't impact them or family they are largely agnostic about the statements we make. I feel this has changed somewhat over the last decade where people have developed a consciousness about the environment, but the reality is they want to hear warm, fluffy statements about how we are not going to hurt them. The money men are savvy about this and see the numbers sitting behind statements. It is about perception, will the public support statements we make, will the business still be there, and will their investment still continue to grow? It is really is as simple as that."* (Risk Manager, GRS)

Figure 4.1 compare the different risk types being used, and that there was a level of alignment of terms between FCORP and GRS:

GRS		**FCORP**
Operational (Safety)	$\longleftrightarrow$	Safety
Environment	$\longleftrightarrow$	Sustainability
Regulation	$\longleftrightarrow$	Legal
Political	$\longleftrightarrow$	Political

Figure 4.1 About Us Risk Types: Public Communication (adapted from Company Websites)

There were four different top-level risks being discussed (figure 4.1). Although the terms used are subtly different, the underlying meaning of each aligned very clearly between cases. This was a product of the market and the environment they worked within.

[18] *This is not in reference to the Basel Accord definition of Operational risk, but a generic term relating to risks occurring in the transformation process.*

It was seen that the externally stated risk policy was aimed at satisfying the inquisition of the public, that risk management was management of negative impact and perception of negative impact. GRS showed there was a deeper level of consideration: that satisfying the public through appropriate communication was a requirement to satisfy the investors, they were seen to predict the public (and therefore the consumer) reaction in their assessments of the business.

There was limited difference separating the two cases in their almost bland production of risk-based communication to the public. It was defensive communication, expressing only positive treatment of threats. The analysts suggested that enough needs to be said to show awareness and priority, but that saying too much might indicate a problem and draw attention to a non-existent issue.

Both cases separated communication to investors and interested public within their websites. They treated them as different targets of information. In communicating to the public, there were attempts to use concise language and duplicity was avoided. In this theme both organizations were consistent with one another.

4.2.2 Risk Types: Investor Communication (RT2)

Investor reports used the same *risk types* (section 4.2.1) to structure discussion to investors. FCORP reports provided an example:

> *"Having recognised a potential fault in [plant A], it was taken out of operation. Rather than returning it immediately to production we have taken the opportunity to fit the plant with enhanced technology, giving it increased efficiency for the next 7 years of operation."* (Report, FCORP).

Further, FCORP articulated a desire to change their risk management communication, encompassing greater awareness and recognition of all their key stakeholders, and not just their investors.

In GRS communication of risk types was consistent between public and investors. This link between public and investor perspective is explained by GRS:

> *"Identifying a risk can just be an opportunity to make investment, the spin to the investor is a positive operational enhancement activity, to the public this is confidence in managing a potential hazard"* (Risk Manager, GRS).

Both cases attempted to demonstrate that risk was well managed, it was a positive message. There was evidence that inference to risk being well managed was linked to the organization's potential to satisfy investors and maintain their support.

The language used in investor reports was similar to the terminology being used in financial institutions, particularly terms seen in the Basel Accord, for example: *counterparty* and *credit risks*, *market risk* and *Operational risks*. This process was driven by two distinct functions: Audit and Oversight.

Investor communication was both about mitigation and to drive investor confidence. It used more precise language, aimed at a financially aware reader. The use of financial risk classifications distinguished the different technical applications of risk. There was a lack of quantitative valuation, in non-financial risk discussed (e.g. Operational risks). These were communicated using a qualitative explanation, for example *"there is risk of sustained media attention"* (GRS Website, 2010).

4.2.3 Risk Types: Internal Communication (RT3)

In documented risk policies the investor perspectives dominated. Risk was articulated in the financial sense and used the classification seen in the financial community. This energy-based financial perspective was embellished with more detailed causes of risk that provided greater detail in context of energy:

> *"The major Operational risks come from the rapid adoption of new technology [off-shore wind production] the lack of internal skills we hold, the high ratio of contractors*

to employees, that I can't change their behaviour overnight... that type of person [contractor] just likes to take a few chances that I don't tolerate from my own engineers" (FCORP, Risk Manager).

In this statement the risk manager had used the term *Operational risk*, as a catch-all category of risks stemming from the operation's activities and identified the magnitude of the risk (i.e. major). It was a reflection of the *inherent risks* brought about through the use of contractors and the inability to adjust their behaviour.

As part of the analysis of the different data sources, the different relationships between risk classifications were mapped. This was to seek whether certain classifications are being used within specific communications, and whether there were dual terms being used. The different risk types had a structured (but undocumented) relationship with each other. Some risk types were sub-categories of other risk types. To expose this difference these were mapped, shown in figure 4.3.

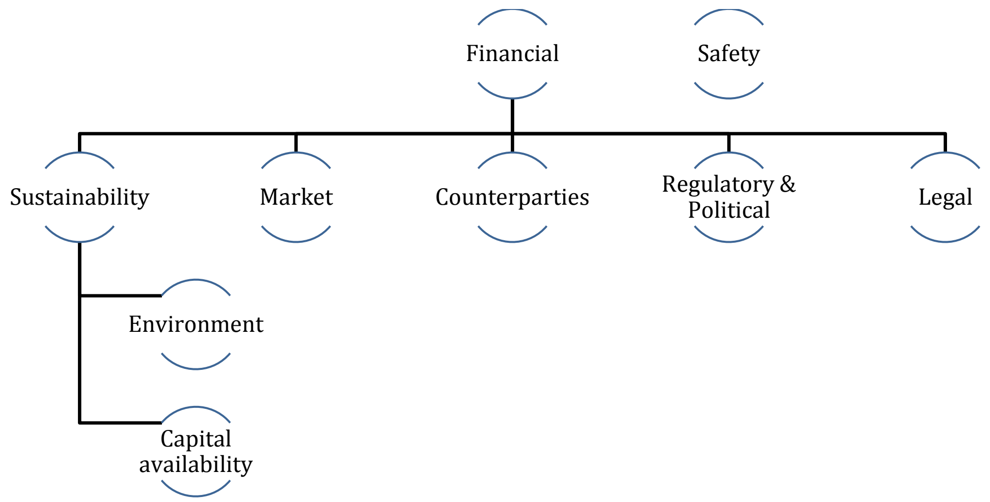

Figure 4.3 Hierarchy of risk (FCORP), developed from internal risk policy document (2009)

FCORP kept *safety risk* as a separate and non-financial risk category. *Safety risk* was a top level of risk. It was not converted into a financial value, instead discussed in parallel to financial consequences of risk (FCORP).

The process of mapping different risk types was also possible in GRS. This showed a mapping of all risks to a financial outcome. Safety risk was converted to a financial presentation through an amended set of HSE guidelines (figure 4.4).

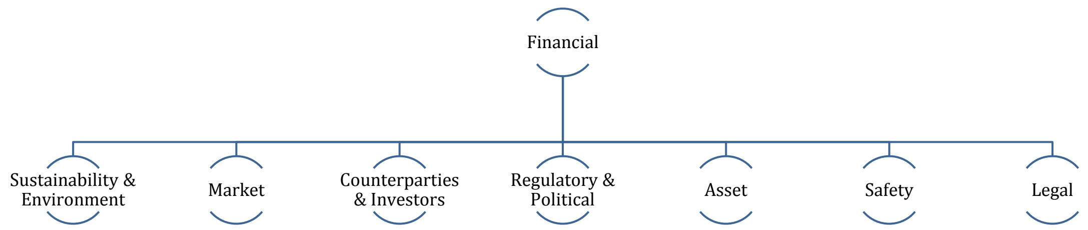

Figure 4.4 GRS Hierarchy of Risk, developed from internal risk management document (2010)

In GRS *capital adequacy* was seen in counterparties and investors[19]. GRS shows a single unit of risk valuation as currency. In GRS, the conversion mechanism from safety to financial used the HSE guidelines (figure 4.5).

	Non-Financial Human Costs (rounded)	Financial Costs (rounded)	Total Costs (rounded)
Workplace fatal accidents	1,084,000	187,000	1,271,000
Reportable injuries	11,500	-700	10,800
Minor injuries	30	20	50
Ill health	8,700	-600	8,100

Figure 4.5 HSE (2011) Average Unit Costs for Injuries[20]

This use of HSE guidelines informed the valuation of health and safety impacts:

> *"we use the HSE across the different market units, that provide us with a nominal value of injury and death. We don't use these figures precisely, in fact we use them as the lower limit of valuation and then use some level of morality to the exact valuation of how much an injured employee is really worth"* (Risk Manager, GRS).

[19] Representation of risk types as a hierarchy is an original presentation appearing through the thematic analysis. On presentation back to GRS, this has been adopted within the Risk Management Process to ensure an organizational understanding of risk types.
[20] Costs to individuals per case, average unit cost for 2010/2011 (£ in 2010 prices)

This quote demonstrated that health and safety impacts were converted to a financial valuation. However, the imprecision and moral issues of this process were significant, and only used as a guide rather than a definitive valuation.

In both cases it appeared that a mix of risk types were employed. Descriptions of risk were either: '*Impact of…'* or *'Impact from…'*. Financial measures of risk were a consistent unit of analysis, although the process was not documented by the firms. Financial risk was a description as "*impact of*…". This is important because the extant literature is not precise in differentiating between the two categories, and yet the implications on the interpretation of the risk description were later shown to be formative on treatment selection (section 6.5).

Within the internal communication there was an expectation to derive the risk information from operational and strategic targets and measures. This was an implicit discussion of risk. This was less positive in articulation, and highlighted threats not fully managed.

The hierarchy of risk, shown in figure 4.3 and 4.4, demonstrated in detail the risk arising from individual processes and how this contributed to the overall risk categorisation in the organization. Although generally consistent between cases, a difference in the perspective and valuation of safety risk emerged. This multi-tiered approach was not expressly outlined, but inherent in manager's articulation, reporting and risk meetings.

4.2.4 Risk Governance (RG1): Risk Policy and Standards

Reference to risk management standards (e.g. COSO ERM) was not always explicit, but there was an underlying influence in both cases. FCORP with national ties and listing on the national stock exchange meant a mandatory adherence to COSO. This was a process of audit and compliance, demonstrating a correct application of the standard. In FCORP it permeated into the culture of the corporate managers, and the articulation of what risk meant at firm-level:

> *"We are COSO compliant, and proud of this as [an] achievement, it is now part of the way we do things around here…"* (Risk Manager, FCORP).

FCORP had a complete but imperfect adaption of an ERM standard in their application of COSO. FCORP demonstrated an understanding of how a risk culture driven by COSO adoption existed within the firm, but that this had potential limitations and misrepresentations.

> *"the old halo effect of working in a plant, systematically permeates all corners of the organization, that risks of any type need to be mitigated – it just doesn't translate well across the business units. Holding a handrail in a power plant has real and material consequences if you don't, walking up a flight of stairs with a cup of coffee in an office isn't comparable. This total risk aversion influences the way you make business decisions… the organization draws to a halt and no one will ever make a decision on experience"* (FCORP, Head of Risk).

This statement was a reflection on the required risk culture in the asset BU versus the service BU, and that with a lack of understanding to the purpose of the approach to risk could permeate into the wider business decisions (i.e. investment) and create an unwanted and *risk adverse* culture (cf. Wiseman & Gomez-Meija, 1998).

In communication of risk the corporate function's discussion of failure was nearly non-existent, unless it was to provide a comparative example or signify market disturbance. For example:

> *"Post-Fukishima, we are required not only to explain the mitigation of a threat, but in detail the requirement is to show that threats do not exist"* [Translated] (FCORP, Communications Policy).

Under COSO the description of risk was developed to consider *velocity* and *proximity* (COSO, 2004). This was seen in the risk management policies in FCORP, but not in GRS.

FCORP recognised the *"difficult to quantify"* or non-financial types of risk and stated a desire to develop this through greater awareness and recognition of non-financial risk types. They felt this this must be *"led from the top"* and reflected in their strategic conversations of risk/risk management.

In GRS the valuation of risk was deliberately simplistic: *impact by probability*. In GRS there was an understanding that they were practicing Enterprise Risk Management (ERM), but no standard specifically (i.e. COSO). There was no national requirement to conform[21]. ERM was being used by GRS to denote a framework; in reality this framework was ISO31000, as evidenced by the alignment of terminology and the risk management process. What ERM meant to GRS was a holistic and integrated appreciation of risks that flowed from bottom to top of the organization that created a standard set of terminology between different market units and functions. This was later found to not be the case:

> *"We call it assessment, they call it analysis, I suppose that is the difference between an engineer and someone who actually talks to customers"* (SHE Manager, GRS).

Both cases indicated a requirement to show efforts had been made in the systematic identification and scanning of the environment, seeking potential threats, even where there was difference in policy the aim was the same. In GRS there was a limited recognition of non-financial measures of risk, but unlike FCORP had not identified this as an area for development of the risk management process.

What GRS and FCORP consistently demonstrated was the desire to demonstrate stability in the energy sector. GRS had an incomplete and partial adoption of an ERM approach. This was because a number of components of ERM were not implemented (e.g. an integrated cycle of control).

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[21] *GRS had recently withdrawn from the Dow Jones due to the onerous reporting requirements of the Sarbanes Oxley Act, and had replaced the gap in risk management reporting with "an ERM process", which was loosely based on ISO31000.*

There was consistency in senior managers' desire to understand their competitor's risk appetite, then to use their ability to take more risks in the market, which without experience would be significant:

> *"We need to leverage our experience and operate in markets that are hazardous to competitors, because they don't understand it as we do. That way we open opportunity for bigger returns and better investment."* (Chief Risk Officer, FCORP).

This was a desire to increase strategic risk taking and business risk, as discussed by Nocco and Stultz (2006), who state that the purpose of companies is to take strategic and business risk.

4.2.5 Risk Governance (RG2): Risk Roles

A Chief Risk Officer (CRO) was appointed within the corporate function, and at market unit management team in GRS. The BU Chief Finance Officers had responsibility for the risk management process. In GRS, the Chief Finance Officer (CFO) was also the CRO at corporate level (this is a dual role).

In FCORP the appointment of a CRO occurred at all three levels: corporate function, market unit and BU. Further a *Head of Credit Risk*, spanning all business units was appointed and worked in Energy Trading. The CFOs had responsibility for the risk management process, and the CRO reported into the CFO.

In both cases, the board responsibility for risk management was with the CFO. This structure was repeated throughout the organization structure until it met the operational functions of the BU. In both cases the CRO and the administration team managing the risk process were separate from each other. A risk manager (not CRO) ran the administrative function of risk. The Board level reporting line of the CRO and association to CFO role was a clear reflection of the financial influence and importance of the risk management process.

Discussions were observed as to the definition of a "*risk professional*"? Although the structures put risk managers in finance departments only one was a qualified accountant; although they felt they should be. None of the risk managers interviewed had any formal risk management qualifications. They were individuals who had experience across multiple functions within the organization, and demonstrated some quantitative analysis skills. The approach of defining *risk managers* was a theoretical desire to read into the subject of risk management, but like many people interviewed found the subject to be: too theoretically focused, around specific valuations or tool usage, or with a focus on the different sub-classifications of risk sources. To great frustration they felt insulted by the need for subject authors to outline the requirement to have meetings and conversations on collecting risks from across their organization:

> *"you wouldn't explicitly tell a business analyst to talk to people, so why the need to tell a risk manager?"* (FCORP, Risk Manager).

They felt that risk management as a discipline was dominated by risk categorization and risk description. Because of this lack of original insight, many were developing or innovating new ways of expressing and articulating risks in their business. However comparing FCORP and GRS, these innovations were largely consistent, giving no unique position to either (e.g. GRS had mapped out a time line of each different risk, with a nominal value attached to expected, realised and desired risk position, whilst FCORP had done the same activity but with a table of desired position and current appraisal of risk taking).

4.2.6 Risk Governance (RG3): Risk Reporting

GRS market units provided risk reports to the corporate centre on a quarterly cycle. There was no feedback loop from these reports into the market unit or BUs. This was poorly reflected on by operational and risk managers in the market units:

> *"We do this [providing risk reports] only as a matter of being a good corporate citizen…"* (FD UK, GRS).

At a firm-level the unidirectional flow of information and the lack of understanding as to how the data they were providing, meant that there was scepticism and concern as to how information was being used. GRS had a particularly strong criticism of this corporate requirement:

> *"I'm very careful what I put in these reports, it is so easy to take the headline numbers, and the limited explanation I am able to put into these reports and get the meaning totally wrong. This isn't helped by the translation [from English] it is subjected to" (*Risk Manager, GRS).

The market unit management team did not understand the purpose of these reports other than providing some limited narrative for the annual reports. This was also an issue in FCORP with limited feedback from corporate centre. It had been recently changed, with some positive perceptions of integration of different functions.

FCORP's UK market unit had adopted a consistent format across their business units to present information. This comprised a couple of pages of narrative called *"the risk story"*. Reflecting *risk proximity* seen in COSO (2004), the risk matrices were broken into imminent, medium and long term threats. Each risk matrix provided in common format: impact and probability values. Because it was a summary report of the risks, the market unit had already *"vetted"* the risks presented to corporate centre. This limited risks to high/medium classifications. To show that the Market Unit was handling risks, the second column had a description of control measures applied. This used a red/amber/green status (*iconic* information, Edworthy & Adams, 1996), to signify relative success of the control. This *iconic* information was attention directing and a subjective influence the Market Unit could apply to the report. Included in the report was a narration of risk velocity (COSO format), between current and previous reports. This allowed them to reflect change in risk over the month. FCORP showed that adoption of the COSO standard had a material influence on reporting standards and perceptions of risks in the organization, towards understanding the speed of risks being faced by the organization.

FCORP had recently (2010) implemented a *feedback-loop* from the aggregated corporate reports back into the market-units. The effect of this was not yet known, but had increased the perceived value of reporting. The feedback comprised an aggregated risk position, across all market units.

However the feedback report offered little operational value as it was 8-10 weeks out of date on return to the market units, so many of the critical risks had materially changed. Figure 4.6 shows the risk reporting evidenced in the firm-level analysis, highlighting the flow and properties of the process.

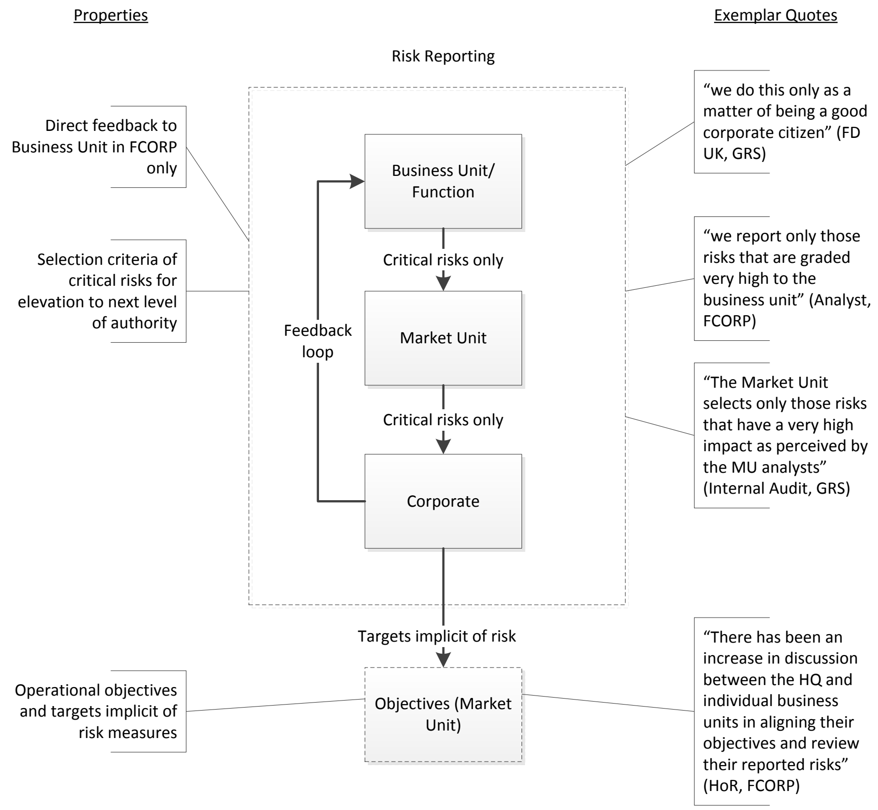

Figure 4.6 Risk Reporting

The risk reporting happened in parallel to the performance management of risk at the firm-level, the two processes were intrinsic. The flow of strategy into the risk communication is presented in figure 4.7.

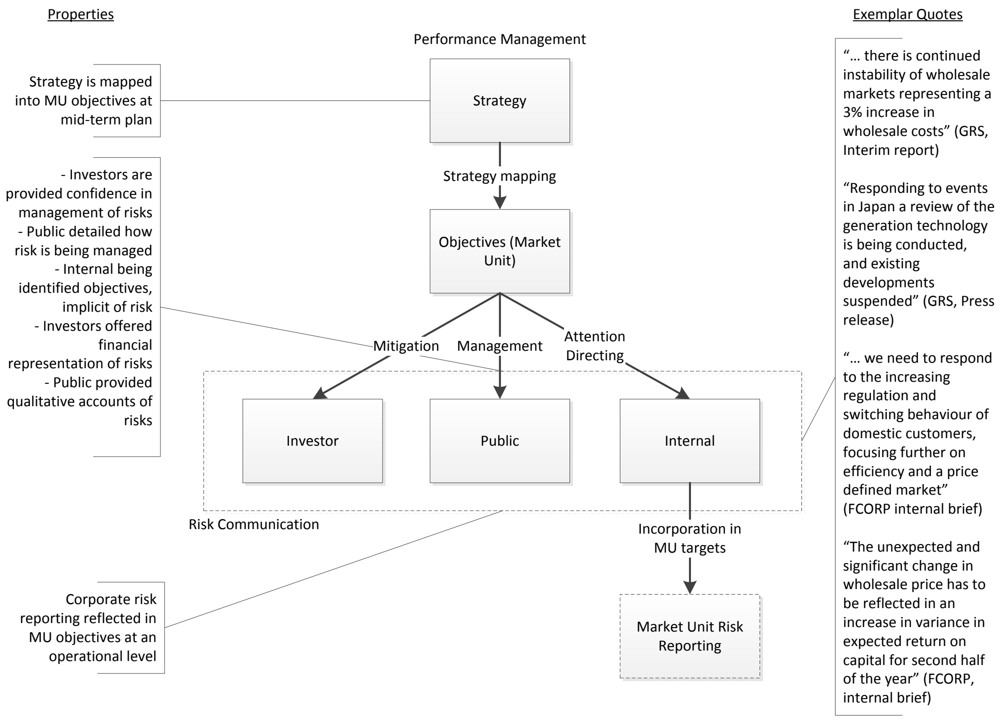

Figure 4.7 Performance Management of Risk

Figure 4.8 draws together the communication and reporting seen in G1-G3 and RT1- RT3 (figures 4.6 and 4.7). In the lines of communication (e.g. investor) the role and the structure of communications is described.

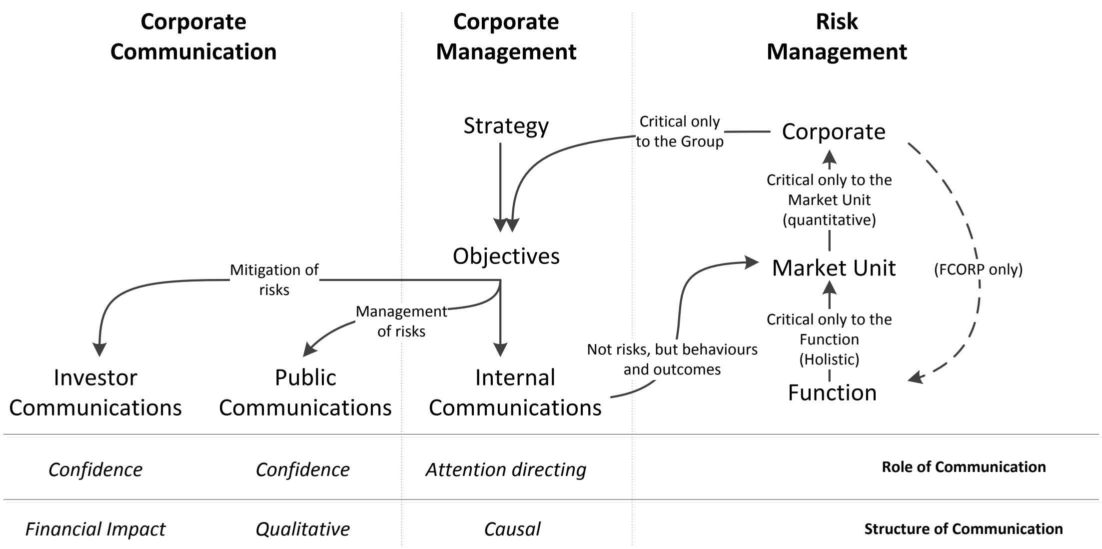

Figure 4.8 Firm-Level: Risk Management and Communication

Figure 4.8 identifies three different influences at firm-level: corporate communication, corporate management and risk management. Corporate communication was an outward facing process, used in developing confidence in risk management. The internal communications, which were attention directing, appeared as part of the central governance function, with cascade of strategy into objectives which were subsequently communicated, it was a top-down flow of information. The risk management process was largely an upward flow of information, filtering at each layer of organizational structure (FCORP showing recent evolution of this process to provide feedback loops). The interface between risk management and corporate management were not well defined, with limited feedback from the risk management process into the corporate objectives[22].

4.2.7 Risk Strategy (RS1): Mapping of risk in strategy

Risk strategy can be understood as statements of *risk appetite* (Hopkin, 2012) and statements of priority, tackling threats in the critical path of the firm (cf. Hopkin, 2012). They are closely related concepts in literature. However in the research, there was limited evidence of both aspects, these are covered in turn.

Risk appetite: Risk appetite was a term used by managers, but with no reference point in meetings or reports, the term did not have any consistency in use. This was consistent with the findings in Beasley et al. (2010) that *risk appetite* is poorly stated in the context of organizational objectives.

Priority and objectives: There was evidence of belief-based statements being used to infer a company objective. But these were difficult to relate back to specific organizational missions. These were implicitly setting rules for risk management, for example: *"we do not hurt people"* (GRS, mission statement[23]).

GRS did demonstrate through its reports, discussions and meetings an order of risk priority: safety was top priority, followed by environmental risks and all other risks were considered in a financial sense and prioritised on value.

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[22] *This description has great parity to the case of Bank of Tokyo-Mitsubishi in Kaplan and Norton (2006), showing strategy cascades down and the risk process is aggregating bottom up.*
[23] *Every site had this statement written on all points of exit and entry into the buildings.*

GRS were critical of current process and stated they wished to develop *"rigour and professionalism in risk management, seen in financial institutions"* (GRS, FD UK). This was a destination statement of what they wished risk management structures to look like.

Priority of different risk types was difficult to identify in FCORP. It was felt that safety risk was the top priority (but not explicitly stated). There was no other inferable order of risk priority.

FCORP had limited desire for risk management to become a separate consideration or process, instead FCORP felt that the organization should be more aware of risk management as an integrated requirement in standard management activities.

The role of performance reports from market units in both cases, were seen and reflected on as immature by senior members of the organization. The risk management systems were operational in design and demonstrated limited strategic benefit. The vision of the firm did seem to steer the organization through great disturbance in the sector, but this did not specify any risk management behaviours[24].

4.7.8 Risk Strategy (RS2): Decision-Making

The corporate functions demonstrated an expectation of subordinate functions' (Market and BU) decision-making. In GRS the corporate risk functions were clear to express that for the big capital investments or the high impact risks, a structured and detailed risk management process had been performed. Further the expectation was for the BU to present their decision-making when challenged, for example:

> *"If the Business Units have gone through a systematic, justified and detailed risk assessment, they should also be able to demonstrate this when challenged. This should not be a retrofitted process, and if we believe that is the case we will become more challenging in our oversight of their function. All potential avenues*

[24] The study did not observe the process in creating company objectives. It is seen that statements of high level risks is the result of a bottom up process, the strategy mapping exercise was a top down process. The two are not necessarily consistent with one another.

should have been explored, and although they [BUs] have different operational demands, their decisions must be reconciled to the corporate vision" (Corporate Risk Manager, GRS)

In FCORP the centralised governance of risk was not as explicit, but it did have a consistent focus on the expectations of rationality in decision, for example:

"Clearly we don't have the same level of understanding to the problems and threats as the Business Units, this is their domain. They are able to synthesise this tension between making operational decisions and the need for reflecting the company's strategy, they don't always align. They do this by exploring the different options available to them, and arriving with the best recommendation. Clearly we subtly influence them through the blunt levers we have in the centre" (CRO, FCORP)

In FCORP, there was the suggestion of using levers to weight their decisions in managing risk. For both firms this demonstrated an expectation of reasoned decision-making, which further inferred that optimal solutions could be found. This positioned the corporate centre functions as quality control of the BU's decision process, whilst recognising that some influence could be exerted on the process.

These eight themes (table 4.3) reflected on the structures, roles and standards exhibited at firm-level. The differences were limited, and the active risk management processes seemed inseparable from one another. The implication of these findings and justification for the next level of analysis is presented in the next section.

4.3 Firm-Level Discussion

There was similarity of accounts between FCORP and GRS; this arose from the similar operating environment and shared markets. The commonality between cases included: risk process, types of risk (articulated and communicated), ERM adoption, approach to mapping risks to strategy and the expectation of subordinate reasoned decision-making. There was awareness of multiple sources of risk, evidence of holistic risk management (Leibenberg & Hoyt, 2003). Risk categories were understood in a similar manner: safety, legal, political and environmental. Risk communication had internal targets and external targets (public and investors). The two external audiences had different language and focus in their communication. This was recognition of multiple stakeholders taking differing value from the relationship. This conformed to stakeholder contribution and requirements described by Neely and Adams (2002).

Risk Categories

There was an undocumented order and relationship of risks. In both cases, financial expression of risk was a top tier risk type. Sub-categories of risks had association to the descriptions used in external communication. Both cases had conversion mechanisms between lower level risk types and financial categories of risk. FCORP differed by keeping *safety risk* as an independent category, not converted into a financial value.

Risk Management Types

Both cases demonstrated characteristics outlined by Mikes' *ERM ideal types* (2009). However, Mikes presents the typology as a singular and static characteristic. It was observed that there was a difference between a current status, and intent to develop. This spanned more than one ERM ideal type. FCORP exhibited *"A Holistic Risk Management Ideal"* (2009:26), evidenced by reflection of non-quantifiable risks (e.g. safety), and strategic conversation developed within senior management. However FCORP articulated a desire to move toward a *Risk-based performance measurement ideal*, where there was increasing embedding and integration of risk management, reflective of stakeholder demands.

GRS exhibited a "*Holistic Risk Management"* approach; but with desire to become increasingly risk quantified. This inferred a move toward *"Risk Silo Management"* (Mikes, 2009:23). In GRS this ability to quantify and understand loss distributions was reflective of a financial company. Interviews evidenced desire to become and *"catch up"* with the financial institutions in management of risk. GRS showed less attention at firm-level to use and develop non-quantifiable measures and articulation of risk. This was under some classifications, a move away from ERM practices (cf. Beasley et al., 2006). Table 4.5 summarises the current risk management type and the desired risk management type, using Mikes' (2009) risk management ideal types:

Table 4.5 Firm Level Risk Management Ideals

	FCORP	**GRS**
Current Type (ERM)	Clearly Holistic. Non-quantifiable recognised and promoted, strategic conversations developed.	Majority Holistic. Non-quantifiable recognised but not promoted as a good approach. Limited strategic conversations developed.
Desired Type (ERM)	Risk-based performance measurement. Encouraging the organization to become risk responsive.	Risk Silo management. Held in high esteem the ability to control and quantify all risks regardless of source.

Risk Standards

Corporate oversight in both cases was quantitatively driven; it was characteristic of measurement activities. There was limited access to risk information/metrics flowing back to business units, and lack of dissemination of analysis. This needed to be explored further at function-level analysis. There was no articulation of firm-level *risk appetite*. Defining *a risk appetite* was a requirement defined in COSO (2004), and more generally as an ERM principle (Beasley et al., 2010). Risk appetite is known to be at the heart of the risk management process, as it defines the risk taking in the organization (Power, 2009).

Risk Roles

There was no documented evidence of corporate functions recognising the role individuals or senior managers had in managing and moulding the risk management process. Although during meetings it appeared as a subjectively driven process, influenced by the characters of senior employees. This was reflective of Gan et al. (2004) who indicated risk propensity is subject to the organization's managers.

Operational Risk

It appeared that *Operational risk* is not specifically reported, other than as a term in GRS equivalent to safety risk. The terms of *market* and *credit* risk were used in retail and trading functions, it did not reflect into generation or distribution functions. The terms *credit* and *market* risk had a similar interpretation as in the Basel Accord, but not used to calculate VaR and capital adequacy. This was reflective of the performance system being used as a measurement tool and not a management tool in the relationships with BUs.

Supply Chain Risks

The cases were operating an energy supply chain within the firm (i.e. vertically integrated). This direct link between functions had been eroded with the de-regulation of the market, and the increased dominance of trading. There was no evidence of managing supply chain risks at a firm-level; instead this was an operational decision being made by the individual BUs.

Use of the Performance System

The corporate functions used performance systems, typical of MCS (Anthony, 1965) to assess the individual business/market unit's performance. This was completed as a financial measurement, with very little qualitative appraisal. There was indication that business units used a multitude of (inconsistent) performance management structures and presentations. This indicated that an adherence to a specific risk management standard did not inform the use of a specific performance system (e.g. BSC). Risk management standards were meant to define structure, definitions and process of risk management. However, there were two different standards being used, but similar processes and structures. There were only limited differences in the terminology being applied. Table 4.6 summarises the finding between FCORP and GRS.

Table 4.6 Summary of Firm Level Analysis

Category	Sub-category	FCORP	GRS	Comments/ Literature
Risk Types: Public Communication	Risk Types	Safety, Sustainability, Legal and Political	Operational, Environment, Regulation, Political	Top four risk classifications map between cases. Positive communication used to develop confidence
Risk Types: Investor Communication	Risk Types	Financially orientated (same language as public communication)	Financially orientated (same language as public communication)	Credit and market risk definitions seen in Basel Accord used for investor communications, Operational Risk does not appear and not developed for capital adequacy
Risk Types: Internal Communication	Performance Management	Measurement only	Measurement only, links on how delivery of objectives mitigate risks	
	Performance Measures	Implicit risk measures in operational targets. Reputation risk not used at corporate level.	Implicit risk measures in operational targets.	
	Performance System	Accounting based (MCS)	Accounting based (MCS)	Anthony's Management Control Systems (1965)
	Feedback loops	Feedback loop developed from corporate function	No feedback loop, managerial criticism for lack of engagement	
	Risk Types	Financial and Safety as tier 1 risks. All other risks map to financial risk through conversion	Financial risk as tier 1 risk. All risks map to financial risk through conversion. HSE guidance for mapping safety and financial risk	Hierarchy of risk explains the relationship between risk classifications. Risk communication to employees as attention directing
	Orientation	Qualitative and Quantitative	Quantitative only	

Category	Sub-category	FCORP	GRS	Comments/ Literature
Risk Policy	Risk Standards	COSO ERM	ERM understanding, but does not adopt any named standard. Exhibits language of ISO31000	COSO (2004), British Standard ISO31000
	ERM implementation	Full	Incomplete	Beasley et al. (2010)
	Risk Identity	Influenced by national context: COSO	International, with some national protection mechanisms for employees	
Risk Roles	Role type	Roles based in finance, risk professionals (managers) based in financial functions no specific technical qualification	Roles based in finance, risk professionals (managers) based in financial functions no specific technical qualification	
	CRO appointment	Appointed at Corporate and MU	Appointed at Corporate, MU and BU	Liebenberg & Hoyt, 2003
Risk Reporting	Measurement	Financial Calculative idealism	Financial Calculative idealism	Power (2005)
	Valuation	No specific technique, but includes proximity and velocity of risk	No specific technique	
Risk Strategy	Risk Management Ideal Current	Holistic	Holistic	Mikes (2009)
	Risk Management Ideal Desired	Risk-based	Risk-silo	
	Links to objectives	Public orientated	Investor orientated	Power (2009)

The next level of analysis moves from firm to function, because preparatory discussions identified potential differences between functions based on different motivations and expectations. BUs were self-contained operating units. This bypassed the organizational reporting structure of Market Units. Market Units were holding functions in the organization's structure, differentiating the geographic responsibilities. The composition of Market Unit management teams was as a collection of BU heads; therefore the function-level analysis represented the BU structure of the organization.

Chapter 5

5. Function-Level Analysis: asset and service

Chapter Five builds on the firm-level analysis. It expands to the function-level of analysis using the case study method. There are four business units analysed in chapter five, these are sub-units of the two firm-level cases.

5.1 Introduction to Function-Level Analysis

The research has showed a number of features of the risk management processes. At firm-level there appeared a consistency between organizations. However there was evidence of different influences from subordinate Business Units (BU) that were not consistent within the firm. This indicated that the generation BU and the retail BU maintained different inputs into the risk management process, for example differences in risk reporting submissions. The function-level analysis sought explanation to these gaps in understanding:

- Risk Management Standards were being applied at the firm-level; however there was a difference between the adoption of a formal COSO ERM standard in FCORP and the generic adoption of ERM in GRS. There did not appear to be a material impact from this difference in adoption at firm-level. It was not understood how the adoption of a risk management standard permeated into the practices of the Business Units.
- There appeared to be different perspectives in risk submissions to risk oversight groups within each firm. The generation and retail businesses seemed to have the greatest contrast in their submissions and process of managing risk[25].
- The framework of *ERM ideal types* (Mikes, 2009) differentiated the desires of the organizations and their ambitions for future risk management, and it showed both a

[25] *There is opportunity to provide a contrast in analysis between Generation and Retail business units within each case organization. This provides a polar comparison as suggested by Eisenhardt and Graebner, 2007.*

current risk management type and a future aim of the firm. This conceptual underpinning helped explain a number of firm-level features, for example the approach to valuation of risks.

- There were consistent descriptions of risk between firms. These were well articulated and understood by central managers. Therefore did this categorisation and description of risk permeate into the different functions within the firm?

The sample in the function-level analysis reflects Eisenhardt and Graebner's (2007) view that samples for case study can be selected where there is the opportunity for unusual research access. This selection of service and asset BU allowed for polar types to be examined so that contrasting patterns in the data may be observed. Asset functions were concerned with the management and protection of tangible assets and operated in a physically hazardous environment, whereas service functions operated information and customer processing operations, where risks predominantly affect reputation.

The remainder of this section is structured as: a summary of cases, development of inductively developed thematic categories, and a function-level discussion, followed by an integrative discussion referring back to the firm-level.

5.2 Method: Case Study

The function-level analysis used the case study approach as described in chapter four (section 4.1.1). It extended the analysis from the two case organisations, splitting each into their separate asset and service functions, which had different foci and influences on their risk management processes.

Defining asset and service

The energy industry, and its supply chain, exhibits characteristics of production, manufacture and service. Reflecting potential differences in organizational output, the functional classification used defined a case as either:

- **Asset**;
- **Service.**

An asset function has a number of fixed assets that provide the ability to undertake the transformation process, of raw materials into energy (electricity). The ratio of tangible to intangible assets may be greater than one, therefore the majority value is held in physical assets. Production operations have processes where production precedes consumption and separate from the consumption by the customer (i.e. electricity). Measurement of quality is objective (i.e. voltage can be measured) and is invisible to the consumer (Slack et al., 2010). The alternate classification is a service function.

A service function has few tangible assets. Transforming resources are typically staff (semi-skilled staff and professionals). Production and consumption are simultaneous, meeting the characteristics of a service process (Slack et al., 2010). In the case of service operations descriptions of quality are often subjective and difficult to measure. In the energy sector there was a mix of financial, reputation and legal influences.

In the energy sector there was a difference between the engineering discipline and the service discipline. The asset businesses had a high proportion of engineers whilst in the retail functions transforming resources were a mix of professional and semi-skilled, many of which had mobility between sectors and industries (e.g. staff from insurance, banking and telecoms). This mix of skill and the difference in staff constitution between functions meant there were many influences on the character of the staff and their risk perceptions.

Both cases (i.e. FCORP & GRS) had BUs displaying characteristics of both asset or service[26]. By selecting two polar examples: 1) a generation BU (asset), and 2) a retail BU (service), there were limited contentions in the classification. The split of asset or service was therefore used as a frame of analysis.

[26] *There are also business units and functions that are difficult to classify using this dichotomy, these tend to be engineering and consulting practices and start-up activities attached to the firm. These are avoided during the selection of cases, so as to ensure polar examples are used in a cross case analysis.*

5.2.1 Sample Frame

Taking the same firms (GRS & FCORP), two business units from each were selected to represent a) An asset function b) A service function. Selection of these cases control for national influence and were all based in the UK. Table 5.1 summarises the nature of the different function-level cases analysed.

Table 5.1 Summary of Case Organizations (Business Units)

	ERS	EGEN	FRET	EAM
Firm	GRS	GRS	FCORP	FCORP
Nature of business	Retail and Services	Generation	Retail	Generation and Asset Management
Location	UK	UK	UK	UK

The UK power and gas market was deregulated in 1998; it was highly competitive in pricing. Both products were homogenous, difficult to differentiate between suppliers and highly politicised. Margins in the market were limited, as a partial response to both issues of differentiation and low margin; competitors in the market had developed supplemental services. These supplemental services differed between market segments. In the domestic market, boiler service and repair was a common supplemental service.

5.2.2 Case Organization: ERS (GRS)

At the time of the research, Energy Retail and services (ERS) was a major subsidiary of GRS within the UK. ERS retailed power (electricity) and Gas to all segments of the market. It serviced over four million power customers and three million gas customers (2010). The sales segments included strategic accounts (e.g. Wembley Stadium) through to corporate, SME and domestic customers. Customers could purchase power and gas independently or through dual-fuel contracts.

Structurally ERS had a board of directors, independent accounts and strategy department. It was managed by GRS on a ROCE (Return on Capital Employed) measure, reviewed annually.

There was no symbiotic relationship with other parts of GRS, so the relationship with the Group was limited. There was a single shared service facilities management for building contracts and payroll functions. ERS had approximately 15,000 staff, and 1,500 contractors (2010).

5.2.3 Case Organization: EGEN (GRS)

At the time of the research, EGEN was GRS's UK generation BU. EGEN had a varied portfolio of assets, with total production over 10,000 MW, this included coal, gas, combined heat and power, biomass and wind[27]. Further EGEN managed two distinct wholesale gas transportation lines. EGEN, similar to ERS, was autonomous in operating activities.

The standard activities of EGEN's operation were split into two distinct categories: production and maintenance. Production phases had the objective of maximum utilisation of assets, focused on minimal outage or downtime. In the maintenance phase, priority was for quality of maintenance and minimising extension of planned outages.

Different assets were used in different phases and demand-times in supplying *The Pool*. The interface to *The Pool* was called Local Dispatch, owned by Group Trading. Local Dispatch was used to call on and off supply from different assets in the EGEN portfolio, in response to the long-term supply contracts, and the more profitable *spot* market. Typically, assets that were more expensive to run were used in supplying the *spot*, where higher premiums were commanded; the cheaper (by unit) generation capacity was used to contribute to base load. Usage of assets considered the ability and speed of technology to be *two-phased* (being brought on and off the network on demand). Those that were faster to bring to production provided agility supplying the market demands. *Two-phasing* a plant incurred increased wear on the plant and often increased the chance of failure of the asset; therefore it was avoided where possible.

[27] *Although GRS had a nuclear interest (development and partnership operation), this was contained in a separate business unit with no operational relationship.*

EGEN had a high percentage of chartered engineers working for it, in total EGEN had 4,500 permanent staff and 1,000 contractors. In the maintenance phase additional contractors were brought onto the plant, *"flooding the site"*, and contractor population increased by 300+ contractors over a four-month maintenance phase.

5.2.4 Case Organization: FRET (FCORP)

At the time of the research, FRET (FCORP Retail) was FCORP's sole retail presence within the UK market. It offered power and gas products to all segments within the market. It had the biggest (by customer number) supply to non-domestic segments of all retailers in the UK. Power and gas were bought separately and on dual-fuel contracts. It had over 5 million customers. It had 8,500 permanent employees (many of which were working on flexible or part time contracts). FRET's segmentation of its customer portfolio was simplistic: domestic, business and large business. Differentiation between business accounts was done on volume or complexity of metering.

FCORP was in direct competition to GRS in the retail market. FRET entered the UK market at deregulation in 1998, and quickly acquired a sizable portfolio of customers. FRET's response to the increasingly price competitive market, and increased mobility of customers, driven by price comparison and switching services, had meant that brand development has been increasingly important. FRET had a strong and recognisable brand within the UK; it had a strategy of sponsoring major events, competitions and celebrities.

5.2.5 Case Organization: EAM (FCORP)

At the time of the research, Energy asset Management (EAM) was a wholly owned subsidiary of FCORP. EAM produced 1,300 MW by gas plant (combined cycle) and 4,000 MW by conventional coal plant. This portfolio included growing renewable energy sources; it had 70MW, but had over 500 MW in the building phase (2010)[28].

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[28] *The significant nuclear production operations were held in a separate business unit within the UK market unit.*

Subject to the same objectives as EGEN, the plants operated in two distinct phases, production and maintenance. Although this differentiation could be seen to change in renewable production facilities (wind), weather limitations could force a maintenance intervention to be taken out of schedule.

5.2.6 Function-Level Data Collection

The data for the case study at function-level, used multiple sources of data to triangulate information (cf. Jick, 1979). It represented subjective accounts of managers, risk meetings and reports in evidence. The data were gathered through:

- Analysis of risk registers and risk matrices;
- Semi-structured interviews with managers, that were operating the BU risk process or responsible for operational decisions in the BU (see Appendix B, function-level interview protocol);
- Observation of risk management groups and meetings (these had different titles, e.g. “performance review” or “risk review”, they were selected because they had the same responsibility of reporting, discussing and providing decisions on risks managed in the BU);
- Inspection of the risk management systems;
- Observation of delivery of risk reports to the managing board.

In total 17 interviews were conducted, six systems observed in operation, five meetings attended and six reports analysed. Table 5.2 summarises the different sources of data used in the function-level analysis:

Table 5.2 Function Level Data Collection:

	FCORP		GRS	
	FRET	**EAM**	**ERS**	**EGEN**
	Retail, Service	Generation, Asset	Retail, Service	Generation, Asset
	5 visits (Sept 2011-Oct 2011)	*4 visits (Sept 2011-Oct 2011)*	*4 visits (Aug 2011-Oct 2011)*	*2 visits (Sept 2011)*
Interviews	Risk Portfolio Manager[FN] Assurance Manager Analyst (Risk) [FN] Head of BCM (Business Continuity Management)	Head of Risk (Unit Risk Manager) Risk Analyst Performance Analyst Plant Manager Chief Engineer	Head of Portfolio Analysis, i/c Risk Management Risk Analyst Performance Manager Operations Manager (Billing) [FN]	Head of Asset Management Plant Manager Risk and Performance Manager Portfolio Analyst
Systems	Risk Register	Risk Register	Risk Log Near Misses Report	Asset and Risk Register
Meetings attended	Risk Review	Performance Review Asset Investment (Special Funds) allocation meeting	Risk Oversight Group, *both ERS and EGEN have their own separate reports and sessions in this meeting*	
Reports	Risk summary (to Market Unit) Risk Matrix (at Sept 2011)	Risk summary (to Market Unit)	Quarterly Risk Matrix (August 2011) Report to risk oversight group	Report to risk oversight group

The firm-level analysis suggested that standards did not define the risk management process, but influenced the language in the risk management process (e.g. proximity of risk, section 4.2.4). There were different degrees of ERM implementation, and there were different focuses on what ERM meant to each case. It was observed that the complex inter-relation of stakeholder groups was understood. There were different risk descriptions being used, but these largely converged on four points, which were: 1) operational safety, 2) environment, 3) regulation and 4) political. There was limited evidence of a feedback mechanism from top down. Risk management therefore fulfilled a reporting and measurement function. It was found that the firm-level relied on financial lag measures. The semi-structured interviews followed an interview protocol to reflect these different constructs and categories sought (see Appendix B).

The observations were conducted over three months (from August 2011 to October 2011)[29]. Notes were made of the observation, the flow of information through the system was drafted as field notes; *risk meetings* were attended in person and notes were made of the different comments. Recording of meetings was not permitted nor was the copying of meeting minutes/slides. Salient points from these meetings were documented as field notes.

Reports were viewed electronically, and on all occasions the report author was able to narrate the report in person. Copying reports was not permitted; field notes were used to record the specific points, and the terminology being used.

Interviews with staff were all conducted in person; this was completed at the site/office of the individual. Most of the interviews were recorded and then professionally transcribed[30]. Where recording was not permitted, field notes were taken and specific comments were recorded as close to actual language used.

5.3 Function-Level Results and Analysis

The data were collected, compiled across the different sources and thematically analysed. Thematic categories are summarised in table 5.3:

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[29] System observations were completed in person at the site of the company

[30] The professional transcription service would identify by timestamp any words or terms that were not understood. These were analysed and completed by myself, in all cases the terminology could be inserted.

Table 5.3 Inductively Developed Thematic Categories at Function Level

Category	Thematic Category	Key Terms	Characteristic Level 3 responses
Questions sought, see Appendix B: *How do you manage risk, what aids you in this process?* *What informs your decisions on selecting risk treatment?* *Observe a risk being recorded from notification through to report.* *Observe a discussion of a risk being prioritised in a meeting.* How risk is being managed			
M1	Risk Systems	Information System, Technology, Risk Register, Asset Register	*"We use an excel spread sheet to record the risk"* (Assurance Manager, FRET). The register is embedded in the asset register
M2	Risk Amnesties	Amnesty, Clean sheet, volume, identification	An amnesty was conducted to surface all risks.
M3	Risk Valuation	Financial, impact, analyst, identification	The financial impact is calculated. The analysts provide an objective view of the risks.
M4	Risk Treatments	Mitigation, decision, portfolio, investment	A portfolio of treatments are used. Selecting which approach to invest in .
M5	Risk Grading	Risk matrix, corporate level notification, boundary risk, RAG status	This is a relative activity. *"Positioning on the risk matrix gives you a relative perspective. We use a RAG status."* (Performance Manager, ERS)

Continued…

Category	Thematic Category	Key Terms	Characteristic Level 3 responses
How is management of risks steered in the organization? *How does the organization reflect on its ability to manage risk?* *Observe the review of risks and the risk management process and standards used.* *Review performance reports, organization and individual performance objectives.* Performance System influences			
P1	Learning in the system	Understanding wrong judgements, qualitative assessment	*"Wrong decisions only become bad ones when they are repeated. You need the qualitative assessment to understand the full detail."* (Plant Manager, EGEN)
P2	Performance systems in use	BSC, measures, reports, safety, objectives	*"Safety is the number one objective."* (Plant Manager, EAM) The communication is based on a number of reports, these are embedded in the personal objectives
What function controls the risk management process? *How is decision making in the risk management process overseen?* *Observe risk steering group and noted roles.* *Reviewed documentation on risk management process in the organization, and job descriptions available.* The Manager			
R1	Options and decisions	Proximity, hedging, treatment, prioritization	*"We prioritise the allocation of capital to those risks that present the most relevant risks"* (HoR, EAM)
R2	The risk manager's role	Oversight, administer, being objective, meetings	The risk manager provides an independent and objective review of the risks

The different thematic categories are analysed in turn.

5.3.1 Risk Systems (M1)

Time was spent in all four organizations (ERS, FRET, EAM & EGEN) exploring and documenting their use of systems that supported the risk management process. The service businesses (ERS and FRET) were recording risk through a register; they used nothing more developed than manually administered bespoke spread sheets. This had significant implications. Although advocating an iterative risk management cycle, learning from previous risks and their treatments, the system underpinning it was fundamentally linear in nature. This meant that learning embedded in the system was corrective and transactional. Much of this process was developed from project risk management processes (i.e. where there is a defined start and end to a project). Therefore as a risk was managed (either successfully or not), or the project reached the end of its impact potential, history and learning was lost as it was removed from the register. Figure 5.1 presents the interfaces observed into the risk register:

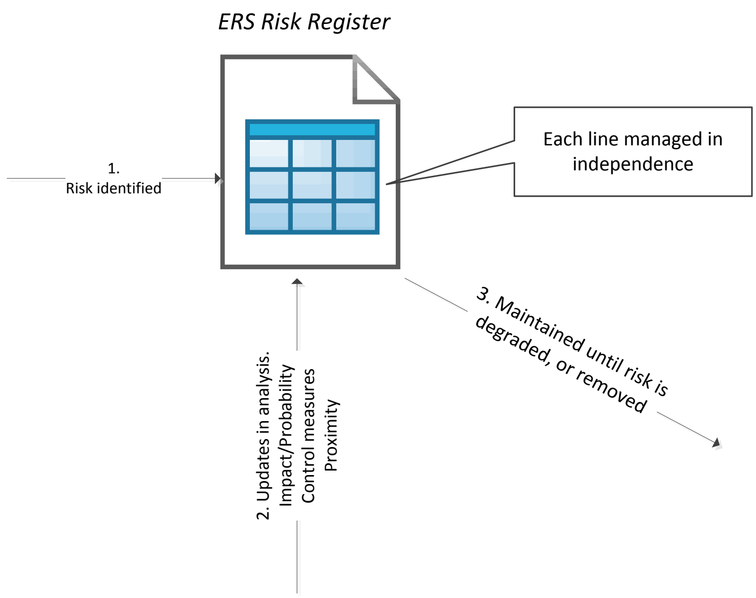

Figure 5.1 ERS Risk Register

Figure 5.1 shows that the register had a limited purpose and two incoming feeds. Risks were identified causing a new item to be recorded, and updates were recorded as changes or milestones were reached. There was no processing within the register.

In contrast the asset businesses had adopted asset management risk modules (an integrated register of risk management) into their systems. This developed from standard engineering practice as every asset presented potential failure options. As assets were standard across the estate, failure or the potential to extend the life of assets was shown, this understanding was embedded in future risk management decisions. The volume of information was so great that a structured system for recording risk was perceived as the only feasible approach. The operational managers and risk professionals developed the asset management systems. In FCORP the language of proximity and velocity did not appear on the risk register, this understanding was super-imposed on the reports generated by the asset register to comply with corporate reporting requirements. Figure 5.2 represents the risk register, embedded within the asset management system. There was continual check and balance of the register reflecting the asset list, and the asset list reflected understanding in the risk register. There was internal processing of risks, providing up to date assessment of impact and identifying potential interaction between assets.

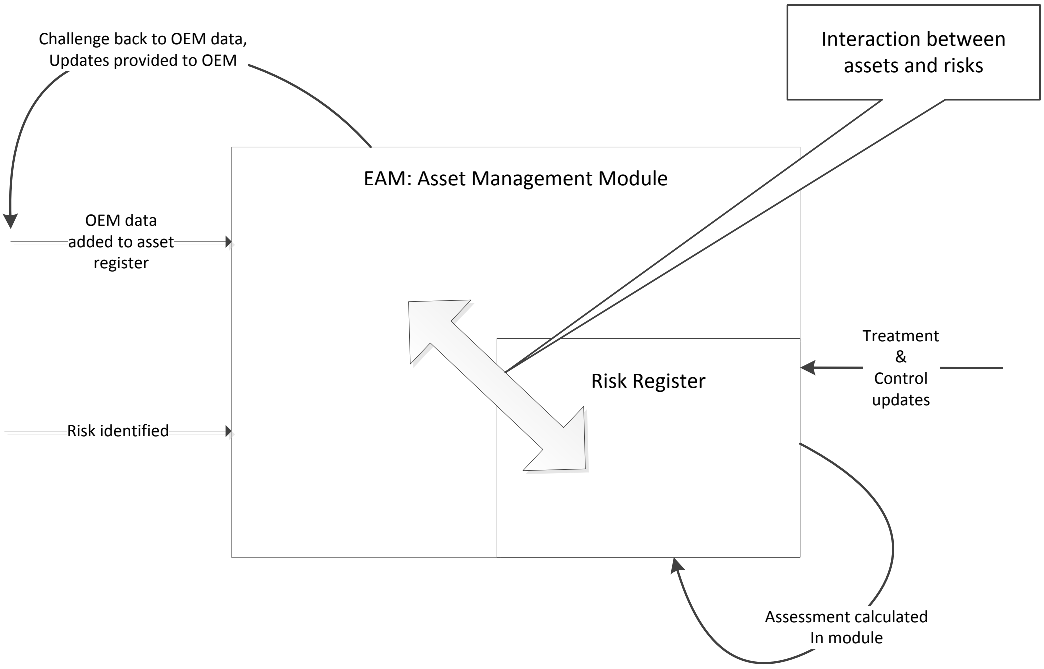

Figure 5.2 EAM Risk Register (embedded module)

Risk registers were embedded modules within the wider asset management systems, drawing together the detailed record of plant and asset design as well as history of failures and impacts experienced. This meant all failures were recorded for posterity, this was an iterative approach and indicated some generative learning characteristics.

5.3.2 Risk Amnesties (M2)

Risk amnesties were mentioned by both FRET and ERS (service functions). Both cases had in the previous two years run a risk amnesty, with the desire to gain better understanding of the risks inherent in their organisation. Both organizations strongly regretted this approach:

"The risk amnesty was in response to a feeling that issues were being hidden or not dealt with inside the organization… so an amnesty was run for identification of the issues so we could get a wider appreciation of the issues and scale of issues in existence. However on reflection this was a poor decision…" (Risk Portfolio Manager, ERS)

Risk amnesties they felt had two damaging outcomes:

a. Managers once reporting a risk had felt a cathartic response, no longer feeling they were responsible for managing the risk, having notified their superiors:
"Nobody took responsibility for risks they had recorded during the amnesty" (Risk Portfolio Manager, ERS)
b. So many risks were reported that it was difficult for the risk management process to distinguish the priorities, and ERS had experienced several high level failures because of this lack of sight and lack of ownership following the amnesty:
"It is good to know the risks out there, but more importantly know the important risks out there. We have been swamped by a volume of low-level risks where we can't distinguish what is important" (Head of BCM, FRET)

In the asset organizations, there had been no mention of amnesties, probably because risk identification was an inherent part of the operational process.

5.3.3 Risk Valuation (M3)

Financial valuation of risk was dominant in service functions. In FCORP, it was a *two-stream* valuation at the firm-level, where safety was recognised as an equal measure with a financial representation. In FRET the hazards were such that safety issues in the FRET were low grade, and instead were converted into lost time and capacity issues in the event of illness and sickness[31].

[31] This was even the case in the consideration of a pandemic flu outbreak, where the risk was considered in terms of percentage operability of the call centres and billing routines.

Financial valuation in energy did not use VaR[32] (i.e. they didn't estimate a risk value for unknown probabilities of risk). Instead the valuation was based on known risk and an estimated impact. The total value of was used for creating a relative list of importance. It was seen that the service functions looked favourably on the processes adopted by financial institutions as a better approach to risk valuation:

> *"we aren't there yet, but I would like to think in four to five years we might be as advanced in our understanding and representation of risk as say HSBC"* (ERS, Risk Manager).

This was a common sentiment repeated across both ERS and FRET. The valuation in the asset functions was not financially driven, but did have a financial component for *mitigation cost assessment* (the cost of the mitigation treatment). Risk categories used a predefined criterion for classification into red/amber/green risk types. It was not possible during the study to expose the different calculations being applied, but under a limited analysis there seemed to be little difference between EAM and EGEN[33] in this assignment.

Different risk types were classified by the asset management systems (EAM & EGEN). Engineering risk had a defined set of financial measures attached:

- Cost of production loss;
- Cost of damage to asset;
- Cost of replacement or maintenance in mitigation.

The cost evaluation of asset redundancy (i.e. as a mitigation approach) was a process performed by both analysts and engineers. This included both a cost of replacement and a cost of increasing redundancy. The proposal stated how mitigation changed the probability profile of a total production failure.

[32] *Value at Risk, see Basel Accord (2004) risk valuation. If VaR is used, it would take a percentage of estimated risk and stated as the VaR figure (usually based on 1% failure in day)..*
[33] *In EGEN, a red/amber/green status could be overwritten by the record owner or manager; but this activity required comment when doing so.*

For safety and environment risks the valuation was a range of qualitative descriptions (15 point scale in EGEN and 5 point scale in EAM). The risk analysts (or assigned engineers) were measured on completing a mitigation proposal with costs within 21 days (EGEN) this was a target (undisclosed) in EAM.

The contrast between service and asset functions was clear, that although asset businesses did not financially value all of their risk types, they did grade the risks based on an underlying quantitative valuation. This was consistent against all categories of risk. In the service functions all risks were articulated in a financial manner, even where the valuation was imprecise because of the inherent subjectivity and estimation in their creation. The imprecision of valuing reputational (cf. Eccles et al., 2007) and strategic risk was understood by the CROs/Risk managers, for example:

> *"…the inaccuracy of our assessments in relation to reputational impact is magnitudes greater than in the more exact science of market risk or even customer portfolios"* (EAM CRO).

Moreover, asset managers and especially engineers articulated a strong belief in valuations and grading completed in their respective risk/asset registers. This was characteristic of the *calculative idealist* as defined by Power (2005). In near total contrast the service functions sought a financial valuation, based on a subjective opinion; they were mindful of the limitations. This was representative of the *calculative pragmatist* (Power, 2005), because the risk data helped steer analysis, rather than using it as a robust measure.

In risk oversight meetings the focus on valuation changed. Service functions used risk valuation for defining the treatment and priority, with unrelenting adherence to the initial valuation. Each risk was dealt with in independence, and compared against a "hurdle rate" (i.e. the cost of mitigation). If the cost of mitigation was less than the predicted impact, the risk was managed (otherwise it was accepted).

Asset functions acknowledged the earlier valuation but used this only as a guide when choosing to invest. The risks were considered in their holistic sense. Further, the risk managers looked at the whole portfolio of risks to consider which risks were treated. This difference seemed almost contradictory in nature, that those functions seeking a precise valuation only used them as indicators. Whereas, service functions were acceptant of the limitations in risk valuation, they relied more heavily on resulting valuation in deciding on treatment.

5.3.4 Risk Treatments (M4)

The function-level analysis did not show any theme of different treatments being advocated across service and asset functions. It was felt that a greater percentage of risks were being treated in the asset businesses because of special capital funds being made available: *"a budget code to be spent"* (EGEN, Risk Manager). Because of this it was inferred that mitigation (i.e. investment in redundant plant) was more prevalent in the asset function, whereas calculated acceptance (taking the risk) more so in the service function.

It was felt by the risk managers that because of the lack of resources to fund the treatment of risks in the service functions, more risks were ignored (unless there was a direct relationship to the decision-maker where they could be personally criticised). In the service functions they had to use operational budgets to resource treatments:

> *"If I have to control a risk through extra staff, I have to find that from somewhere else in my budget, something else goes without"* (FRET, Operations Manager)

The nature of service function's markets also meant that there was an opportunity to hedge individual positions as departments:

> *"as long as my overall position is positive by the point of review, I can do what I like, lose a few, win a few, if I could make the EBIT return by making cotton dolls I would still be in business by the end of the year, therefore it is a matter of understanding my whole portfolio and the precision of my objectives. I can usually survive and do well by*

achieving the big-ticket objectives, and fail a few others where I can justify my lack of direct control..." (ERS, Operations Manager).

Asset functions valued their risks individually but in reference to the collective operation's risks; it was understood that each risk had a dependency on the whole system. Mitigation and acceptance were perceived as commonly available treatments and within a manager's authority:

> *"It is totally within my authority, probably expected of me, to find effective means to reduce the potential impact if this event was to materialise"* (Operations Manager, FRET)

All grades of manager made risk mitigation decisions, but the default position that all managers had, was the ability to accept the risk:

> *"The default position available to me as plant manager is to accept the risk…"* (Plant Manager, ERS)

This was used except in circumstances of *safety risk*, where the primary company value (i.e. *"we don't hurt people"*) was in jeopardy. This was a boundary condition, over-riding all other treatment decisions; it indicated that action must be taken to control the risk.

5.3.6 Risk Grading (M5)

The uses of risk matrices were a central part of the service functions' risk process (ERS & FRET). Senior managers used the risk matrix to aid an understanding of the risk *portfolio management*, where risks were relative to each other.

Subjective assessments were inherent in service functions grading of risks. The use of the risk matrix was well developed in ERS. As risk was understood to be a combination of probability and of impact (section 2.1), these formed the matrix axes. Both axes used qualitative descriptors to standardise valuation. Multiple descriptions for impact, safety, and reputational risks were provided. Figure 5.3 reproduces part of the ERS risk matrix:

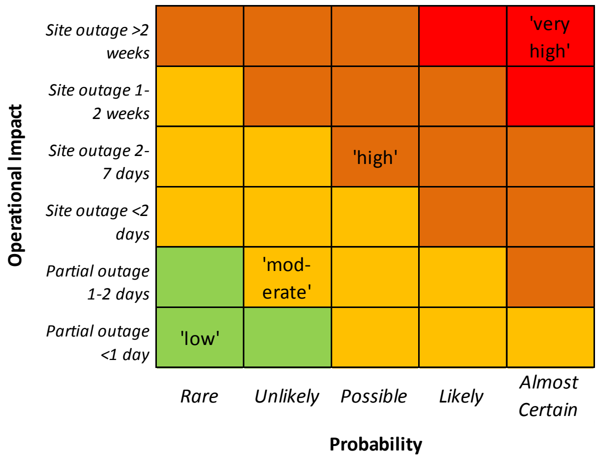

Figure 5.3 Example Risk Matrix

Demarcations were created in the risk matrices, including "very high", "high", "medium" and "low" risk types (based on probability X impact). These lines of demarcation between regions were understood by the operation: that only *very-high* risks were reported to corporate centre and *high* risks to the Market Unit. It was observed that another influence impacted risk categorisation: Managers were observed to increase grading where they wanted attention, perhaps to gain resource or capital support for treatment, or to create a *"burning platform"* (particularly when taking post in a new role). Alternatively, risks were graded lower where they didn't want attention because of the knowledge of increased senior management focus or to hide potential issues they thought they were able to handle without intervention. This was gaming of the system. Therefore subtle modifications of grading on risks close to the boundary caused a loss of information provided to the market unit and corporate centre.

An extract from ERS risk matrix showed how they mapped reputational and operations risk consequences using qualitative descriptions. They were open to subjective valuations

Table 5.5 Qualitative Impact Descriptors (ERS Risk Matrix, 2009)

Reputation	Operations
Widespread and sustained public media attention	*Site out of service for 2 or more weeks*
Sustained public and media critism [sic] in UK	*Site out of service for between 1 and 2 weeks*
Sustained regional public and media concern	*Site out of service for between 2 days and a week*
Extensive regional public and media concern	*Site out of service for up to 2 days*
Limited local and public and media concern	*Part of site out of service for between 1 and 2 days*
Isolated complaint with no anticipation of coverage	*Part of site is out of service for less than 1 day*

There was a desire to provide a scale of magnitude of impacts that allowed a comparison between different types of risk (i.e. reputation and operations). Although this provided a framework for impact categorisation, there was still opportunity for subjective biases, for example *"sustained"* versus *"extensive"* was not defined, and deferred to the decision-maker. Further, that although this was represented as an interval scale (cf. Hair et al., 2011), analysis demonstrated this was representative of an ordinal scale (cf. Hair et al., 2011). The reality was that the category bands were not equal and could be misinterpreted.

This same risk matrix also qualitatively described the five different ranges of likelihood. This reflected Fischhoff's (2009) discussion of anchoring, that the provision of a reference point would alter the individual's judgement of the situation (section 2.7.11). The individual was required to estimate the probability of the event based on these descriptions. ERS provided two different bands of probability: a) a full description based on past experience, b) single phrase descriptor, see table 5.7.

Table 5.7 Qualitative Probability Descriptors (ERS Risk Matrix, 2009)

Full qualitative descriptor	Single phrase description
Conceivable only in extremely rare circumstances	*Almost inconceivable*
Hasn't happened yet but could conceivably happen	*Rare*
Has occurred here or elsewhere albeit infrequently or as an isolated event and/or could happen again	*Unlikely*
Has happened sporadically on one or more occasions and is likely to happen again	*Possible*
Happens regularly	*Likely*
Frequent event/ ever-present	*Almost certain*

This risk matrix exhibited characteristics from the AIMIC (2002), which used a 5x6 matrix to value risk, and provides both qualitative and quantitative descriptors. The risk matrix provided an understanding of the separation of different *impact areas* (ERS Risk Matrix, 2009) for example *reputation* and o*perations*. In addition to these two risk types, ERS had 14 further *impact areas*, for which they provided specific consequential descriptions, for example legal impacts, safety impacts and financial impacts.

Risk matrices were not used in the asset functions. Therefore it was seen that a difference in the risk management process existed between service and asset functions in their grading, and tools used for grading risks.

5.3.7 Learning in the System (P1)

The difference in learning between asset and service functions included: the learning cycle and the knowledge repository being built. In service functions, risks were being managed as an individual transaction (this is evidenced in the application of the risk register, section 5.3.1). In asset functions, risks were being managed as a portfolio of threats, which through their identification and treatment was reflected in a holistic understanding of causes and consequences (section 5.3.1). In doing so, the asset functions attempted to remove the subjective valuation of risk, by building a knowledge base of previous issues and individual component relationships. This had developed a more precise understanding of probability (through historical record) and for new risks being recorded; probability of failure was automatically valued by the system through documented failure rates (i.e. the failure rate of an off-shore transformer). This knowledge developed beyond the company itself and extended to data being provided by OEMs (the register would record both the OEM failure rates and also the developed understanding through operation of that component).

In the service functions, learning was inhibited by the transactional nature of the process. The history of risk valuations and outcomes was removed from the register on closure of the risk (when it became degraded or controlled). This was justified because:

> *"No two scenarios are the same, we haven't got the capability at present to develop a long, long term history and understanding inter-dependence of risks"* (ERS, Risk Analyst).

Therefore all the knowledge and experience was contained in the staff and their memory. This was a weakness in maintaining an organizational history of events and risk management, as staff were mobile within the organization and throughout the energy sector. This was called *"the disturbance of corporate memory"* (COO, EAM).

5.3.8 Performance Systems (P2)

EGEN had a complex and detailed set of measures within the performance system. They used a *traffic light*[34] presentation, year to date and month to previous year month comparison. However none were explicit of risk targets.

Calandro and Lane (2006) suggested that a risk scorecard may be used to performance manage the risk management process (section 2.9.7). However, the use of risk scorecards was not evidenced in any of the cases. Further, there was no evidence of BSCs (Kaplan & Norton, 2000) or Performance Prisms (Neely & Adams, 2000) being used in the asset

[34] *Traffic light presentation is the use of red, amber and green to denote bad, indifferent and good. In both cases this is an accepted format.*

functions. Instead the performance management process was being conducted through a collection of measures and targets in organizational statements and individual's objectives. In service functions there was evidence of some *"Scorecard like adaptations in use…"* (Manager, FRET).

Group/ Organizational Objectives:

Asset managers felt that their smaller working groups (by virtue of plant production teams) needed less attention to presentation format:

> *"they understand their contribution to overall success of the operation, and just need some simple data to inform that decision"* (Manager, EAM)

Performance reports were limited in direct reference to risk, (as seen in exhibit 1). In EAM specific measures based on production and LTI (lost time injuries). Exhibit 1 was the "dashboard" placed in the entrance hall, refreshed on a weekly basis to inform staff of performance, it contained only three measures (YTD LTI: Year to date, lost time injuries).

September 2011

YTD LTI = 3 days
Days since last LTI = 211
Production = 67.8%

Exhibit 1: (EAM target results, Renewable Plant)

In service functions, managers and analysts did not feel they had any explicitly risk-based objectives; they were measured by outcomes delivering broader business objectives. In both cases operational managers felt there was a difference when adopting risks personally. Examples of objectives used in service functions included:

> *"Deliver the EBIT target of [x]% in 2011"* (FRET)
>
> *"Maintain call centre availability at an average of 98% availability in month"* (FRET)

Individual Objectives:

There were individual objectives being used to supplement group objectives. There were limited differences exposed between functions. They were contingent on the individual's past performance, their role and varied in the language used. There were limited examples observed that were attributable to risk management, for example:

> *"Demonstrate you have documented, recorded and assigned threats to safety and environment that you observe in your role and as a member of the [team]"* (Individual objective, EAM).

This related to identification process in the risk management cycle.

> *"Demonstrate your upholding and support of Rule One: We don't hurt anyone"* (Individual objective, ERS).

This related to identification, analysis and treatment of risks.

It could be seen from these examples that risk measures were being expressed as *measures* of past performance. In service functions there were no individual or organizational measures explicit of risk targets. This reinforced the implicit nature of risk management being performance managed.

5.3.9 Options and Decisions (R1)

Senior managers in asset functions were considering proximity of risks as they allocated capital funds in mitigation treatment; this was regardless of organizational adoption of the COSO standard that advocates the use of proximity as a dimension of risk. Managers were using risk valuations as statements of precision. However recognising the complexity of the environment and making relative decisions on priority, pragmatic decisions were being made on which risks attracted investment. This highlighted the role of individual experience.

Having broken down risks into different time horizons and adopting a portfolio approach to risk prioritization, treatment of risks in asset functions was controlled and scheduled; there was limited time pressure. When asked how an unexpected risk gets funded for treatment, asset representatives believed:

> *"it is an uncommon scenario where you see unidentified risks materialising. Sometimes we misjudge the probability but this feeds back into the asset register for future calculations… there is expectation of having identified all risks, where we haven't any response then comes out of the operational budget, although an overspend on risk treatment is rarely criticised."* (Risk Analyst, EAM).

In service functions there was greater articulation of managing the risk as a portfolio including both *upside* and *downside* risks. There was evidence of hedging practices (selection of inversely correlated market positions, for example the supply and purchase of green energy certificates). Furthermore in the service function, individual managers were making decisions on risk treatments independently. These decisions occurred in isolation to knowledge of wider system or related risks. Therefore, this was not an integrated practice, as advocated by ERM standards. Managers demonstrated a limited understanding of risk proximity, instead decisions were based on, "*do we, and can we afford to treat the risk*?" (Operations Manager, FRET). Instead, service functions felt that by not treating a risk (acceptance), a positive gamble was made, avoiding an operational cost.

This transactional and isolated treatment of risk was symptomatic of risk management being reactive and short-term. Managers in ERS and FRET described operations managers as highly pressured and forced into making *"not thought through"* decisions, because of both the volume and time criticality of decisions they were faced with. In response, these fast or immediate decisions were reflected on as the benefit of having experienced operations managers:

> *"…they use gut instinct, with many scars from previous decisions, you aren't a proven manager unless you have a few scars to show…"* (Operations Manager, ERS).

In service functions, the explanation of risk mitigation choices showed less use of calculated and considered methods, that the decision-making strategies were highly localised and selective in nature. This could be described with reference to Payne et al.'s work (1988), that discrete decisions in asset functions conformed to *weighted additive or MCD* strategies in the absence of time pressure. Whereas, in service functions, *satisficing* (i.e. decisions meeting the requirement regardless of optimality) or *lexicographic decision strategies* (i.e. where a single decision criteria is being used, ignoring other variables), were employed.

5.3.10 The Risk Manager's Role (R2)

Risk managers were employees with authority to deploy resources in controlling risk. The difference in authority appeared pronounced between senior and middle managers. All organizations had named risk analysts, who were considered as risk managers. This was a stretch of the definition as in service functions the risk managers did not control any resources other than in the reporting of risk.

However in these *risk manager* roles, a difference was exposed between asset and service functions. In the service functions, there was no pre-requisite training or education that was required to hold this position. It was seen as a junior role (non-managerial grade), and largely administrative in function; these would have been better described as reporting administrators. The role was based around the collection, aggregation and presentation of the vast registers of risks. They were tasked to chase the appropriate managers for updates on risks and treatments being employed. They did not add any professional oversight or analytical experience to the task. In both service organizations the analysts seemed focused on the next board or oversight report and an accurate and usually *"easy on the eye"* (Manager, FRET) presentation of the risks. In risk oversight meetings, they offered a minimal background to the risks when challenged and then operated as the conduit between the oversight group and the responsible manager in conclusion of the query or issue.

In the asset functions risk analysts, were considered *"risk professionals"*; they were able to deploy resources and make investment decisions. These were experienced engineers or asset managers, that had through selection, (and in the case of EAM had passed a challenging exam[35]) been awarded a coveted role as a *risk manager*. Several of these roles were then extracted from operational (or specific plant) activities and brought into the central functions. Instead of administering the risk register they operated as an internal point of expertise to the level of accuracy in the risk assessment, and had a strong role to play in the selection of the risk treatment. Their involvement in the risk oversight meetings was as a critical consumer of the risk reports. Their influence on the senior members of the organization (both EAM and EGEN) was substantial, and usually the only point where system grading of a risk was over-ruled. On cross-examination in the oversight meetings these risk managers would have the full detail (Performance Review meeting, EAM), and would be expected to represent the risk in fine detail, without having to refer to the operational managers. Because of this the operational managers gave *"open door and priority access"* (performance Manager, ERS) to these risk managers who were seen as a major point of resolution and access to special capital for treatment of the risk.

The risk managers in asset functions (especially EGEN) were able to influence the operational and senior managers to ensure that appropriate objectives were in place across the teams. Therefore the operational managers felt there was a clear relationship between the use and availability of risk registers, valuation routines and risk oversight meetings and the role of the risk managers.

A difference can therefore be drawn between service function *risk administrators* (administering the process), and asset function *risk managers* (deploying resources and adding specialist knowledge to the process).

[35] *In the case of EAM these roles had a salary grade increase and a special duty payment in their time in the function.*

5.4 Function-Level Discussion

The function-level exposed a difference in the risk management, complementary to the firm-level. There was *"an engineering core"* (HoAM, EGEN) in asset functions[36]. There was limited movement across the organization. The *engineering backgrounds* in common between asset function staff, was a strong influence in the convergence of perception seen in the asset functions, as the language and methodologies employed were consistent with one another.

In contrast in service functions, staff identified their high mobility between organizations and sectors. Therefore there was great volatility in roles and authority lines.

A major difference between functions was the level of development and integration of *risk systems.* The asset *risk systems* were embedded in existing software and process. Staff did not separate processes between managing risks or managing the operation, this was integrated. In service functions this seemed less mature; there was limited integration in risk processes or systems with operations functions. The risk register in service functions was a "*stand alone excel spread sheet*", managed intermittently as a secondary role of an analyst. This was still a legitimate medium for controlling risk (Panko, 2006), however was seen as less mature than the embedded nature and knowledge developing approach seen in the asset functions.

There appeared a complexity in risk management decisions, not fully explained in literature. This difference in decision process informed the group-level analysis, which seeks a representation of the mental models held by managers and their collective groups (group selection is discussed in the next chapter). Service functions took each risk on a transactional basis, meeting or failing a hurdle for being allocated capital. All capital spends on managing service risks were seen as *"Opex"* (Operational Expenditure), an additional cost on the business. Perceptions were different in the asset functions. Risks were seen as engineering challenges occurring as part of the standard operational process. Asset

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[36] *Plants are the term used to describe power/gas stations and associated engineering locations.*

managers looked at risk treatment as investment in plant or operation (perhaps because there was physical evidence of investment), but these decisions were made as part of a *portfolio*.

Each case evidenced use of performance management systems. Asset functions extensively used *wall-board performance updates*, these included a few important measures against a target. Service functions relied heavily on the collection of performance data, but this was aimed at the management teams. Interpretation of performance measures and response to them was considered a task for individual managers.

Generally, the performance system and the risk management process seemed to exist in independence from one another, there was little evidence of risk measures being embedded in targets and the risk was independent of other performance systems. However, the risk register and asset register were intrinsic to one another.

Table 5.8 summarises the different findings between service and asset functions. As there was convergence in understanding between EAM and EGEN and separately ERS and FRET, these case specific findings are consolidated to represent an asset and service perspective.

Table 5.8 Summary of Function-Level Analysis

Category	Sub-category	Asset (EAM/EGEN)	Service (ERS/FRET)	Comments/ Literature
Character	*Operating model*	Multiple assets, standardised and simple operating model	Complex operating model	
Risk systems	*Software*	Asset management software, module integrated	Spread sheet	
	Data archive	In-perpetuity	Removed at end of cycle	
	External data	OEM (feedback loop)	None	
	Description of process	Iterative	Transactional	
Risk amnesty		No	Yes	Service functions regret having run risk amnesties
Valuation	*Assessment*	Objective, inherent in system, use OEM data	Subjective, internal knowledge only	Power (2005)
	Treatment	Mediated by expert opinion – portfolio approach	In independence, qualitative idealism to meet "hurdle rates"	
	Types of risk	Safety, Engineering and Environmental	Multiple-types financially converted	
Treatments	*Budget*	Special budget	OPEX	
	Default	Mitigation	Acceptance	
	Perceptions	Authority defines availability of treatment		
	Financial valuation	Aids selection of treatment	Defines the requirement for treatment cost	
	Consequences of treatment	Investment	Cost	
Grading	*Approach*	As a portfolio each considered	Selected by criteria through breaching boundaries	
	Presentation	Red, amber, green	Risk matrix	
	Filtering	None observed	Defined by boundary	
Learning	*System*	Corrective at individual risk level	Corrective at portfolio level	Argyris & Schon (1988)
		Developed through system history	Reliant on individuals	
	Individuals	Part of the profession	Only for senior staff	
Performance Systems	*Type*	Few measures	BSC (amended)	
	Approach	Behaviour	Outcome	Agency Theory

ERS and FRET (service) were similar in the themes emerging from the analysis. EAM and EGEN (asset) also demonstrated similarities. However the asset and service functions differed from one another. Although different on many levels, the points of note are:

- The asset functions used embedded risk management systems, to record, value and maintain in perpetuity data on risks. The service functions used manually valued, and transactional risk registers. Data on these systems was removed after the risk has expired. This drove many of other differences at the function-level, which included the loss of learning opportunity, the failure to manage risks as a set of interconnected risks and lack of expertise being developed in risk analysts;

- The budgets used for risk treatment in asset functions came from *special revenue* budgets. These are budgets were reserved for the development and improvement of operations in direct response to risk. This opened up the treatment of risk to be perceived as investment. In service functions, risk treatment came from the operational budgets. This meant that risk treatment was a cost to the operation, and required a diversion of capital from another source;
- Risk managers in the asset functions were experts. They were senior engineers or project managers that through a proven track record controlled, challenged and championed issues through the risk management process. In service functions these risk managers were administrative in nature, providing limited ownership and expertise in the process.

5.5 Integrative Discussion (Firm & Function)

The firm-level analysis showed limited differences between cases, with similar perspectives and structures. At firm-level the market seemed to influence perspectives of risk. Furthermore, the firm-level analysis identified one distinguishable difference between the firms in their adoption of risk management standards (COSO ERM in FCORP and informal ERM adoption in GRS).

At the function-level, differences between service and asset functions were pronounced. Within the analysis, several theories/concepts were recognised as providing distinction between the asset and service functions, including: *Calculative Cultures* (Power, 2005), *ERM Ideal Types* (Mikes, 2009) and *Decision Strategies* (Payne et al., 1988; Pennington & Tuttle, 2007):

Calculative Cultures (Power, 2005): It appeared that the asset function was *calculative idealist,* and service was a *calculative pragmatist*, because asset functions had invested in developing objective valuation systems, based on previous historical data, and used this to inform their valuation. Service functions had developed an appraisal of the risk/s based on subjective opinions, with some indications of predictive values of impact, demonstrating a *pragmatist* approach to valuation. There was a discrepancy, as typing of culture at the analysis phase did not provide a full description. In the overt decision-making process (the treatment phase), this categorisation reversed. Asset functions demonstrated a *pragmatist* culture, increasing the value of expert opinion and subjective account, reducing the focus on the numbers. Service functions demonstrated an *idealist* culture in rigorous adherence to the numbers (which were derived subjectively) in forming a decision on treatment. This change ignored the subjective basis of the risk measures and incorrectly assumed a precision in the numbers advocated by the *idealists*. Table 5.9 summarises this change in calculative culture.

Table 5.9 Function-level Calculative Cultures

	Asset	**Service**
Calculative Culture **at Identification and Analysis**	Idealist	Pragmatist
Calculative Culture **at Treatment selection**	Pragmatist	Idealist

ERM Ideal Types (Mikes, 2009): The discrepancy in calculative cultures is understood through the *ERM ideal types*. Asset functions demonstrated a *Type 3: Risk based management*, with risk valuation embedded in understanding the value of its business. Service functions were less easily categorised, but demonstrated characteristics of *Type 1: Risk silo management*, with a fixation on quantification; but yet to implement any robust tool e.g. VaR.

At the firm-level, different *ERM ideal types* appeared as subtle differences in the *Holistic Management Type* (although there were differences in intention, see section 4.3). However this had changed at the function-level and the individual risk management types in the function were pronounced. Importantly functions seemed to converge on different types and stable in their classification. This was a major change between the findings in firm and function-levels.

Decision Strategies (Payne et al., 1988): At the function-level, there were different decision strategies being used between functions. This is evidenced by the arguments being delivered during the oversight meetings, for example:

1) The service functions, whilst appearing *pragmatic,* hid imprecision in analysis through explaining the need to take a specific course of treatment; this was a pre-determined investment approval process. The service functions exhibited selection and treatment on a single financial attribute, and this decision was made on achieving a *hurdle rate*, this exhibited a *satisficing* strategy, which is a *non-compensatory* decision strategy (Payne et al., 1988). It was not known whether this was a response (i.e. a *coping strategy*, Pennington & Tuttle, 2007) to information load and time pressure, or a deliberate selection of approach.
2) The asset functions appeared quantitatively driven, exposing the full analytical process and explaining why the different treatments were considered, excluded and why final choices were made. Payne et al. (1988) describe this: the asset functions appeared to be *weighting* the different attributes being considered, this was a *compensatory decision strategy*.

Research at the firm-level analysis highlighted four points for further investigation, these are summarised in table 5.10:

Table 5.10: Summary of findings and questions from firm-level analysis

	Firm-level finding	Question carried forward into function-level
1	Risk management standards are being applied differently between firms. There appeared no material impact from this difference.	How does the risk management standard permeate into the business units?
2	Risk submissions from the firm's business units differ in their perspective.	What are the differences in perspective between the business units to risk management?
3	The firms exhibit different risk management ideal types (both current and future intention)	Is the firm's risk management ideal type exhibited in the business units?
4	There are consistent descriptions of risk in the firms (based around four types). These are understood by the managers.	Does the firm's description of risk permeate into the business units?

These questions carried forward from the firm-level analysis are discussed in turn:

Permeation of risk management standards:

There was no evidence in the transmission of risk management standards into the business units. There was awareness of the standards; however there were no choices of process design or classification based on either COSO ERM (FCORP) or ERM (GRS). Therefore risk management standards were a mechanism residing in the corporate function, and were a firm-level decision. It suggested that if adoption of a formal standard were removed there would be no material change in the risk management process at function-level.

Differences in risk management perspective:

At the firm-level the different business units were operated as a portfolio, bringing different market risks and different operating risks. In the business units there was a change from the use of vertical integration (as a firm-level risk management strategy) toward a management of specific risks; and in the case of asset functions, management of risks was a set of inter-dependent threats. For example, within the firm a risk position was hedged between the generation and retail functions, with *backed* volumes of production and supply[37]. This had changed with the decoupling of generation and retail and the interaction of trading

[37] *This meant that whether wholesale or retail became profitable, the market returned profits to the company.*

functions in the centre of the market; whereas, in a business unit (i.e. FRET) a risk was managed in isolation of its impact on the firm's performance.

ERM Ideal Types:

The research showed that risk management ideal types did not permeate through the organization. The firm-level analysis demonstrated the ability to categorise the firm's risk management type. However the firm's risk management type did not reflect in the business units. There were strong and different characteristics seen in service and asset functions. It was unexpected to see the different functions between cases converging. This provided an indication that it was the nature of the operation that derived the risk management ideal type and not the firm.

Descriptions of Risk:

The descriptions (and the understanding) of the different risks types demonstrated consistency across all firms and business units. However there was different risk types being managed in asset functions compared to service functions. Asset functions discussed environmental, production and safety risks, whereas service functions discussed financial, reputational and legal risk. This indicated that there were different *weights* attached to each. These different weights were based on importance to each function. This inferred a potential for *bias*, as explained by Hsee and Hastie (2006). It was not clear whether this bias was a projection of memory or beliefs.

Summary:

It seemed that difference between functions is independent of individual firms. Asset functions show similarities and service functions show similarities, but within firm the differences between asset and service functions were distinct. It was unclear whether there was a normalisation between firms through transmission of ideas between the two service functions or two asset functions, which would explain this similarity. Service functions competed with one another and had clear legal separation in the retail markets. In asset functions, the only point of sharing was use of common OEM providers; this would not be enough to influence the business' risk management process.

Within the function-level there has been a dichotomy of risk perspective and management influences emerging from the analysis (either characteristic of a service or asset organization). However there were clear examples (i.e. example of offshore wind risk treatment) that demonstrated potential differences between populations of manager and their perspectives on risk management. Furthermore, the function's culture and processes did not explain fully the influence that performance systems had on the management of risk.

Specifically two questions emerged from the function-level analysis:

- *How does the difference between levels of managerial seniority influence the risk management decision process? (see section 5.4), or*
- *What is the impact of an individual's experience and beliefs on the selection of risk treatment?*

Therefore reflecting the difference between management levels and the observation that function orientation was an influence on the risk management process, the frame of reference moves to a segmentation of management level, whilst maintaining function separation. The focus of research moves away from the structures and organizational process and takes greater consideration of decisions and the paths in decisions.

Chapter 6

6. Group-Level Analysis

Chapter Six builds on the firm and function-levels of analysis. It expands to a new level of analysis (the group-level). At this point, the process of systematic combining includes thematic analysis with causal mapping to understand the manager's mental models and perspectives. It results in four group causal maps and quantitative analysis of these maps. Arguably the use of causal mapping is a continuation of the case study approach (cf. Nadkarni & Shenoy, 2004), but a difference in analytical approach.

The research at the firm and function-levels showed that there were differences between service functions and asset functions in their perceptions and management of risk. There were differences in the risk systems being used, and different approaches to risk valuation dependent on function. However the path to selecting risk treatment was not yet understood in the context of the performance system. Furthermore there was an indication that managerial seniority (presumed authority) and the individual's experience and beliefs influenced the decision-making process. The group-level analysis seeks an understanding of these gaps in understanding.

The use of causal mapping as the means of analysis was influenced by:

1. The experience in the function-level analysis, showing that the understanding of treatments were consistent between managers. But the influences on this decision were fundamentally different (section 5.4);
2. The concepts being explored in progressing from the function-level had narrowed, and the *journey* (path of decisions) was identified as being critical to the understanding of how the risk managers might be influenced through performance systems.

3. Causal mapping is an exploratory method (cf. Akkermans et al., 1999; Wilk & Fensterseifer, 2003), and relevant to *nascent theory development* (Edmonson & McManus, 2007:1160).

In analysing the group-level, there is a focus on the decision influences, and understanding the complex paths of decisions. This was achieved through a process of interview, to gather the rich accounts of managers and their perspectives of risk, and represented as causal maps, using a process of causal mapping (cf. Huff, 1990).

The structure of Chapter 6 begins with a return to literature, to reconcile the organizational and managerial view of risk. Next, the method section outlines considerations, challenges and analytical approaches used in causal mapping. This continues to discuss the research strategy being applied in the group-level analysis; including the sample frame, the approach to data collection and the techniques used for analysis. Next, the results and analysis are conducted in parallel, using qualitative and quantitative techniques. The chapter concludes in two levels of discussion: 1) Discussion of the group-level results, and 2) An integrative discussion reflecting on the firm and function-levels of analysis.

6.1 Reconciling the Organizational and Managerial View of Risk

At the firm and function-level there has been an assumed role of performance systems. In the literature review (section 2.8) it was found that no single model or framework either theoretically or empirically informs the relationship between performance systems and selection of risk treatment. If the selection of a treatment is considered a discrete and rational decision (cf. Chater & Oaksford, 2000), the performance system should be the only mediating influence on the analysis and selection of treatment (as was expected by the firm) on the specific context of a risk. This theoretical relationship is outlined in figure 6.1. If objective then the biases and beliefs held by the manager would not influence this decision.

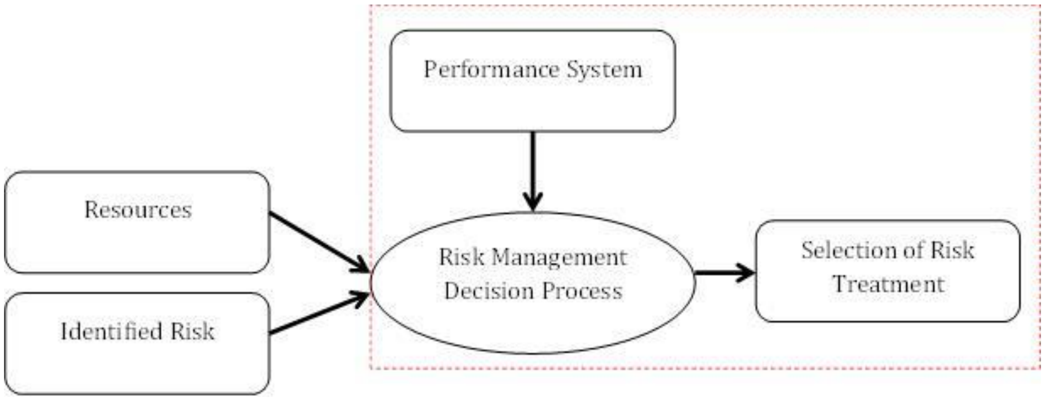

Figure 6.1 Simplified Risk Management Decision Process

Following the firm and function-levels of analysis, the research showed that the market derives some of the types and classifications of risk (i.e. credit risk), the types of risk being experienced (i.e. environmental risks), the risk management standards adopted (in the firm-level analysis did not significantly alter the process of risk management or communication, for example the adherence to COSO ERM or informal use of an ERM standard), and specialised language being used (reflecting the specification of the standard, e.g. *velocity* and *proximity* of risk). The greatest influence was seen at the function-level, whether an operation was an asset or service function, this included influences on volume of risks being identified and managed, systems being used for risk control, and valuation approaches to risk.

The integrative performance system model (section 2.8.7); reflected the functional view of the performance system, it assumed a bi-directional formation of strategy. That strategy is influenced both by a bottom-up process, as well as a top-down process. This is reflected in the design of the group-level analysis, which separates different communities of managers in the design of its sample. The next section highlights the different perspectives of risk that may be taken.

The level of significance or magnitude of a risk will affect the perception of the risk, whether it has strategic or operational impact. This may produce differential approaches to decision-making (Ritchie & Brindley, 2004). Different levels within the organization will have different thresholds and attention to levels of risk (Nocco & Stultz, 2006).

Companies are in business to take *"strategic and business risk"* (Nocco & Stulz, 1996:9). A financial perspective: market and credit risk management has been the focus of strategic decision-making; and that this is strategic risk taking (Baird & Thomas, 1985). This infers that risk decisions can be strategic, but does not isolate where risk is strategic. Operational risk management is as an issue of protecting the organization from loss (Power, 2005). This is where *people, process and systems* (Basel Committee, 2006) are the source of failure. The Basel definition specifically excludes *"strategic risk"* (see section 2.4.1). Disruption risk literature demonstrated a development of operational capability as being critical to effective treatment (Sodhi, 2005). However operational capability is a consideration for operations strategy (cf. Juttner et al., 2003). Therefore, even if Operational risk excludes strategic risk (as stated in the Basel Committee definition, 2006), the consideration and management of operations risk can still be strategic.

A different perspective on the same problem is presented by Crouhy et al. (2006), that strategic risks can be considered either: Operational Strategic Risks (OSR), or Operational Failure Risks (OFR). This differentiates whether risks are endogenous (internal to the organization, i.e. failure in business process) or exogenous (external to the organization).

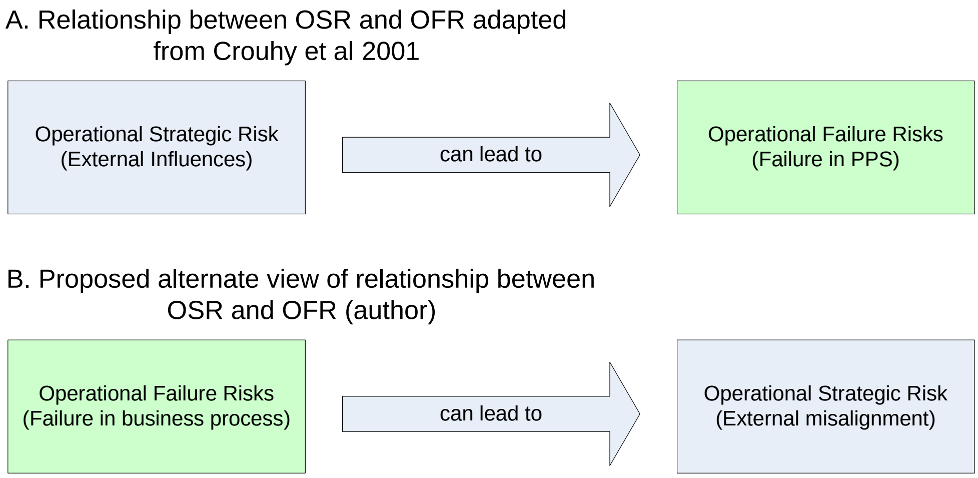

Figure 6.2 Operational Strategic Risks and Operational Failure Risks

The model presented by Crouhy et al. (2001), may be reversed. Logically *Operational Failure Risks* can lead to *Operational Strategic Risks*; endogenous risks can cause external misalignment, itself a strategic risk.

It seems that the term strategic is used to denote both the type of decision as well as the significance of the risk. Strategic risk in the sense of significance appears to be a description of an impact that has long-term and high value. Strategic risk taking (the type of decision) appears to be a decision that has a long-term perspective and considerate of the capabilities of the organization as a whole (cf. Kaplan & Mikes, 2012). For risk, this may be statement of *risk appetite*. Statement of *risk appetite* is outlined as a requirement in COSO (2010), where *risk appetite* has been commonly articulated as the strategic statement of risk in an organization (Davies & Haubenstock, 2002; Davies et al., 2006; Kumar & Persaud, 2002). When performance managed, *information symmetry* (the imbalance of information between parties) impacts risk management decisions (Yang et al., 2009) and perception of *risk appetite*, (the desire to personally or organizationally take on risk, cf. Davies et al., 2006; Davies & Haubenstock, 2002; Kumar & Persaud, 2002).

This provides a justification for differentiating between managers that are privileged to strategic decision-making and those that are by their position in the organization focused on operational decision-making. This distinction informs the design of the sample frame (section 6.3.1). The remainder of the chapter continues by outlining the method of causal mapping, defining the sample and analysing the results, before concluding with a discussion of results.

6.2 Method: Causal Mapping

When researching risk management, perception of risk is paramount, as it is understood to be highly subjective (Slovic, 1964). This was evidenced in the function-level analysis. In turn this leads me to look at the belief sets influencing treatment selection. Causal mapping was used in project management studies to expose the underlying belief sets and therefore the risk decision processes (Edkins et al., 2007; Maytorena et al., 2004; Williams et al., 1997), and provides a precedent to the use of the method.

Application of the causal mapping approach is popular in the investigation of individual's and group's cognitive models (Axelrod, 1976; Hodgkinson et al., 2004; Huff, 1990). Causal mapping is a family of techniques for representation and elicitation of individual's beliefs (Hodgkinson et al., 2004; Wilk & Fensterseifer, 2003). Consistent with the Critical Realist paradigm, causal mapping is undertaken to expose the cause – effect relationships; what Bhaskar (2008) would term *generative mechanisms*. Causal mapping is a term used interchangeably with cognitive mapping when used to discuss the mapping of perceptions and beliefs; this is the creation of causal maps based on subjective accounts. In undertaking causal mapping (of cognition) participants are presented a set of interview questions relating to pre-defined variables (cf. Hodgkinson et al., 2004). In this research the performance system functions and the risk types and treatments derived through literature, and are used to represent the variables.

The causal mapping method is a positivistic analysis technique, which through a degree of procedural convention (Ackermann et al., 1992), commonality in output (Langfield-Smith, 1992) and integration of collection and analysis provides a structured method for analysis without losing the richness apparent in qualitative data. It is this richness that offers extreme value in researching matters that are not necessarily observable (Godfrey & Hill, 1995). However a problem with qualitative data is the large data sets it provides, it is difficult to find a structured way in which to analyse the data. There is a relative richness of data, but there is a lack of accepted rules for processing it (Hodgkinson et al., 2004). Causal mapping has greatest power when pictured in graphical format (Axelrod, 1976). The map is the visual representation of an individual or group's belief systems; and representation of their mental models (Ackermann et al., 1992:2), for example in structured problem solving (Wilk & Fensterseifer, 2003) or to provide structure for handling and analysing large volumes of documentary data (Ackermann et al., 1992).

Where causal maps are created, they require coding and the original language kept as accurate record of an individual's beliefs. To make comparison within and between respondents, involves increased treatment and exposes the risk of interpretation, as the coding and aggregation of accounts. This aggregation is completed through a cycle of coding. A first cycle of coding, is done to maintain as much of the original language used by participants as possible, selecting repeated concepts between participants, separating the data source into ideas. These ideas may be a single phrase or sentence (Ackermann et al., 1992). These concepts are noted and impact recorded where there is a relationship between ideas (nodes), the relationship (arc) is analysed, identifying where nodes are cause or affect. This may be developed into a matrix (cf. Kelly, 1988). A matrix provides a basis for quantitative study, building the strength of perceived relationship within a frame; it can be used to identify conflicts within the models. The convention (Ackermann et al., 1992) suggests that in final presentation, goals are positioned on the map's right and the process is worked back from *goals* to *strategic directions* and finally to *potential options*. To reduce the modeller's subjective interpretation the original language used in the transcript should be retained as far as possible (Ackermann et al., 1992).

The strengths of visually mapping of the model are the order and visual representation that can be derived from rich data. It allows for new terms, concepts and descriptions to be introduced that were originally outside of the researcher's *a-priori* knowledge (Daniel et al., 2003). The method is flexible, ranging from individual to group participation (Suwignjo et al., 2000), and allowing *aggregation* or *averaging* of individual's results to create a group vision (Langfield-Smith, 1992). At this point of group modelling the results yield some of the most insightful views, where differences and similarities in population beliefs can offer theoretical development; however it is the *grouping* of models that generates the greatest contention in method and in interpretation, as it is subject to researcher bias.

Group models are understood to be a good representation of the cognitive processes occurring within the group, but may not be a representation of an individual's mental model

(Hodgkinson & Clarkson, 2005); it highlights cultural knowledge, collective belief systems and organisational culture in particular as contingent influences, for example: the need for a shared map in coherent social groups (McCaskey, 1972), unaligned linkages in supply chains (Akkermans et al., 1999), resolving vicious belief circles in manufacturing projects (Williams et al., 1995) and deconstructing processes in construction projects (Edkins et al., 2007).

Studies have shown ability for causal maps to progress onto secondary quantitative data analysis, allowing for comparison of group cognitive consensus (cf. Langfield-Smith & Worth, 1992; Markoczy & Goldberg, 1995). Their approach advocates a potential to transfer causal maps into quantitative data. Caution should be taken when employing quantitative analysis as the essence and subtlety of a belief system through a purely numeric presentation is lost (cf. Eden, 1992). This approach should be contained to providing a mark of comparison between individuals and groups at best, and as a companion to the visual maps being presented. It is with this understanding that the research strategy in Chapter 6 is defined next.

6.3 Research Method

The question posed in the group-level summary is *how the difference between levels of management seniority* (designated by their seniority and function in the organization) *influence on the risk management decision process*. Further *what is the impact of experience and beliefs on the selection of risk treatment*? For this phase, the research moved away from the alignment to case organizations, and looked at the decision-makers as distinct groups of managers; and thus created group-level causal maps.

6.3.1 Sample Frame

This is a group-level analysis. The groups are defined through the influence of the function-level analysis that demonstrated a difference between asset and service functions. This separation of function is maintained. A further separation of the sample is sought in the management level.

Data were collected from two groups of managers as their perspectives on risk as expected to be different. The performance management literature suggests that managerial level may influence how metrics are understood. Senior managers are less aware of risk exposure than operational managers and staff (Simons, 1999:86) and there are potential differences in the perception of performance measurement between management levels (Bremser & Chung, 2006). Further the function-level analysis demonstrated a difference in influences on reaching a treatment or control between different groups of managers. This appeared to be due to different levels of authority, and potentially different experiences.

Bremser and Chung (2006) split C-suite (CxO roles) and P-suite (process managers), in their study of performance measurement. Unlike Bremser and Chung, this research is not restricted to being a sample of executive roles only, and the categorisation in this research must incorporate European wide terminology; for example selecting on job names (e.g. *Director*) may not be appropriate. As some of the case organizations are based in German systems, where *director* and *managing director (Geschäftsführer & Geschäftsleiter)* have subtleties that are difficult to control. Instead it is appropriate to look at an approximation of personal risk bearing (cf. Wiseman & Gomez-Mejia, 1998)[38].

For managerial groups a distinction is made:

S-suite (Senior-suite), senior managers direct the organization, take strategic responsibility and direct the company. S-suite maps closely to C-suite roles (cf. Bremser & Chung, 2006). In this research, S-suite was identified by the following role titles:[39]

1) Chief Executive Officer (CEO)/ Managing Director[40] (MD);
2) Chief Finance Officer (CFO);

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[38] In one case organization the role title did not have an effective mapping of manager and executive/ director, instead there was a local hierarchy: there were 'A&B level managers' and 'C level managers', in this case the roles were clearly banded in organizational responsibility (in organization charts) and following some discussion with the Human Resources department the adopted classification could be overlaid.

[39] Individuals already contributing to firm or functional level analysis are excluded from this sample.

[40] The role MD is comparable to CEO in some instances where the organizational unit demonstrates full autonomy, and operates as a separate business unit; in the case of FRET (EAM) and ERS (EGEN).

3) Chief Operating Officer (COO);
4) Chief Information Officer (CIO);
5) Chief Risk Officer (CRO);
6) Directors (undesignated)/General Managers;
7) Strategy Manager;
8) Members of the senior managing team or executive members of the managing board.

M-suite (Middle-suite), middle managers operate the organization, contribute but not deciding on company strategy; similar to P-suite roles (Bremser & Chung, 2006). Individuals are process managers generally with staff reporting to them; this includes matrix management responsibility. In order to be considered a manager the individual had to control some of the company's resources (i.e. staff or capital budgets). In this research M-suite included operations, project and asset managers. Therefore M-suite managers are considered as operational decision-makers applying the strategic vision; they are accountable to S-suite managers.

Interview Participants

Interviews were conducted with managers and executives from FCORP and GRS (both functions in both cases), lasting between 60 and 90 minutes. A balance between asset and service functions units was maintained, with equal contributions from each. Each managerial group (i.e. S-suite, service function) was interviewed until concept saturation (cf. Nelson et al., 2000; Axelrod, 1976) was achieved.

Concept saturation is the need to exhaust, to a practical level, the number of new concepts being introduced by successive interviews (Nelson et al., 2000). Demonstrating concept saturation is a time consuming process when undertaking interview collection in a highly distributed sample set (cf. Scavarda et al., 2006) and requires both data collection and data processing to occur in near parallel. The practical approach in managing this required for a single data collector, who became knowledgeable to the responses, informally recording the number of new concepts introduced at each successive interview. Formal representation of concept saturation was demonstrated post completion of the coding phase.

Although there was potential to interview Risk Managers, (risk managers as defined in firm-level analysis) they were excluded from the group accounts, as these specialist roles can have a strong bias towards *calculative idealism*, where there is a strong focus on the development of quantitative analysis (cf. Mikes, 2009). Rather than control for the variation between specialist and generalist risk managers, the latter was sought. The sample frame is shown in table 6.1.

Table 6.1 Group Level Analysis Respondents

	Role	**EGEN (GRS)**	**ERS (GRS)**	**FRET (FCORP)**	**EAM (FCORP)**
	Number of visits	*(3 visits)*	*(4 visits)*	*(4 visits)*	*(3 visits)*
S-suite	Managing Director	1	1	1	1
	Director/ CxO	1	1	1	2
	CRO	1	1	1	
	Plant Manager	3			3
M-suite	Operations Manager	1	2	2	
	Programme/ Project Manager		2	1	1
	Risk Manager			1	

It was not possible to identify the causal influence at function-level analysis. Reflecting the understanding with performance system literature, the link with stated and implicit goals was explored (i.e. risk mitigation). In the role of the manager, both the effect that performance system places upon them as risk decision-makers, but also how the manager cascades the goals and behaviours into their own teams was sought.

6.3.2 Data Collection

The approach to causal mapping and creating group maps followed Hodgkinson and Clarkson's (2005) outline: Knowledge elicitation, construction of cause maps, analysis of cause maps and aggregation of cause maps. This defined that individual maps are created, coded and developed before aggregation. Using the sample frame (section 6.3.1) this was split into four group maps. The process followed eight steps:

1. Data was acquired through semi-structured interviews (protocol included in Appendix C). Interviews were recorded and professionally transcribed;
2. Transcribed accounts were coded, identifying terms of influence and the subject and object of each statement of causality (termed nodes); There are six means of linking concepts (Axelrod, 1976):
    - *Positive;*
    - *Negative;*
    - *No effect;*
    - *Indeterminate (but non-zero) effect;*
    - *Not positive;*
    - *Not negative.*

    Huff (1990) supplements this with two further concept links: *Equivalence* (terms that had equal meaning) and *Example* (statements that were justified through an account). These lead to a range of terms indicating influence, for example: *but, because, if, so, therefore…*

3. The nodes were reduced, to a smaller number of consistently named nodes (Scavarda et al., 2006), this was an iterative process, in this case these were three iterations:
    a. Grouping comments based on their subject and action, with minimal change in language being used;
    b. Using the node categories based on the *performance system nodes* (i.e. communication or measurement) and *risk management nodes* (i.e. use of risk tools), developed from literature (see table 6.2), highlighting nodes not yet aggregated;

c. Taking the unassigned nodes and developing a new aggregated description of the meaning of the subject;

4. The coded accounts and their causal relationships (*arcs*) were entered into a matrix (Kosko, 1986), for individual accounts. An example matrix from step 4 is presented in figure 6.3.

Id	Description	Risk (Generic)	Reputation Risk	Financial Risk	Operations Risk	Safety Risk	Regulation Risk	Speculative Risk	3rd Party Risk	Legal Risk (DPA)	Net Risk	Strategic Risk	Margin/ Credit Risk	Project Risk	Asset Risk	Engineering Risk (Type)	Behavioural Risk (Type)	Contract/ Sub-C risk	Environment Risk
	Risk Types																		
1	Risk (Generic)																		
2	Reputation Risk																		
3	Financial Risk																		
4	Operations Risk																		
5	Safety Risk																		
6	Regulation Risk																		
7	Speculative Risk																		
8	3rd Party Risk																		
9	Legal Risk (DPA)																		
10	Net Risk																		
11	Strategic Risk																		
12	Margin/ Credit Risk																		
13	Project Risk																		
14	Asset Risk																		
14.1	Engineering Risk (Type)			1											1				
14.2	Behavioural Risk (Type)																		
14.3	Contract/ Sub-C risk								1										
14.4	Environment Risk																		

Figure 6.3 Example Coding Matrix

5. Individual maps were combined, through the addition of the matrices in the sample. Nodes and arcs demonstrating a majority opinion (Bougon et al., 1977) within the sample are included in the group map;
6. The group map was presented as a causal diagram (section 6.4.1);
7. Individual maps were analysed;
8. Maps were compared, looking for patterns in mental models between samples.

There were over 42 hours of recorded (audio) interview[41]. This was professionally transcribed. I conducted all interviews. Only the participant and I sat in the room during the interview. Seven of the transcripts were returned to the participant to confirm true and

[41] *All groups contained at least one female*

accurate recording and representation of the interview[42]. Confirmation was received from five participants, and no response from two participants (this did not indicate a disagreement with the transcription).

Node Definitions and Descriptions

The coding approach uses the structure of performance system functions (section 2.9), risk treatments (e.g. *insurance*, section 2.6) and risk types (e.g. *reputational risk,* as sources). The node descriptions are provided in table 6.2.

Table 6.2 Node Descriptions[43]

Node	**Description**	**Characteristic responses/topic**
Performance System Nodes		
Strategy alignment (section 2.8.3)	The strategic statement, vision and mission. Includes objectives, activities and definition of targets.	Risk appetite Competitive advantage Business plan
Measure (LAG) (section 2.8.1)	Collection and analysis of data. Includes type of data, frequency and process.	Plant availability, Lost Time Injuries, profit to date.
Measure (Lead) (section 2.8.1)		Predicted outcomes or trends, usually based on forecasts or in complex cases models of linear regressions. Intra-measure analysis of company outcomes
Communication (section 2.8.2)	Formal distribution of information. Presentation of data, including communications protocols.	Control charts Corporate report Written reports Stakeholder meetings
Control structures	The internal control influence within the organization. This is a representation of the key internal stakeholders, including corporate/central control mechanisms.	Audit and compliance Corporate risk team CEO
Learning (section 2.8.4)	Activity and structures behind learning, development and reflection.	Competitor understanding Understanding symptoms Critical incident review

Continued…

[42] *The transcription service on occasion, could not understand words being said. Most often this was a case of not understanding technical terminology being used. Where this occurred the transcription service time stamped the transcription, this was then reviewed, and in nearly all cases the correct terms were inserted.*
[43] *Table excludes risk types, and risk treatments, these descriptions are consistent throughout the study.*

Node	Description	Characteristic responses/topic
Risk Management Nodes		
Structured decision making (Risk management process)	Structured decision-making process, including policies and procedures for risk management. Identify, assess, treat and control cycle.	Risk Policies Treatment authorisation Risk prioritization
Measure (Risk Measures)	Collection and analysis of risk data. Includes type of data, frequency and process.	Risk value, probability, impact (using different consequential descriptors) and frequency of historical failures (including OEM specifications). Impact of past failures. VaR
Risk Tools	Use of tools and risk standards, systems or risk management structures including risk committees in managing risk.	Risk Matrix ERM/ ISO310000 Risk Register
Other		
Beliefs	Role, attitudes and beliefs of individuals or groups	Personal risk aversion Value of common sense Being professional
Environment	Environment the organization exists within, including national considerations, market conditions, regulated or governed practices and influencing legislation. It includes representation of the external stakeholders.	HSE executive Competitive market Regulator Licence conditions External stakeholders

To confirm suitability of coding and association to node, assignments of individual statements were independently reviewed. A research assistant from the business school and final year PhD student undertook this review. First they confirmed the nodes, at this point it was suggested that Measure (BP) of the Business process (already identified as distinct from *risk management* measures), could be further separated into LAG and LEAD measures.

Resulting from the coding, it was found that measures in the system could be broken down into three different groups[44]:

1) Measure as a lag indicator (i.e. Measure of achieved operational performance, Net Promoter Scores, number of staff employed even matters such as measures of process maturity);

[44] *This has been done with the knowledge of the resulting reviewer feedback regarding separation of LAG and LEAD measures*

2) Measure of risk, specifically utilizing the term risk or risk measures embedded within risk tools (i.e. VaR, RAROC , Equivalent Value (EV), OEM probability scores, volume of risks, proximity of risks);
3) Measure as a lead indicator (i.e. estimations of plant availability).

Secondly, a sample of nodes were selected (2 for each reviewer), and working back through the coding schema, considered the assignment and association of the original statements. No conflicts in coding were found at this point.

Map Aggregation:

There are two methods of creating a group map, this is a choice between:

1) An *aggregate* map (Edens, 1989). It combines all individual maps (without loss) into a single representation;
2) An *average* map (Bougon et al., 1977). This majority view is where consistent relationships are represented as the group map.

I was originally agnostic about which approach (i.e. *average* or *aggregate*) to adopt. I considered the benefits of an *aggregate* map being a full representation of all the different paths; however the benefit of the *average* map became apparent in an early pilot of the process. It was shown that a map quickly became un-readable where there are more than 30 arcs. The *average* approach is reflective of Hodgkinson and Clarkson's (2005) view that maps will be a good representation of the cognitive processes occurring in the group, even if it is not an exact representation of the individual's mental model. It also provided for a more focused analysis between maps in the discussion section. In this research, group causal maps are constructed, using an *average* approach and is reflective of Bougon et al.'s (1977) approach.

Concept Saturation

Concept saturation is the demonstration of data collection being complete, by identifying a point where no new (or very limited) insight is elicited from sources by further collection. It provides a level of confidence that a representative picture is being recorded. This is demonstrated by reaching a point of redundancy, it *"determines the adequacy of the sample size"* (Armstrong, 2005:24). Scavarda et al. (2006) in their methodology for constructing collective causal maps predicted a geometrical decline in the number of new concepts for each respondent.

The figure below demonstrates development of new concepts through successive interviews. All samples found redundancy by the 7th interview. This was fortunate as it allowed for balanced samples (i.e. equal numbers of respondents in each group) throughout the analysis.

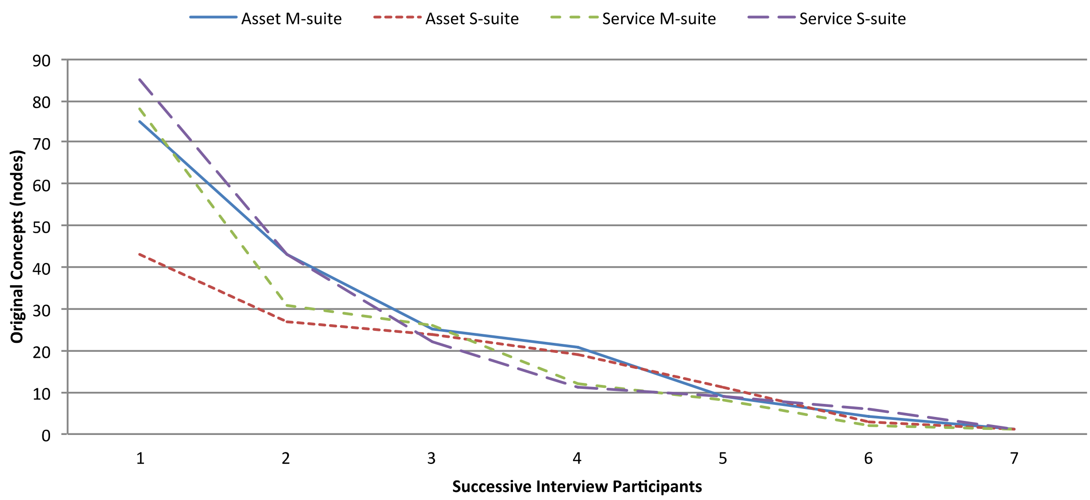

Figure 6.4 Concept Saturation

In S-suite (service and asset) there was value in developing from 6th through to 7th interview. In M-suite, there was less benefit between the 6th and 7th interview. There was not the geometrical decline seen, as suggested by Scavarda et al. (2006).

6.3.3 Data Analysis

The causal maps were presented in graphical format at the start of the results section. Secondly the maps were quantitatively analysed using three different calculations:

- Map complexity, a description of the map and its complexity;
- Map density, a description of the map and its degree of links between each node.
- Node centrality, a description of a node and relative assessment of its importance in the map;

Map Complexity (M^C):

The Map Complexity Calculation is an original measure to calculate the number of links in the map, based on the total number of potential links in a map. Map complexity is based on a simplified version of Langfield-Smith and Wirth's "*Formula 12"* (1992). This provides an indication to the complexity of the map, regardless of the number of concepts being presented.

$$Map\ Complexity = \frac{\sum a}{(N(N-1))/2 + N}$$

Where ais the number of arcs and N is the number of nodes

Equation 6.1 Map Complexity

This calculation returns 1 where a relationship exists between every node, and highly complex. It returns 0 where no relationships between nodes exist. This allows for self-reinforcing arcs to be recognised.

The difference in complexity score inferred both a difference in detail of mental model. Or it identified where extraction of procedural and cognitive detail has not been complete with other group models. Nodal complexity calculation occurred post aggregation of individual accounts.

Node Centrality (N^C):

Centrality (Armstrong, 2005) is a nodal measure (N^C). It is a ratio the number of arcs it has against total number of arcs contained in the map. This test has been developed by Knoke and Kulinski (1982). The result of 1 for a node would infer that all relationships reflect back to a single node. This measure is used to highlight the important nodes in the map. Nodes with high centrality scores demonstrate a position in the mental model with high referential or influenced links. These become critical points of interest. In application it is these nodes that are investigated for their ability to influence the outcome (goals) of the mental model.

There is a modification in this research that differentiates between nodes that are a central influence and nodes that are central outcomes. This differentiates whether a node has centrality through virtue of being an influencing force (*"Out-degree"* Armstrong, 2005), or whether it has centrality of being an influenced node (*"In-degree"* Armstrong, 2005).

Map Density (M^D):

Map density is a map level measure, it is *"the ratio of links between a concept and the total concepts in the map"* (Armstrong, 2005; Carley & Palmquist, 1992). This works at map level, where the calculation is the total number of *arcs* in the map divided by total number of *nodes* in the map. This is similar to the map complexity calculation; however this gives a ratio of nodes to arcs. Where the map density (M^D) is greater than 1, this indicates more arcs than nodes. This infers that there is an expression of understanding between cause and effect between nodes. Where density is less than 1, then there are concepts for which the cause or effect is unknown, or the concept is potentially unrelated. The three measures are used together to describe the structure of the map.

6.3.4 Reflection on method

The process of mapping interviews developed over several months. Initially each interview was taken and coded with the intention of creating an individual map of the interview. Coding interviews began by breaking each transcription into its constituent parts then linking successive concepts as they appeared. Relationships were described as one of Axelrod's six relationships. Maps were created manually, starting at the centre of a blank A3 paper. A concept description was used, although for practicality this was an abbreviation of transcribed words. Arrow lines were drawn between concepts, and the map continued until the end. An early working copy of a hand drawn map is included in figure 6.5.

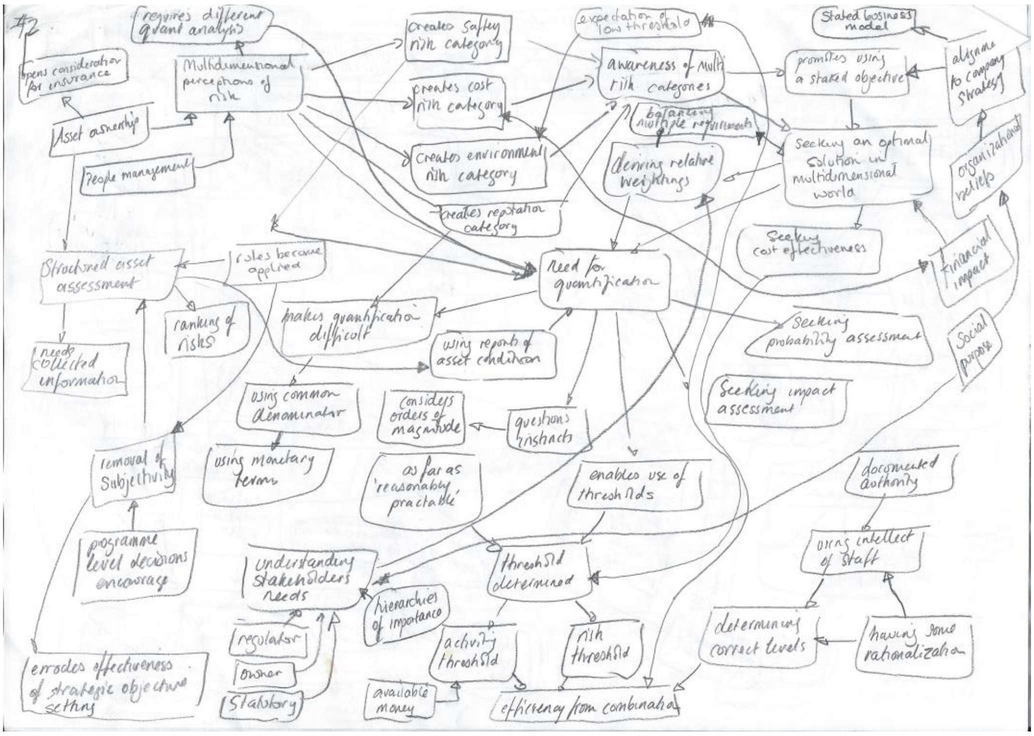

Figure 6.5 Example Handwritten Causal Map

The realization was that the map was a useful by-product, and not the core output. The record of paths (arcs) and shared nodes were the main output, which in a final presentational layer could be crafted into maps.

After several interviews were analysed, four issues became apparent.

a. Because the start of interview and weight/density of concepts contained did not have any particular relationship, maps needed linkages across pages and large gaps appeared in regions of the map;

b. Linkages were complex, where a participant related concepts back to points earlier in the interview. The impact of this was that arcs overlapped, and sometimes became unreadable/difficult to follow;

c. There is a space issue and although larger pieces of paper could have been used (with the limitations above), the temptation was to abbreviate too far from the words being used by the participant. This highlighted an issue that codification and creation of relationships should probably be performed in two distinct steps;

d. As aggregation of different interviews began, it was time consuming[45] searching for related concepts across large maps. It raised an almost unavoidable potential for duplication/omission. This imprecision was intolerable and alternative mapping processes are developed.

In result, a bespoke Microsoft Access (2007) database was used to store, code and create the data used for creating the causal maps. The maps were graphically drawn in Microsoft Visio[46]. Using the results from these maps, nodal complexity, density and centrality were calculated for group map analysis.

6.4 Group-Level Results and Analysis

The group-level are presented as causal maps[47]and a thematic analysis. In this section results and analysis are combined.

The group maps shown are *averaged* maps (cf. Bougon et al., 1977), split by *asset* and *service* functions, *S-suite* and *M-suite*, providing a 2x2 sample frame. Each map was created from

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[45] *It was estimated that 1 hour of interview would take 14 hours of transcription and coding, however this was found to be almost double using this method***.**

[46] *A number of off the shelf system solutions were investigated. Tools such as Visio, Smartdraw and Decision Explorer reviewed. These were largely visual aids, subject to many of the problems associated to the manual process; none of them overcoming the potential for omission during aggregation. NVivo 8 was reviewed in depth, with vendor training and consultancy from vendor representatives. Although the coding process became more precise, with greater ability to associate concepts back to original statements, ability to record (in a directional manner) relationships between concepts was limited. It became clear that the method was becoming adjusted to suit the tool.*

[47] *It is possible to trace back to the individual statements associated to the individual nodes and arcs. Reference is made to these statements in Chapter eight.*

seven interviews[48] (see section 6.3.2). Within group maps, there were a number of nodes that did not demonstrate a commonly agreed relationship with any other node, (however the node exists as a common concept). These *floating nodes* are not included in the maps; they infer no causal force. *Floating nodes* were included in the map calculations, as they form part of the mental model, even though they did not infer a causal relationship. In describing the composition of a map three measures were used:

Significant Nodes:

The number of nodes per group ranged from 22 to 26. This demonstrated a small difference between groups. However, the range of results indicated that there are different considerations between groups. Through logic, a higher number of significant nodes indicated a greater number of concepts affecting the mental model of the group.

Arcs:

Arcs represent the total number of relationships between the nodes in the mental model. The number of arcs ranges between 18-27. A higher number of arcs indicated more relationships were articulated between nodes.

Presented Nodes:

There were nodes in each of the group's mental models that did not have an established arc with any other node, these were called *floating nodes*. *Floating nodes* were not presented in the maps but were included in calculations, as they did not demonstrate causal force but formed part of the mental model. *Presented nodes* are nodes, which have an associated arc in the mental model. The difference between significant and presented nodes, gave an indication of how the different concepts were linked in the mental model. The results showed the number of un-associated nodes ranged from 3 to 7 nodes.

[48] *With seven interviews per sample, a majority view required at least four consistent statements between nodes for the arc to be represented.*

Table 6.3 provides a comparison between group maps, highlighting the *significant arcs*, *significant nodes* and *presented nodes*.

Table 6.3 Cognitive Map Summary Nodes and Arcs

Group	Arc	Significant Nodes	Presented Node
Service M-suite	18	22	15
Asset M-suite	24	26	18
Service S-suite	24	24	19
Asset S-suite	27	23	20

Asset M-suite showed the highest number of significant nodes in the group model. However, only 70% (18 of 26 nodes presented) of these nodes had relationships with each other. Whereas, asset S-suite had a high inclusion of nodes into the model; demonstrating a more integrated mental model. In service, there is a corresponding increase between M-suite and S-suite. Service S-suite had a more integrated mental model (19 of 24 nodes), than service M-suite (15 of 22 nodes). This was not due to decreased types or treatments, but inclusion of different influences on the map (e.g. risk tools).

6.4.1 Causal Maps

Figures 6.6 (Service M-suite), 6.7 (Asset M-suite), 6.8 (Service S-suite) and 6.9 (Asset S-suite) present the causal maps.

Figure 6.6 service M-suite Map

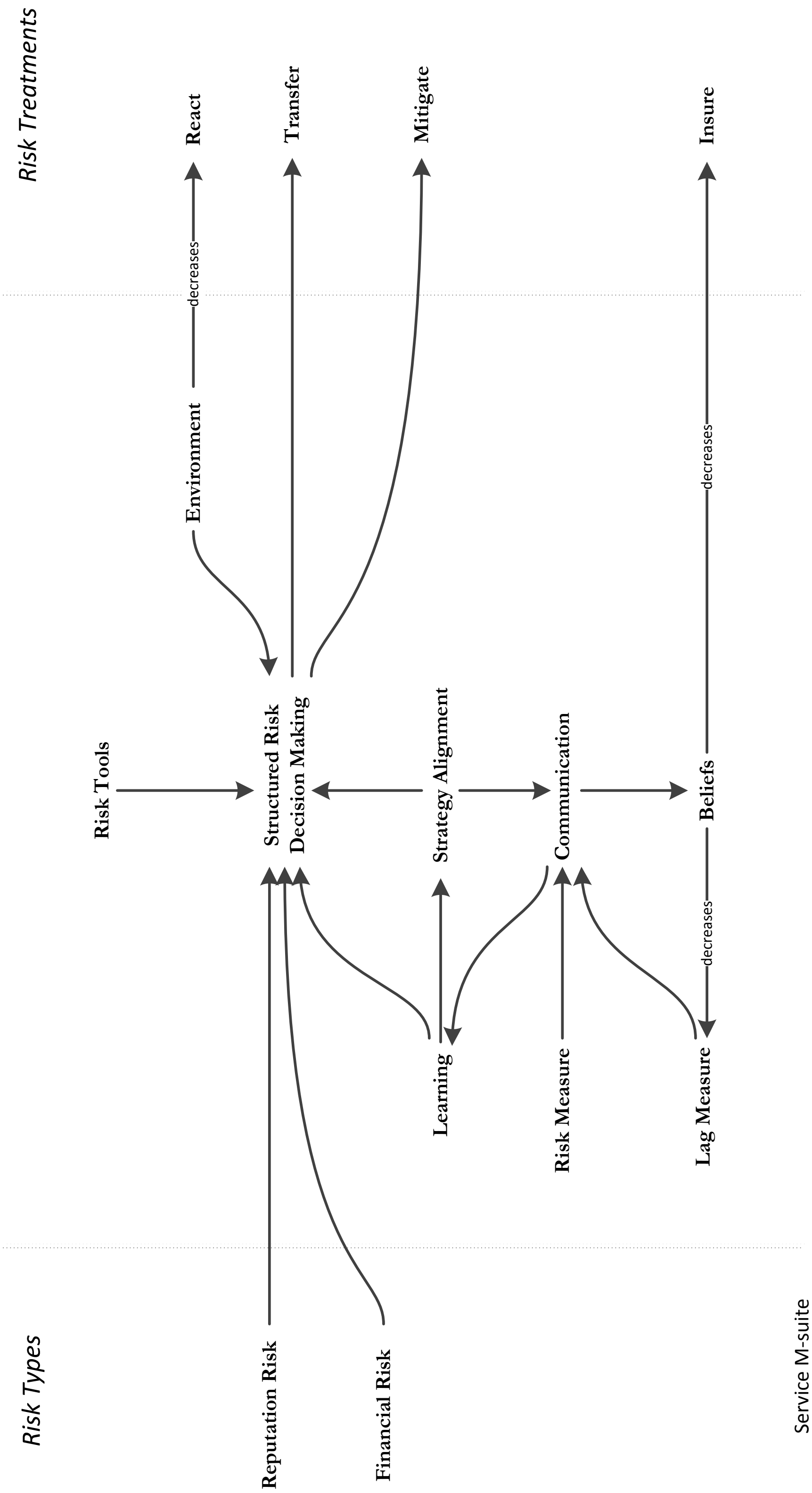


Figure 6.7 asset M-suite Map

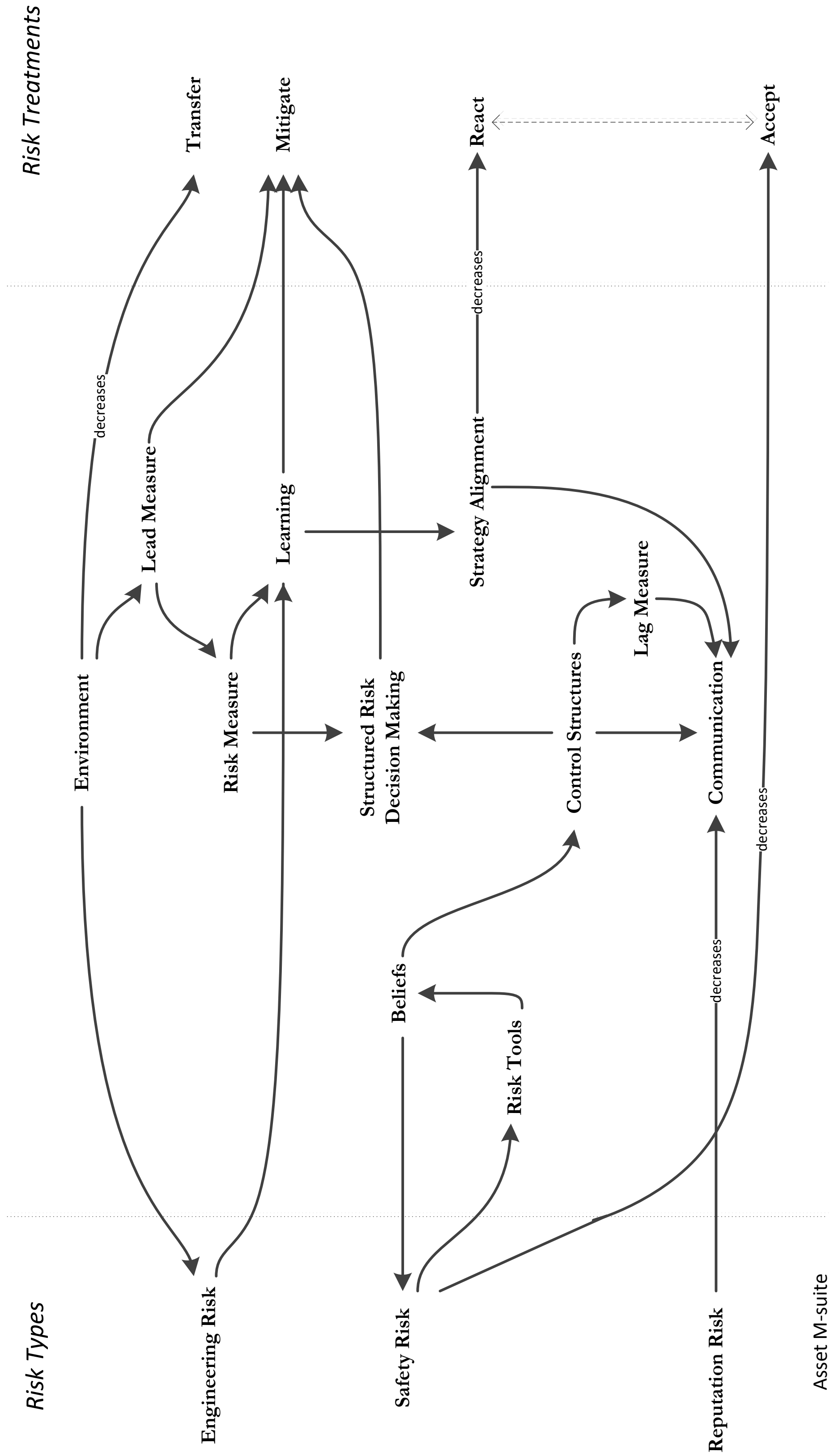


Figure 6.8 service S-suite Map

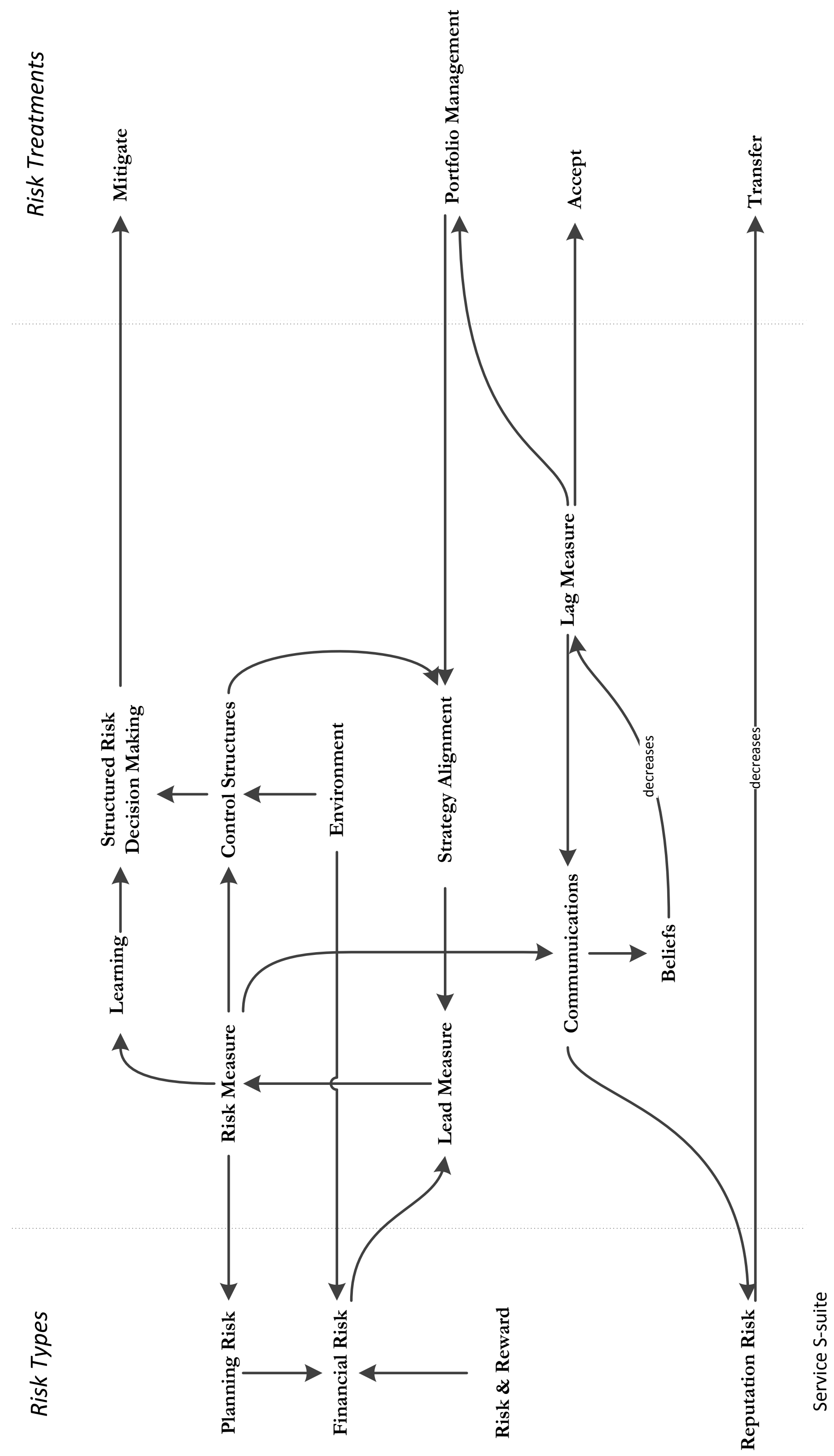
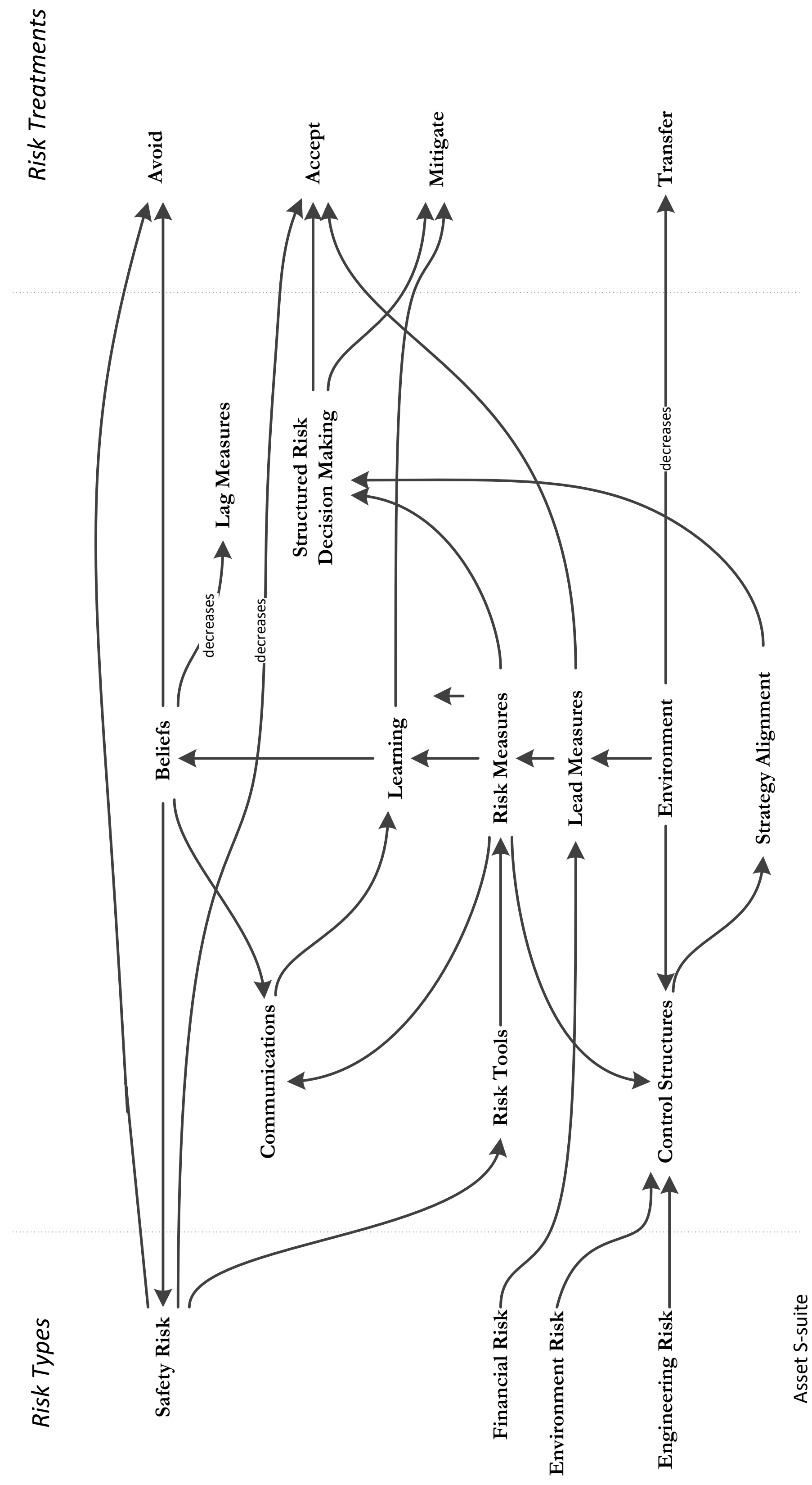


Figure 6.9 asset S-suite Map



6.4.2 Map Complexity (M^C) and Map Density (M^D)

Map complexity (M^C) and density (M^D) calculations describe the relationships between arcs and nodes. They are map level descriptions. Section 6.4.1 established the quantity of different nodes and arcs, this is a relative calculation within each map.

Map complexity calculation (0 – no relationships - 1 relationships between every node) provides a description of the interconnectedness of nodes within the map.

$$Map\ Complexity = \frac{\sum a}{(N(N-1))/2 + N}$$

Where ais the number of arcs and N is the number of nodes

Equation 6.2 Map Complexity Calculation (author)

Map density is a different perspective on the same data, representing the ratio between arcs and nodes, (e.g. a result of 1.2 suggests for every node there are 1.2 associated arcs on the map).

$$Map\ density = \sum a \ / \sum N$$

Where a is the number of arc and N is the number of nodes

Equation 6.3 Map Density Calculation (Armstrong, 2005)

Map Density and Complexity are both map level measures. Map Density provides an average of ratio between nodes and arcs. Map Complexity, demonstrates the degree of interconnectedness.

Table 6.4 Map Complexity and Density Results

	Arcs (a)	*Significant Nodes (N)*	*(N(N-1))/2 +N*	**Map Complexity**	**Map Density**
Service M-suite	18	15	120	.150	1.20
Asset M-suite	24	18	171	.140	1.33
Service S-suite	24	19	190	.126	1.26
Asset S-suite	27	20	210	.129	1.35

These results show that there were limited differences in Map Density between the groups (1.20 to 1.35) indicating more arcs than nodes[49]. The Map Complexity results demonstrated a moderate difference between M-suite and S-suite maps; with higher complexity in M-suite (.140 and .150) than S-suite (.126 and .129). This finds that there were more potential paths in the M-suite maps. With a Map Complexity score of .150, this finds there were 15% of potential paths in the map expressed.

6.4.3 Node Centrality (N^C)

Node centrality is a node level measure. For each group the central nodes were presented. Further, the nodes of central influence and central outcome affect are identified. The difference between central influence (the causal influence in the model) and central outcome affect (a centrally affect node) are explained in figures 6.10 and 6.11.

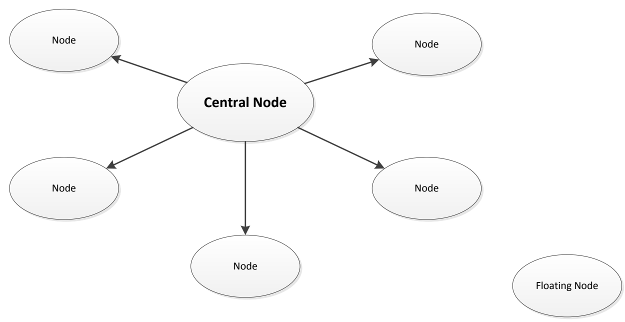


Figure 6.10 Nodes as Central Influence

[49] *This calculation is performed before removing the floating nodes.*

Figure 6.11, demonstrates where the central node was the central outcome affect. The central outcome affect node was the consequence of the other nodes.

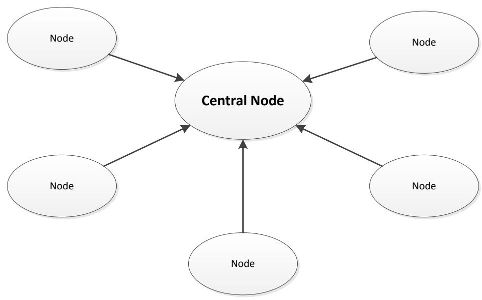


Figure 6.11 Nodes as Central Outcome Affect

This measure was specific to each node in the map. A high centrality score (relative to other nodes on the map) indicated the importance of that node in the mental model. Table 6.5 compares the central nodes for each group. The top result was *Structured Decision-Making* (SD-M); it had the greatest power across all maps.

Table 6.5 Group Node Centrality Scores

	Central Node	N^C *	**Central Influence**	N^C *	**Central Outcome**	N^C *
Service M-suite	SD-M	*.53*	Communications	*.17*	SD-M	*.33*
Asset M-suite	Control structures	*.22*	Safety	*.13*	Communications	*.17*
	Communications	*.22*	Environment	*.13*		
	Learning	*.22*	Control structures	*.13*		
Asset S-suite	Measure (RM)	*.25*	Measure (RM)	*.17*	Financial	*.13*
	Belief	*.25*				
	Control structures	*.25*				
Service S-suite	Measure (RM)	*.26*	Measure (RM)	*.15*	Control structures	*.11*
			Belief	*.15*		

N^C: Node Centrality, this only includes the number of arcs i.e. either incoming (affect) or outgoing a specific node divided by the total number of arcs. Top nodes from each group are provided in a centrality table.*

This difference between being an influence or outcome was seen in the *communications* node, which in service M-suite was a significant influence node, and a significant affected node in *asset* functions. This analysis demonstrated that there were very different central influences on the mental models between groups. However *Risk Measures* appeared as the central node for each function's S-suite, where it was not central for M-suite. Asset (M-suite and S-suite) identified no dominant node, as the top centrality score was shared across three nodes.

Table 6.6 summarises the top 15 nodes and how these compared in usage across maps.

Table 6.6 Group Node Summary

Node Centrality (N^C)		**Asset M-suite**	**Asset S-suite**	**Service M-suite**	**Service S-suite**
SD-M*	*Node*	0.17	0.20	0.53	0.16
Communication	*Node*	0.22	0.15	0.33	0.21
Measure (RM)	*Node*	0.17	0.25	0.07	0.26
Learning	*Node*	0.22	0.20	0.20	0.11
Belief	*Node*	0.17	0.25	0.20	0.11
Control structures	*Node*	0.22	0.25	-	0.21
Strategy alignment	*Node*	0.17	0.10	0.20	0.16
Environment	*Node*	0.17	0.15	0.13	0.11
Measure (Lead)	*Node*	0.17	0.20	-	0.16
Measure (Lag)	*Node*	0.11	0.05	0.13	0.21
Mitigation	*Treatment*	0.17	0.10	0.07	0.05
Acceptance	*Treatment*	0.11	0.15	0.07	0.05
Safety	*Type*	0.17	0.20	-	-
Financial	*Type*	-	0.10	0.07	0.00
Risk Tools	*Node*	0.00	0.05	0.07	-
Reputation	*Type*	0.06	-	0.07	0.11
Transfer	*Treatment*	0.06	0.05	0.07	0.05
Engineering risk	*Type*	0.11	0.05	-	-
Portfolio management	*Treatment*	-	-	-	0.11
Avoidance	*Treatment*	-	0.10	-	-
Insure	*Treatment*	-	-	0.07	-
Planning risk	*Type*	-	-	-	0.05
Environment risk	*Type*	-	0.05	-	-

Structured decision-making (SD-M)*, was the top node in discussion and linkage. Communication, similar to the firm-level analysis is the next major node, there was a difference between S-suite and M-suite that *communication* is an influence in M-suite and a outcome affect node in S-suite; this is a major change in understanding within the same function. The performance management system components (i.e. lead measure) featured high in the node table, as did the *Belief* node. It showed an increasing interest in understanding managerial beliefs in the mental models.

6.5 Group-Level Thematic Analysis

The data from the interviews were thematically analysed, using the same method as firm and function-levels. The thematic categories are summarised below in table 6.7.

Table 6.7 Inductively Developed Thematic Categories (Group-Level)

Category	**Thematic Category**	**Key Terms**	**Characteristic Level 3 responses**
Questions sought: What approaches do you employ to achieve these goals? What leads you to choose between different approaches in managing risk?			
G1	Decision-Making	Structured decision-making, rationality and intuition	*"The criteria for reaching a risk response is controlled through the risk reporting software" (M-Suite, Asset)* *"No system is going to tell me what the right thing is to do, I make 100 of these decisions a day…" (M-suite, Service)*
G2	Barriers	Levels of authority, requirement for committee approval	*"In order to make this investment [for mitigation] I need to seek approval through the budget line" (M-Suite, Asset)* *"These [outsource] are big, strategic decisions, ones that require the intelligence and insight of the managing board to adjudicate on" (S-Suite, Service)*
G3	Subjective influences	Reference points, subjectivity and experience	*"I don't care what the policy is, I experienced the fall out of the last death. No policy would have mitigated against it" (S-Suite, Asset)* *"The OEM data is always low, over the last 5 years we have always improved on their stated figures" (M-Suite, Asset)*
G4	Environment pressure	Time pressure, data quantity	*"The environment moves so fast, it isn't about the optimal choice, but a good choice" (M-Suite, Service)*
G5	Decision order	Directives, Rules, Beliefs, Morality and Experience	*"We don't hurt people, that is our mantra… so you can't be taking risks when it comes to safety" (M-Suite, Asset)*

6.5.1 Decision-Making (G1)

The first of the group-level themes reflected on the way managers perceived their structure of decisions.

Asset S-suite managers reflected on engineering practice and engineering skills, and a high value was given to a structured decision process. A decision, regardless of the time pressure needed to be methodically thought through, distilling the important influences, but then understanding the complexity of the environment to reach an informed decision:

> *"The environment we operate within is complex, but actually very stable, this means that a methodical approach can be taken to robustly describe the problem being faced. We use the experience and knowledge of our engineers to achieve this. This then allows us to reach a plan of action in a considered and defendable method"* (Asset S-suite).

Service S-suite managers demonstrated a conscious approach to their complex environment, acknowledging the velocity of their environment. In contrast the environment was less stable than in generation. The decisions that were made relied less on engineering science, but the experience within their management community:

> *"The framework we operate within is unhelpful, as it provides limited alignment to the reality of what is being faced. So the challenge is to provide a logical development of the risk being faced, relating to past issues, experienced both within [the firm] and from previous organizations we have worked"* (Service S-suite)

Asset M-suite managers reflected much of their senior colleagues, that the engineering discipline had led them to think in structured approach. Further that although they might not reach an optimal solution to a problem being faced, they could differentiate between a good and bad decision:

> *"There is no excuse for making an incorrect engineering decision, but the search for the perfect solution may be the difference between days of analysis and months of analysis.*

The benefits of the perfect solution may be offset by the sheer time it takes me in the extended analysis. But to face peer review and challenge means you have to be able to articulate the influences on your choices" (Asset M-suite)

The major difference in the structure of decision-making appeared in M-suite service managers, this was justified as a product of the number and speed of the decisions they had been facing. It exposed a lack of structure or reasoning, as they were perceived as making independent and transactional decisions:

> *"You know what is right and wrong, this place moves at a speed that doesn't benefit from or reward a drawn out thinking process. It is like the infantry officer who reacts by instinct, and then only at the end of battle reflects on what they have done. Welcome to retail."* (Service M-suite)

It was seen that S-suite managers were consistent in their need and approval of highly rational and reasoned decision-making; the levels of investment and complexity of the environment requiring, rather than prohibiting, a need for structure. Asset managers demonstrated the role of the risk valuation systems as part of this structuring:

> *"The criteria for reaching a risk response is controlled through the risk reporting software" (Asset S-suite).*

It was seen that the difference in decision-making was a combination of both rationality, reasoning and in service (M-suite) the use of intuition. Intuition was explained in asset managers as knowledge and experience that was used in broader decision-making.

6.5.2 Barriers and Treatments (G2)

The second theme exposed, were the barriers to decision-making. These barriers were separated between individual authority (based on seniority or role) and collective authority, where the: *"Intelligence and oversight of the group is paramount in decisions of this magnitude"* (Service S-suite).

It was perceived that selection of some treatments was a strategic decision, for example: withdrawal from a market or operation and the decision to outsource. In these cases it was felt that these were decisions taken by executive members of the organization:

> *"This is a significant strategic decision to remove ourselves from the marketplace"* (Service S-suite)

This was a product not only of the levels of capital being committed but the permanence of the commitment. The authority to make these decisions resided in the S-suite and sometimes had to be a *"decision of executive consensus"* (S-suite, FCORP). Therefore the decisions to take these risk treatments were not available to the individual managers, regardless of seniority. Further there was an understanding of relative cost of treatments:

> *"There are basic thresholds where a plant manager needs to seek the approval of the managing board"* (Asset S-suite)

The difference in perception between cost of mitigating impact and mitigating probability was consistent. Mitigating probability was seen as a cheaper, but more specific treatment for example implementing quality control steps in the process:

> *"I can make simple low cost process changes, that act as a control to ensure these events do not materialise"* (Asset M-suite)

The reduction of event impact was much more organizationally challenging and expensive:

> *"in a systems thinking approach, impact reduction is a far more reliable treatment, but expensive as it requires greater capital investment"* (Service, M-suite).

These accounts infer an order that impact mitigation is more expensive than probability mitigation. The cost of treatment further inferred the level of organizational authority needed to reach a decision.

The costs and permanence of decisions were articulated across the accounts of participants in interview. Table 6.8, provides evidence to the main treatments discussed:

Table 6.8 Treatment Authority, Cost and Permanence

Treatment	Authority	Cost	Permanence
Avoidance	**Collective** *"This is a significant strategic decision to remove ourselves from the marketplace, and a matter for the senior management team"* (Service S-Suite)	**High** *"The investment made in entering a market is significant, therefore when you decide to extract the organization, this comes at a significant abandonment of investment"* (Service S-Suite)	**High** *"The reality is once you have come out of a market, management and shareholders will not support a re-entry, it is a one-way street"* (Service S-Suite)
Acceptance	**Individual** *"It is within my discretion to accept Operational risks"* (Service M-Suite)	**Low** *"Accepting a risk costs you nothing, until it all goes wrong, where the costs can then be very high"* (Asset M-Suite)	**Low** *"On accepting a risk, I can immediately change my mind, and decide on another action… this is sometimes just a holding point"* (Service S-Suite)
Insurance	**Collective/Delegated** *"The framework contract for insurance is managed by the corporate centre, however I choose which assets to insure"* (Asset M-Suite)	**Moderate** *"Insurance is about reducing the variability in paying for failure, but the insurance companies make their penny, and you pay for that also"* (Service S-Suite)	**Low** *"Insurance lasts as long as you renew it, however we get lazy and don't challenge what we are insuring so the list grows rather than being efficient in its use"* (Asset M-Suite)
Outsource	**Collective** *"The decision to outsource is made in consultation with the broader managing board"* (Service S-Suite)	**High** *"Outsourcing is an expensive choice, it seems cheap when you first start, but the costs grow and grow as time goes on. You can mitigate to a degree by having a Rottweiler of a contract manager"* (Service M-Suite)	**High** *"No-one outsources for a year, these are deals almost in perpetuity, all be it with different suppliers. A slight change in the market, that has seen a few reversals, but the reality is once you lose the operation it has gone for good"* (Service S-Suite)
Mitigation (impact)	**Individual (senior)** *"Designing in redundancy is a strategic decision, and is a fine balance, and one I would expect to be consulted upon"* (Asset S-Suite)	**High** *"Designing in redundant plant, costs up front, and in long-term maintenance. Plus successive managers look at the unutilized plant and see it as waste"* (Asset M-Suite)	**Moderate** *"Once the plant is bought, you are committed, you can bring it into primary production but this is rare and sometimes move it around the fleet depending on the component"* (Asset S-Suite)
Mitigation (probability)	**Individual** *"I can make simple low cost process changes, that act as a control to ensure these events do not materialise"* (Asset M-Suite)	**Moderate** *"There is always a cost to control measures, but this is often hidden. Each small addition adds up. It is like boiling a frog…"* (Service M-Suite)	**Moderate** *"I can deploy simple process changes quite quickly within my operation, but as the practice permeates across the organization, it can become harder to modify or undo"* (Service M-Suite)

The balance between providing authority limits to decisions and the continued ownership by M-suite was highlighted as a problematic area, that where a risk or its selection of treatment had been escalated to S-suite, M-suite managers lost attachment to the issue:

> *"It is somewhat a cathartic activity, where managers refer a decision to me, they also feel no long-term responsibility. What they need to understand is that they are the owner of the risk, and I operate as a check and balance to the investment being requested"* (Service S-suite)

However this view was different in M-suite, finding that the process of presenting a treatment decision to either senior management or to managing boards, was a bureaucratic exercise. The extended process served to separate them from the risk decision process:

> *"Because the notification process is so protracted, the report so inflexible and the timescales extended. As soon as I need senior management approval for investment, and not forgetting the decision is made behind closed doors, I have very little to do with influencing the decision. One day I just get told I either have or don't have the budget. It is much better if I can find another way within my authority to get it done, even if it is only a partial solution"* (Service M-suite)

It was seen that there were seniority and collective decision barriers in reaching risk treatments. Further that this process was divisive in maintaining lines of ownership.

6.5.3 Subjective Influences (G3)

There were a number of subjective influences on the selection of risk treatments. This seemed unaffected by the level of formal reasoning in the process (section 6.5.1); in particular the memory of previous events and using comparisons with stories and experiences. These influences permeated across all levels and function types.

Asset managers, who were confronted with safety risks (e.g. the risk of employee fatality), referred to previous health and safety issues throughout their decision process:

"I wasn't the plant manager at the time, but I was part of the investigation team in the enquiry… It wasn't so much that he died, but the way in which he died and the young family left behind him. I never forget it, and although policy is good, policy can't cater for all situations… Now that I have that responsibility [plant manager] it [the investigation] is the first thing I think about" (Asset S-suite)

The scale of reference did reduce in M-suite, but also demonstrated a reliance on previous experience and events:

"The young lads have a different mentality, they just haven't been around long enough to experience when things go wrong. It is my role as senior engineer to keep them safe until they have acquired that knowledge. There are some things in this place that look benign, but I am ultra-cautious of them, because I have seen what really happens if you get complaisant" (Asset M-suite)

In service functions the focused moved from the safety issues to financial and reputational risks. The difference between S-suite and M-suite perspectives was only different in the level of significance to them and the organization:

"If we get lazy I can see the same issues appearing in this business as the new connections business, and fearing a big financial loss the management team turn against you. Before you know it you are either being broken up or sold off to the highest bidder" (Service S-suite)

Service M-suite accounts demonstrated a greater fragility in their position within the organization and that in middle management perceptions of performance was attributed to recent activities and not the long-term good an individual had delivered:

"There was a story of [middle retail manager], years of high performance, and one bad customer who went to the press. It got regional coverage for about 2 weeks. 2 weeks later he carried the can and found himself in the departure lounge. So you must always insure [sic] you have your parachute packed!" (Service M-suite)

Throughout the interviews there were references to stories and events in the organization, which the managers reflected upon in influencing their decisions. These provided a significant subjective influence[50].

6.5.4 Environment Pressure (G4)

The fourth theme was the awareness of the environment. There were specific influences in the context of their operation, which affected the risk management decision process. In service and asset functions there was a perception of high volumes of information that required processing. However, in service functions there was the additional perceived influence of time pressure in making the decision:

> *"It is all about identifying the important issues and spending time on these. The daily risks being faced, you just deal with quickly, it is a law of averages, and as long as you get the bulk of them right you can stay afloat"* (Service M-suite)

Service S-suite saw the role of their subordinates as having done the detailed analysis, distilling the important factors and presenting discrete decisions for approval:

> *"I don't have the time or the process knowledge to manage the detail of each risk, and it is a bad indication where I have concern and dive into the operation, a line manager should be worried where I do... They need to make sense of their complex world to give me confidence in their analysis, and present me a range of options for challenge… I need to connect up all these different silos into one cohesive picture to manage the overall risk bearing in the business unit"* (Service S-suite).

Asset functions, demonstrated an influence of changes in the level of analysis between S-suite and M-suite managers, but also inferred a detailed understanding of the operation at senior levels:

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[50] *Many of the stories were second or third hand, and notably there were repeat stories that through evolution had changed to reflect their own circumstances.*

"This is a fairly standardised environment, and engineering has a core set of principles which I as the Chief Engineer feel I can offer to assist the line managers. However we operate at different levels of analysis, by the time a decision reaches me it has often been aggregated to a level where I need to unpick it to get back to the real operational concerns in hand. But I also need to operate in a world that non-engineers can understand, sadly that is too often an expression of capital" (Asset S-suite)

The engineering discipline appeared as a common language between M-suite and S-suite asset managers. However M-suite demonstrated their limitations of visibility:

"Engineering practices are a common language, regardless of seniority we can converse with each other. However they [senior managers] have an appreciation of what is happening across the fleet. The volume of data I am managing is significant, and they [senior managers] can't be expected to know the detail as much as me… I'm sure I could learn loads from my counterparts in other plants, but there just isn't the time" (Asset M-suite)

Therefore, a difference between service and asset managers appeared pronounced in the interaction between S-suite and M-suite managers. The engineering language appeared as a means of maintaining links between these two communities.

6.5.5 Decision Order (G5)

The final theme that appeared in the interviews was the awareness of an order to decision influences. It appeared in the analysis that three categories of decision-making influences could be established. These were:

1. Organizational directives, which were the first instinctive response of a manager: *"It [an organizational rule] is an instinctive response for everyone, you don't even go through a thought process"* (Asset M-suite);
2. Individual beliefs:

"I fundamentally believe that we have the morale obligation to ensure people go home to their families at the end of the day" (Asset S-suite); and

3. Reference to the performance management system:

"where we have flexibility in the decisions being made, you have to interpret through the broader targets in the organization how you may impact performance" (Service M-suite).

These influences are shown in figure 6.12.

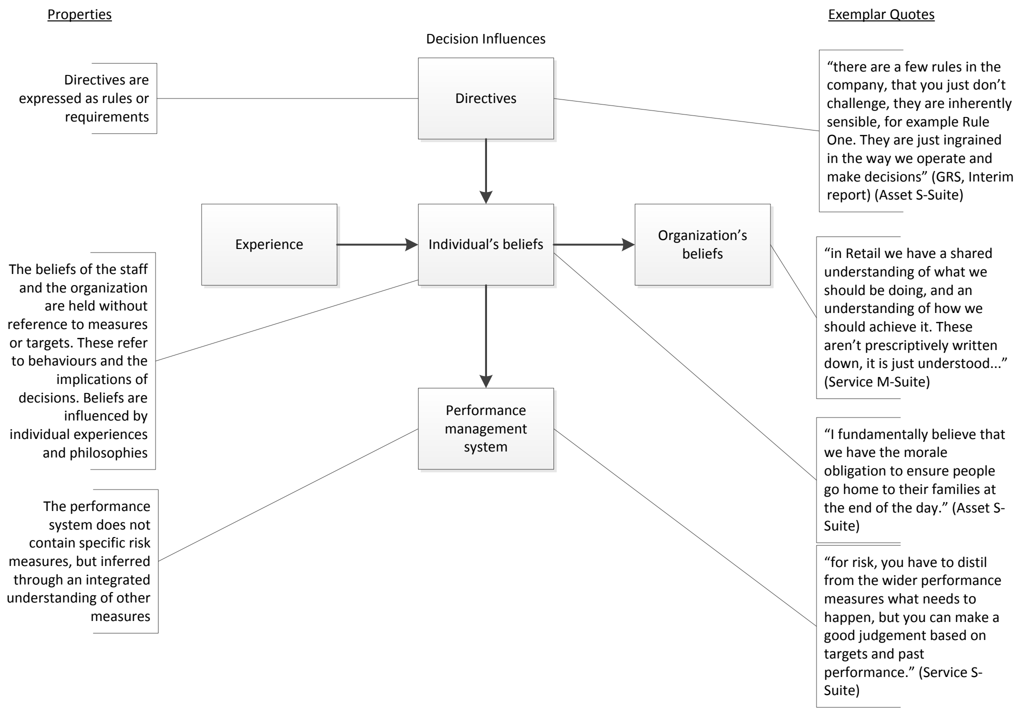

Figure 6.12 Decision Influences

There was shown to be an order of these decisions when faced with uncertainty. The instinctive responses (defined through rules) were supplemented with and later justified by the beliefs of the individual. Individual and organizational beliefs were found to be reconciled by managers, for example:

"Do I influence the way the organization thinks or have I just become part of the corporate machine? I would like to think it is a bit more symbiotic than either extreme, we reconcile our views with the company and in doing so influence the way the organization thinks" (Service M-suite)

It was found that reference to the stated performance measures was made where an individual's beliefs hadn't previously defined the outcome. However it was seen that an interpretation of the broader performance measures was required to make sense of these decisions:

> *"If the decision isn't obvious then I will try align the decision to the broader performance requirements of the organization, but this isn't always obvious, and there is some level of interpretation required"* (Asset S-suite).

The order of these decision influences is summarised in figure 6.13.

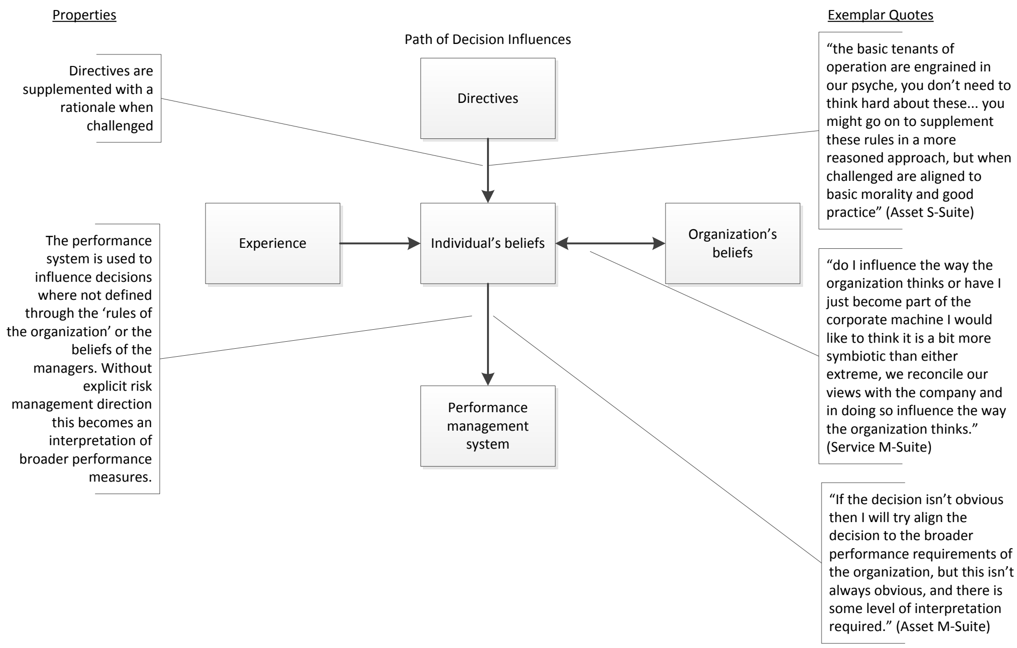

Figure 6.13 Order of Decision Influences

The final finding was the formative influences on individual beliefs and the creation of directives. It originated from the interpretation of organizational performance measures, which translated into beliefs of the managers in how they should achieve these objectives, for example:

> *"In order to achieve the company's targets, I believe you must be consistent in developing a good reputation, I suppose this is managing reputational risk… It isn't defined, but an understanding you develop"* (Service S-suite)

It appeared that the directives (e.g. Rule One, we don't hurt people) had been formed through evolution of individual and collective beliefs. These beliefs were so fundamental to the operation of the organization that they were established as organizational rules, these may even be considered organizational beliefs. Figure 6.14 outlines these formative influences.

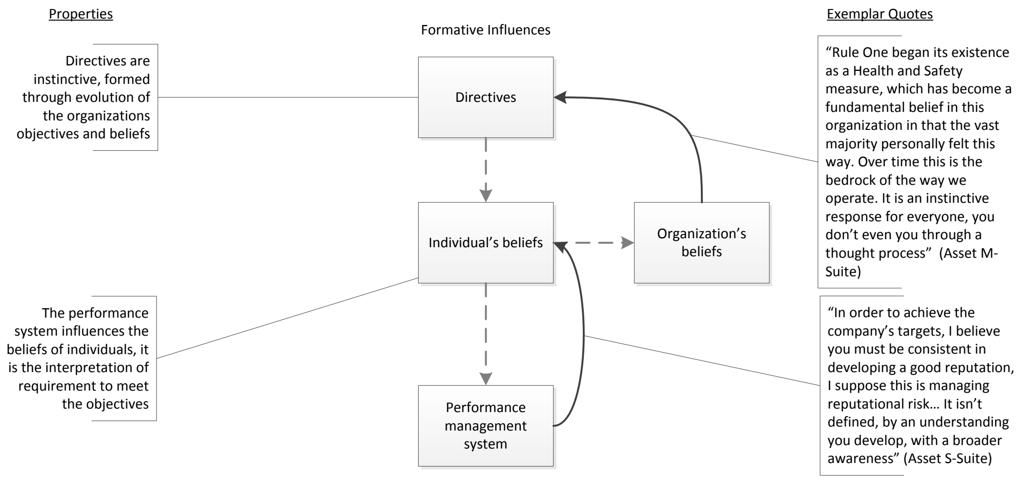

Figure 6.14 Formative Influences

This analysis demonstrated both an order of decision influences and further the process of establishing these different influences.

The influences shown in the thematic analysis, complemented the causal map analysis, it demonstrated the subtly and subjective influences of the decision-making process in selecting risk treatments. The next section combines this understanding, beginning with a review of the conflicts within groups.

6.6 Discussion

6.6.1 Causal Maps: Intra-Sample Conflicts

Four group maps were created. The maps represented the average opinion of that group.

However although rare, there were cases where accounts within group that contained conflicts in understanding. These were intra-sample conflicts. These were points of disagreement occurring within the group. The intra-sample conflicts were found in cases of M-suite managers. There were three specific intra-sample conflicts:

- Disagreement in direction of causation between *reputation risk* and *communication* nodes. Asset M-suite;

  The majority view was that *reputation risk* causes a reduction in *communication* of organizational measures. The alternate view was that (good) communications decreases potential reputational risk.

- Disagreement in direction of causation between *communication* and *belief* nodes. Service M-suite;

  The majority view was *communications* influences *belief* of the manager. The alternative that use of *communication* is an outcome of the manager's personality and belief set. This would reverse direction of causation.

- Disagreement as whether, *lead measures* and *risk measures* were equivalent concepts, or separate in understanding. Service M-suite; [51]

  The majority (4) view against alternate view (3) was close; between perceptions that *lead measures* influenced the concept of *risk measures* or vice versa; the former dominated.

6.6.2 Dominant Risk Types

Risk types were different descriptions of risk (Ackermann et al., 2007). Respondents used different descriptions during interview. The causal maps showed risk types on the left hand side. These were represented as inputs of the decision process. Many respondents were able to list the different risk types that were important to their roles. There were some risk types that had very specific outcome and consequence in the decision process.

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[51] *This conflict existed before the separation of LAG and LEAD measures, as recommended by the reviewers. Articulation of the conflict was improved following the revision.*

There was agreement between samples to terms used in describing risk types; this was consistent with firm and function-level analysis (e.g. *Safety Risk*), it was a common term through all levels of analysis. An unexpected result was that all samples identified *Reputational risk*. *Financial* risk occurred with greater regularity in service and in asset functions the terms: *Engineering risk* and *Safety risk* was used with greater regularity, see table 6.9.

Table 6.9 Risk Types

		Reputation	**Financial**	**Engineering & Safety**	**Environment**	**Planning**
Asset	M-Suite	■		■		
	S-Suite	■		■	■	
Service	M-Suite	■	■			
	S-Suite	■	■			■

At firm-level *Financial*, *Safety*, *Environment* and *Reputation* risk were all used as descriptions of risk types in investor and public communications. The group-level analysis exposed a number of other descriptions of risk: *Engineering* and *Planning*.

6.6.3 Dominant Risk Treatments

Risk treatments were the approaches to manage risk. These were the *goals* in the causal map and placed on the right hand side.

Participant reference to types of risk treatments was extensive and language used to define the risk treatments was consistent (e.g. mitigation). The list of treatments extended beyond the foundational literature review, which included: accept, transfer, insure, outsource, avoid, mitigate and option taking. The treatments identified within the group maps are summarised in table 6.10.

Table 6.10 Risk Treatments

		Acceptance	Acceptance (React)	Transfer (O/S)	Transfer (Insure)	Mitigate	Hedge/ Portfolio
Asset	M-Suite	■	■	■		■	
	S-Suite	■		■		■	
Service	M-Suite	■	■	■	■	■	
	S-Suite	■		■		■	■

There were additional treatments being identified: hedging and portfolio management. *Hedging* was described as: *"the activity of offsetting upward movements in the environment with highly correlated downward movements"* (Service S-suite, GRS). Therefore where an aspect of the market causes a loss, there was an equal and opposite reaction resulting in gain. This highly developed understanding reflected on the financial and energy markets. There was limited mention of hedging in any asset manager's account.

Portfolio Management was understood in a similar manner. This was described as *"a bucket of concerns, some which will return better than you thought and some that will do worse than you expected, net effect will be close to your prediction, and hopefully positive"* (Service S-suite, FCORP). This was understood to reduce sensitivity to any single operation, activity or marketplace, by reflecting on the result as an aggregated set of issues.

There was contention in understanding the difference between risk acceptance, reactive management and risk taking. They all appeared to result in the same course of action: do nothing. However the accounts demonstrated a subtlety to this distinction:

- *Reactive management* was criticised for a focus on developing a response function, where there was a lack of attention to risk identification;

- *Risk acceptance* was seen as a passive activity of deciding that the risk did not meet the *"hurdle rate"* for the next level of treatment (i.e. an active treatment was more expensive than the perceived impact);

Risk taking was seen as a different mind-set, which does not create a judgement relative to cost of treatment, instead it was the decision to take a risk based on an *absolute judgement* that the organization wished to retain the risk as identified.

In developing the causal maps *reactive* management and *risk acceptance* were left as unique terms as they inferred different perspectives on the same treatment.

6.6.5 Influences on Decision Process

There were several influences on the decision process exposed. The first was the difference between *intuitive* and *reasoned* decision-making (section 6.5.1). The second was the influence of *time pressure* and *information load* (section 6.5.3). The third was the influence of *biases* (section 6.5.2), and finally an inference on *decision strategy*. These are discussed in turn.

Firstly, Kahneman (2003) separated the difference between *reasoning and intuition* as two types of decision-making; whereby intuition is a decision process requiring little reflection, quick and almost instant (cf. Hodgkinson et al., 2008). Reasoned decision processes in contrast are deliberate and calculated. In the analysis of manager's decision processes (section 6.5.1), it appeared that asset managers were characteristic of *reasoned* approaches, and influenced in this activity by the existence of both the embedded risk systems (section 5.3.1) and the engineering discipline. Service S-suite managers demonstrated a reasoned decision process. Whereas, service M-suite provided evidence of intuitive practices, for example the quick response to previously similar conditions. The use of intuitive practices was understood as a by-product of time pressure and information volume in their environment.

Secondly, Payne et al. (1988) suggest that both *time pressure* and *information load* affect the decision process. Time pressure causes a number of coping strategies to be employed: acceleration, filtering and change from *compensatory* to *non-compensatory* decision strategy (Maule & Edland, 1997). *Filtering* was evidenced in service M-suite managers, as they selected the critical risks for greater attention (section 6.5.1). Therefore two different approaches were seen: for the volume and low-level risks, the manager was responding intuitively (and quotes reflected this was based on a law of averages), and the top risks were filtered out for a reasoned assessment.

However, this was not the only evidence of coping strategies being used, in the case of S-suite managers there was an expectation that *filtering* (Maule & Edland, 1997) was completed by their subordinates to reduce information load on senior level decision-making. Therefore both individual and organizational *filtering* of decisions was performed.

Thirdly, *biases* in decision-making were evident. Critical incidents were highlighted as reference points. Asset managers were dominated by safety incidents: including the process, the organizational impact and the personal impact this had on them. It was notable that *weighting* (Tversky & Kahneman, 1981) and *framing* (Marteau, 1989) provided through interpretation of performance system measures or targets did not feature in the accounts. Instead, there was a clear move away from needing to demonstrate *formal rationality* (Chater & Oaksford, 2000) in decisions regarding safety, for example the dismissal of documented procedures or valuations. This was a move explained by Sullivan-Taylor and Wilson (2009) as *ludic fallacy* (section 2.6.7), the perceptions of managers in what may happen based on experience.

Biases were evident in several forms. There was *projection bias* (Hsee & Hastie, 2006), where the decision-makers situation affected the decision, for example the consideration of losing one's job. This encouraged *loss aversion* (cf. Wiseman & Gomez-Meija, 1998), for example a fixation to protecting against loss, even where it was improbable. There was a dominance of *memory bias* (Hsee & Hastie, 2006), where past accounts had had such a significant bearing on the individual that the experienced outcomes (i.e. safety) were over-weighted in the decision process. In service managers, the dominance of health and wellbeing (in asset functions) was replaced by the dominance of reputation as the critical measure.

It was inferred in the causal maps and the thematic analysis, that two different decision strategies were used: *compensatory* (the weighting of multiple attributes, seeking optimal solution) and *non-compensatory* (the reductionist approach to selecting the best option on a few key variables) (cf. Payne et al., 1988). Combining the understanding in section 6.5 and 6.4, the S-suite managers were seeking *compensatory* strategies to be employed, even where the aggregated presentation of risk (as it arrived with them) had already reduced the decision attributes. This conformed to the need for optimal investment decisions to be made (cf. Pennington & Tuttle, 2007). In service M-suite managers the impact of time pressure and the volume of decisions resulted in *non-compensatory* strategies being employed, therefore reducing the cognitive load (Wedell & Senter, 1997) and *filtering* the information volume in a time pressured environment. In asset M-suite managers the presence of risk decision tools (i.e. risk register), enabled greater appreciation of historical data, and although time pressure did not always allow for an optimal solution to be found, the decision was reasoned and selected on specific attributes. This was characteristic of *Lexicographic* or *Semi-Lexicographic* strategies being employed (cf. Payne et al., 1988). The difference in strategy appeared to be an outcome of a complex relationship between the environment (time pressure and information load), the seniority (and hence filtering of subordinate staff) and the culture (including experience and professional standards).

Having highlighted the difference between groups, the discussion continues to analyse where there were commonalities between groups and converging mental models.

6.6.6 Map Commonality

To understand how similar the different models are between groups, figure 6.15 provides a quantitative comparison[52]. This is calculated as a fraction of the number of shared arcs between groups.

[52] *This calculation is completed as the number of shared arcs divided by the sum of unique arcs between groups; 0 indicates no shared arcs and 1 indicates all arcs are shared between maps.*

	Asset S-suite	Asset M-suite	Service S-suite	Service M-suite
Asset S-suite		**0.32**	**0.13**	0.02
Asset M-suite			0.02	0.05
Service S-suite				**0.11**
Service M-suite				

Figure 6.15 Shared Arcs between Groups

There was a commonality amongst all maps (0.02) this represented a single arc being shared. The commonality between M-suite was limited and not discussed (0.05).

Shared aspects of metal models were found between:

- Service managers (0.11);
- Asset managers (0.32);
- S-suite managers (0.13).

There was a contrast between S-suite and M-suite maps. There was a level of commonality between S-suite maps across functions. There was minimal convergence in M-suite decision maps between functions.

There was a single cause-effect relationships appearing across all four maps, and a number of shared treatments and risk types:

1. Structured decision-making led to mitigation treatments;
2. Reputation risk was common;
3. Use of outsourcing, mitigation, and acceptance treatments were common across all maps.

6.6.7 The S-suite Manager

Analysis across the two functions (asset and service) in S-suite highlights two areas of commonality:

- A common mental model of measurement through to strategy, this was the *core model* encompassing six nodes; and
- Risk measures were the central node.

The S-suite Core Model:

There was consistency in map, between six of the nodes: *control structures*, *environment*, *strategy alignment, lead measure, risk measure and learning*. Some of this relationship may seem intuitively obvious; however it was only common in S-suite (Asset and service). Figure 6.16, identifies the common nodes and arcs in both S-suite maps (asset and service).

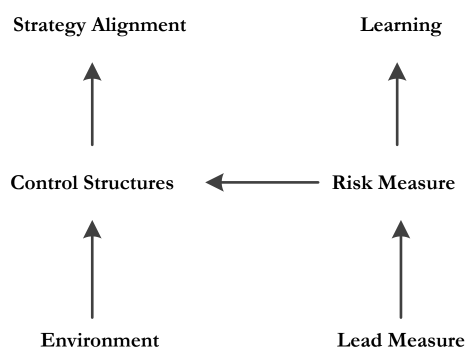

Figure 6.16 S-suite Core Model

This shows that the *environment and risk measures* influenced *control structures. Control structures* influenced *strategy alignment*. Independently *lead measures* influenced *risk measures* which influenced *learning*. Taking each of these nodes in turn:

Environment was the context in which the organization existed, respondents existed within similar markets and influenced by European cultures (chapter 4). It included the national influences, market influences, dynamics such as regulation and legislation. It included both macro and micro constraints, for example:

"a major risk is compliance and that is financially orientated, and regulatory compliance in the financial area" (Service, S-suite).

Control structures were the influence and role of executives (including corporate functions). They were the line of authority within the organization. They included internal and external audit functions.

Strategy alignment was the strategic statement of the firm, including vision and missions; it included the activities in the organization to map the strategy into the performance system. As a performance system it was most often seen as an issue of mapping or interpretation of vision and mission into operational priorities and targets (cf. Kaplan & Norton, 2000). The node represented the degree of coupling between operational activities and strategic statement. This included: risk appetite, control of objectives, CSR and developing strategic thinking in the organization. For example:

"…because if you can quantify you can set levels and you can determine and take a look at the risk appetite and you can determine where you want to go" (Asset, S-suite)

This didn't reflect the choice that organizations had to enter or leave certain environments at their discretion; this was identified as a *withdrawal* risk treatment.

The second relationship was consistent with understanding that the executive role was to develop a strategy and influence its delivery. This can be completed both through the performance system as well as the risk management process. *Control structures* had a causal influence on *strategic alignment*. This prescribed to the top-down perspective of control in an organization.

The Risk Measure was Central:

S-suite node centrality scores showed that *risk measure* was the central node for both asset and service (N^{C}= .21 & .22). It appeared as an influencing node in both accounts (N^{C}= .17 &

.15). This inferred that risk management measures, (e.g. Equivalent Value calculations), VaR, failure rates, volume and proximity of risk) were central to S-suite understanding. It was found that *risk measures* weren't just a route of discussion for S-suite, but instead a fundamental influence; and that risk management as a discipline was far from a supporting activity. It was an influencing process that became central to the decision making process, for example:

> *"[the corporate risk reporting] process, involves no strategic understanding of health indices of our equipment and suchlike to set the strategy of network engineering. That includes very much the risk group, things like the AERO process [Risk classification process], and the CRAM matrix [Risk prioritization process]. We have other associated processes like the operational safety team, which help manage day-to-day risks. In quantifying and understanding the risk, understanding what it will cost to mitigate? That allows us to make judgment."* (Asset, S-suite)

This demonstrated a division between the strategic concerns of risk management from the operational daily management of risk; that the different systems, reports and valuations became tools to highlight the issue and priorities. Even strategic decisions would refer back to the risk management measures as a benchmark of capability, for example:

> *"We have a strategy of maintaining a broad portfolio, and working with everybody so that if shifts change the market we can keep busy by doing something different but in the same market. It is our ability to adapt to the market that keeps us competitive."* (Service, S-suite)

Portfolio management was seen specifically by service managers as a risk management treatment, it affected their core organizational structure, their selection of ventures and development of products. The views were that not only could they develop their position in their market, but also that over an extended period they could influence the market and environment itself. This was reflected by both the cases[53].

S-suite Characteristics:

In finding, the S-suite manager's mental model is generalized as:

- Risk measures were the central node in their mental map, and it is a role of influence;
- Awareness of both the external environment and measurement of risk as an influence on the organization's control structures;
- Alignment of the organization's strategy and objectives was influenced by the *control structures*;
- Risk measures were predefined by lead measures;
- Risk measures were used to develop organizational learning; and
- There was not an exclusive set of treatments being considered by S-suite (although service S-suite demonstrated an increased awareness of *portfolio* and *hedging* practices).

6.6.8 The Service Manager

There were commonalities demonstrated between S-suite and M-suite in service. Service managers shared five arcs, three treatments and one risk type:

1. There was a communications – belief loop;
2. Learning influenced the ability to develop *structured decision-making* (which led to mitigation treatments);
3. A common recognition of financial risk.

[53] *This treatment of portfolio management was not included in the risk treatment review as it was felt to be a speculative risk management practice (the potential for loss or gain in making a decision). At the time of the data collection the case organizations (being vertically integrated) were considering the low risk, low return and highly regulated distribution market, and whether they should continue to operate in this market. Six months later it was seen that several of the power companies abandoned operating in this market as the risk appetite of the organizations were unaligned with competing in the distribution market.*

Communications – Belief Loop:

In service managers, *beliefs* were influenced by performance system components: *Communications* and *Lag measures* (indirectly), shown in figure 6.17:

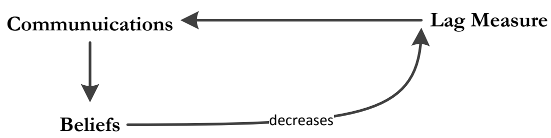

Figure 6.17 Service Manager Belief Loop

Lag measures were an expression of past performance. In service managers this link between *lag measure* and *belief* was mediated by the role of *communications*. Selection of *lag measure* had a bearing on the *beliefs* held by the individual. This was explained as a directional effort that over time (many months and years) the individual started to articulate their beliefs in reference to the underlying measures, for example:

> *"for many years we have been faced by increasing levels of work-place accidents, on stairs in cars, until our collective managerial attention was focused on this trend it had been largely ignored… It is a matter of common sense that we don't hurt people even in our offices, and it took a campaign of education to change the way mangers think about this"* (Service, S-suite).

Communication was the formal distribution of information coming from the performance system; this included corporate and business unit reports, investor and public information and the ad-hoc *"wall-board"* communications in offices (sections 4.2.1, 4.2.2, 4.2.3).

Beliefs existed outside of the performance system as defined in this research. These were feelings and emotions about conduct, risk-aversion, what it meant to be professional and extended as far as common sense. The node did not differentiate between differences in beliefs, just that individual beliefs were being brought to effect in the mental model.

As this loop was established as an influence on managerial beliefs, there was a contradiction being faced; that *beliefs* detracted from focus on *lag measures*. Service managers were particularly keen to establish that lag measures were not progressive; they focused upon what has happened and not thinking about the current and future outcomes. It was established that the environment was volatile and the situation constantly changing, that risks could not be avoided by looking backwards. *Lag measures* were useful to develop an understanding and not repeat past errors, whilst common sense was seen as the best risk tool a manager could possess. This established a negative relationship between *beliefs* and the use of *lag measures*.

Learning and Structured Decision-Making:

Service managers understood that *learning* influenced the ability to conduct a structured and reasoned decision process. Across all maps this was found to increase the selection and application of mitigation treatments. The influence on learning was not consistent between S-suite and M-suite in service. Although was shown that risk measures was an input into the learning process (indirectly in the case of M-suite).

Financial Risk Type:

Service managers were consistent in their identification and articulation of financial risk (N^{C}=.15 & .06). This was not a node of high centrality in the map, but did appear as a common reference point for nearly all accounts within the service manager community.

Characteristics of the Service Manager:

Therefore the service Manager's mental model can be generalised as:

- An individual's *beliefs* reduced reliance on *lag measures*;
- *Lag measures* were perceived as the main thrust of organizational performance reporting;
- *Communication* of *lag measures* eroded the manager's belief of *lag measures*;

- *Learning* was understood as the main influence on developing an improved *structured decision-making* process, this increased the deployment of *mitigation*; and
- Reference to financial risk was common across service managers, they referred to outsource and acceptance as common across all mental models.

6.6.9 The Asset Manager

There were a number of areas of convergence and similarity within asset managers' mental models:

- Direct links, from risk type to risk treatment without mediation from the performance system nodes;
- There was a *Risk tool – Belief* loop;
- Core mental model; *Environment* to *structured decision-making*;
- Common perceptions of *engineering* and *safety* risk.

Direct Risk to Treatment Links:

The focus of asset manager maps was different. There were a number of direct risk types to treatment selection, which did not appear as pronounced in service functions.

There were three treatment influences appearing in both M-suite and S-suite:

1) The path from *safety risk* to immediate prohibition of *risk acceptance*. There were no intervening influences on this decision. The appearance of *safety risk* did not define a treatment;
2) *Environment risk* had a similar direct and prohibitory relationship to *risk transfer*. Transfer of risk was considered in terms of *outsource (not insurance)*. The appearance of *environment risk* meant that this was a problem that could not be *outsourced*, and if the operation was already outsourced, meant that as the principle contractor in the operation, they would have to directly manage this risk and not leave it to the third party;

3) The final direct influence was the relationship between *learning* and *mitigation*. This was a positive relationship, whereby the use of *mitigation* was felt to be informed and improved by learning, and that learning was embedded as part of the performance system. This was reflected upon both at an individual and organizational level.

Risk Tool – Belief Loop:

Asset managers shared a causal loop. Although there was a subtle mediating difference in the S-suite map, there was similar outcome. In S-suite appearance of *safety risk* was influencing proliferation of *risk tools*. This reflected adherence to risk standards, risk registers (but in asset functions not the use of risk matrices). Risk tools gave access to risk measures. Risk measures were identified as predictive or evaluative: *"providing quantitative estimation to bolster experience and gut instinct"* (Asset, M-suite). It was this combination of quantitative measurement and experience that formed a relationship with *learning*. In a more intuitive relationship that *learning* influenced *beliefs*; the asset manager felt that their experience was improved, whilst taking advantage of their experience, both as a product of time in role and as educated engineers. The S-suite feedback loop is identified in figure 6.18.

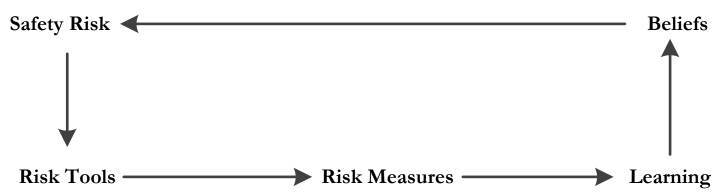

Figure 6.18 Asset S-suite, Feedback Loop

The strongest relationship was between *beliefs* and *safety risk*. The underlying principle was that they were operating in a physically hazardous environment, when *"things go wrong, they go wrong big… accidents are usually life changing or life terminating"* (Asset M-suite). On several occasions accounts were prefixed by… *"even if it wasn't a stated objective or a legal obligation, the ethical and moral beliefs which all humans should have, would lead to the same answer"* (Asset M-suite). In this way the asset managers reflected that their beliefs were dominant over the company values. The M-suite manager's safety risk to belief loop is represented in figure 6.19.

Figure 6.19 M-suite Asset Manager, Feedback Loop

Therefore, the asset S-suite relationships were reflected in a simplified version by M-suite. M-suite did not articulate the path to *beliefs* through *risk measures* and *learning*, instead they demonstrated that risk tools had a bearing on beliefs, in much the same way as S-suite.

Core Mental Model:

Asset managers shared a core understanding encompassing five nodes and two treatments. There was a consistency in the understanding that the environment drives an increase in the use of lead measures. Further the environment decreased the ability to transfer risk (especially in outsource arrangements). It was found that generation teams understood their long-term responsibility and investment as being eroded though outsource agreements.

Lead measures underpinned the ability to create risk measures. This use of risk measure had two effects: a) It increased the accuracy and ability in structured decision-making (which increased the deployment of mitigation treatments), b) risk measures increased learning within the organization. The core mental model, identified in both service and asset M-suite managers is presented in figure 6.20.

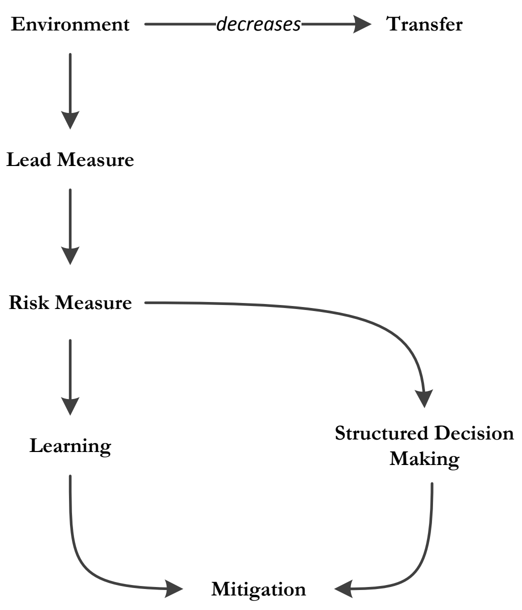

Figure 6.20 Asset Manager Core Mental Model

The asset manager's core mental model demonstrated that there were a high proportion of shared mental maps between asset managers (S-suite and M-suite).

Engineering and Safety Risk:

Asset managers used a specific terminology of *engineering risk*, to describe the risks caused through engineering practice in their operations (i.e. the maintenance and production phases of the plant). Secondly, asset managers focused on safety risk. Safety risk was not isolated to employees, and also considered members of the public.

Characteristics of the Asset Manager:

These decision maps found that risk tools and the proliferation of risk measures are associated to each other. The characteristics of the asset manager are summarized below.

- Safety risks drove the proliferation of risk tools;
- Risk tools influenced the beliefs of the manager;
- There was a moral link between the asset manager's belief and the importance of safety risk;

- Asset managers had a direct association between certain risk types and certain treatments (or prohibition of treatment);
- Asset managers identified engineering and safety risk, in addition to reputation risk;
- There were no specific treatments for asset managers, beyond outsource, mitigation and acceptance.

6.7 Integrative Discussion (Firm, Function & Group)

The move from firm to function, demonstrated a development of understanding and focus. Function differences were pronounced between service and asset functions. The increased granularity in frame of reference and corresponding change in analysis exposed a number of differences between S-suite and M-suite managers.

Managerial Beliefs

The group-level analysis identified that managerial *beliefs* are a central influence on the risk management decision process (0.21 to 0.07). This puts into question the full and unmediated influence of the performance system on decisions. This effect of individual beliefs was consistent with the extant literature (Peterson & Beach, 1967; Tversky & Kahneman, 1981; Slovic, 1964). *Beliefs* were shown to directly influence choices of risk treatment, for example decreased use of *insurance* (Service M-suite). The *belief* node influenced a range of different performance system functions; but this was inconsistent between group maps. *Belief* was influenced by a range of performance system functions: *communications*, *risk tools* and *learning*. *Environment* (the market, society and culture the organization operates within) influenced *beliefs*.

It was this role of *beliefs*, and the inconsistency in the influence *beliefs* had in the maps that led to the last frame of reference (the individual) and the method employed in chapter seven. This was done to expose whether there were specific influences of *beliefs* outside of function or managerial group.

The difference in influence on treatment selection developed an understanding from Levers of Control (Simons, 1994, 1995), although this was not fully aligned: *Boundary systems* mapped to the direct influences (especially in their prohibitive approaches), *belief systems* mapped to the individual *belief* node and the reference to performance system nodes to *diagnostic* and *interactive* systems.

Risk Types

There were three different risk types, which evoked a prescriptive response from managers: Financial, Safety and Environment. There were only a few approaches in measuring and targeting safety risk or environmental risk. There was confusion about technical SHE[54] measures e.g. TRIR (Total Recorded Injury Rate). Managers didn't understand the calculation behind the TRIR measure.

Risk Standards

Risk standards (e.g. COSO) were not central to the risk decision-making; however *risk tools* did appear as a common node. *Risk Tools* included: risk-recording systems, valuation algorithms and risk matrices, but excluded any risk standards (e.g. ERM). The maps found no reliance on risk tools to define the risk process, this was a positive limitation as indicated by Lewis: *"It may be that believing a risk management system to be comprehensive is itself potentially dangerous…"*(2003:219). However the literature suggested that risk systems have an increasingly important position within the firm (ONE AON, 2007; Babaliyev, 2012; Hopkin, 2012).

Risk Valuation

The importance of risk valuation in *risk measures* was consistent across three groups (and majority of accounts). *Lead measures* predefine risk measures, and risk measures influence structured risk decision-making[55]. The structured decision-making node (SDM-node) was

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[54] *SHE is Safety, Health and Environment measure in the UK.*
[55] *This was the case in all accounts, where only service S-suite had learning as a mediating influence between risk measure and decision-making.*

shown as an influence in selecting mitigation treatments. The valuation approaches did not refer to VaR or Risk Adjusted Return On Capital (RAROC) to any consistent level. However, asset functions showed an inclination toward RAROC and service functions VaR. The risk measures were seen to be simplistic (i.e. probability and impact calculations, where impact could be multifaceted).

Moving to the next level of analysis

The function-level presented the following questions, the findings are summarised in table 6.11.

Table 6.11 Summary of findings and questions from function-level

Question from function-level	Finding at Group-level
How does the difference between levels of management seniority influence the risk management decision process?	There was a fundamental difference between the mental models of S-suite and M-suite managers. Although S-suite managers had some consistency between asset and service functions, a desirable quality (Dilla & Stone, 1997). S-suite demonstrated a greater awareness of different forces on their decision-making; they also had less complex mental maps.
What is the impact of an individual's experience on the selection of treatment?	Managerial beliefs have a fundamental role in decision-making, it demonstrated the performance system influence was heavily restricted by beliefs, and the performance system was not the principle influence on the selection of treatments

The group-level analysis showed that risk management decisions do not follow a structured or rational order of activity. It demonstrated different paths to treatments, and different order of performance system functions used. This was a strong indication of the complexity of influences in selecting a treatment. Section 6.4.9 outlined the underlying influences on the different perceptions in selection of risk treatment. The last frame of reference, the individual-level, tests these influences on risk decisions and the use of risk treatments (i.e. insurance).

Chapter 7

7. Individual-Level Analysis

Chapter Seven extends the group-level analysis, to the individual. The research focus is developed to qualitatively understand the perceptions and use of risk treatments and specific sensitivities to information affecting risk judgement.

7.1 Introduction to the Individual Level Analysis

In Chapter 7, the individual-level analysis is the lowest frame of reference in the study. The preceding chapters have researched the firm, functional and the group-levels; which analysed the collective decision-making processes, their structures and their influences. The individual-level recognises the behavioural influences on the individual decision-maker. This is broken into two phases of research (4a and 4b). Phase 4a investigates the sensitivity to measures and outcomes. Phase 4b examines the use of treatments. Phases 4a and 4b are written up as a single discussion, and had the same frame of reference (the individual), and method (i.e. survey). Figure 7.1 outlines the path of research development.

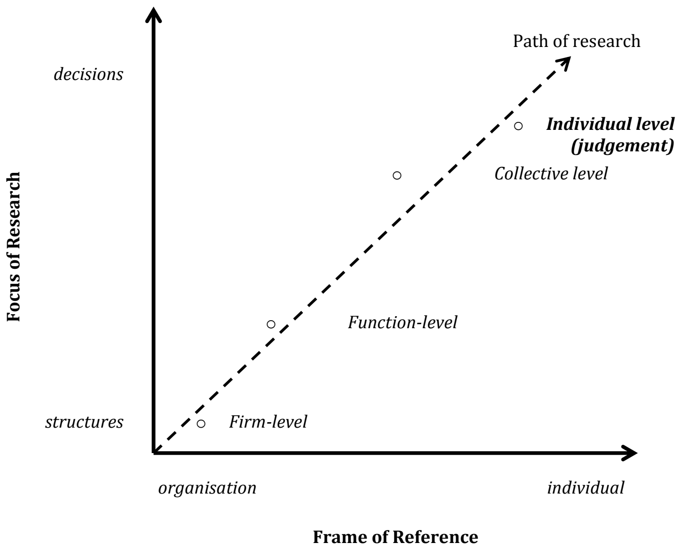

Figure 7.1 Path of Research Development

Data collection was completed by an on-line survey, comprising two parts:

- **Risk Sensitivity Survey (RSS),**
- **Treatment Application Survey (TAS).**

This resulted in 238 completed surveys (28 were incomplete and discarded). The surveys were analysed. In the survey there were 33 different and mutually exclusive results received from each participant. The design of the 17 risk sensitivity questions was derived from literature and earlier levels of analysis. The analysis of data was split into five parts:

Part 1: Data were collected using a survey (RSS). It identified the impact of 15 different influences. The results were split using the sample frame in Chapter 6 (i.e. Asset, service, S-suite and M-suite), presented as descriptive statistics;

Part 2: The data were analysed further using an Exploratory Factor Analysis (EFA), this created a number of factors from the observed variables from the RSS. The EFA provided an approach to explain the latent influences on the decision-maker. The resulting factors are named and described;

Part 3: The factors from Part 2 were analysed between populations (sample frame defined in Chapter 6). The difference between populations was tested by independent sample t-tests (ISTT). ISTT showed where there is a significant difference between two-independent variables (i.e. managerial level). This indicates where populations were significantly different in sensitivity;

Part 4: Data was collected by survey (Treatment Application Survey). It identified the use of different risk treatments; this was demonstrated by the use of Chi-squared tests. The results are split using the sample frame in Chapter 6, presented as descriptive statistics, and contrasted to the differences between populations;

Part 5: The results from Part 1 (sensitivity) and Part 2 (treatment usage) were compared to identify whether underlying sensitivities demonstrated a propensity toward a specific treatment. Users and non-users of a treatment were compared using Independent Sample t-Test. Figure 7.2 summarises the research pathway used in Chapter 7.

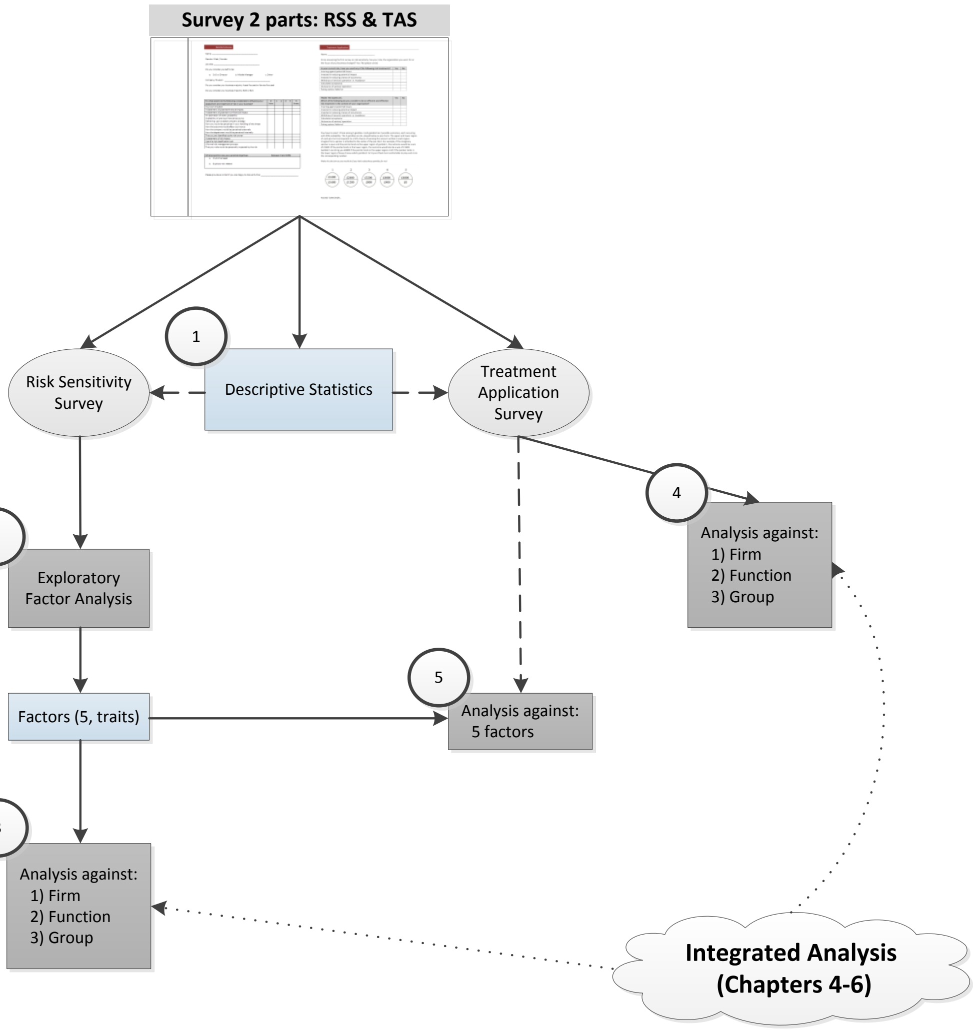

Figure 7.2 Chapter 7 Research Pathway

The remainder of chapter seven is structured:

1) Data collection and data analysis: creation and use of surveys, the development of variables and how analysis was performed;
2) Descriptive statistics for two survey parts (step 1);
3) An exploratory factor analysis, identifying five factors latent in the 17-question sensitivity scale (step 2);

4) Analysis of risk sensitivity survey against levels (step 3) and treatment application survey against levels (step 4);
5) An analysis of treatment usage against factors (step 5);
6) Summary of results.

7.2 Method: Survey

Phases 4a (risk sensitivity) and 4b (treatment usage) collected data through survey. Surveys are used to gather responses from individuals across distributed locations (across the United Kingdom), maximise the potential number of respondents and limit the cost of data collection (Bryman & Bell, 2007). Survey methods can provide quantitative data through structured questionnaires, and can elicit a range of numerical data representing beliefs, opinions, attitudes and general background information on individuals (Hair et al, 2011). Electronic (email) surveys require participant self-completion. However the benefit of using a survey is the potential to collect large amounts of information without the researcher being present and at low cost (Hair et al., 2011). There are known issues with levels of completion using this method, and the potential for respondent bias as they become limited to computer users.

Surveying is an accepted and dominant method within the empirical Operations Management community (Carter et al., 2008; Gattiker & Parente, 2007), although quantitative data is criticised as not rich enough (Barnes, 2001) by the qualitative OM community (cf. Meredith, 2009). It provides an opportunity for gathering vast and easily manipulated data sets, then available to complex statistical analysis. Barnes (2001) proposes that surveys should be kept to the realm of factual based data collection, this ignores that surveys are inherently perception of situation by the respondent.

Benefits and Limitations of Survey Methods

Surveys allow for distant responses to be made, both geographically and temporally. People that may not normally be accessible to the researcher may become available if interest and value can be installed in the respondent (Bryman & Bell, 2007). The time taken to generate responses, in researcher hours, is significantly reduced. Tools such as on-line survey sites can simplify the tracking and following-up of respondents. The distance and limited relationship between researcher and respondent, creates little flexibility to present open enquiry, confirm understanding or reach deeper into reasoning. A survey will only yield results within the framework provided, and is rare to offer insight beyond these boundaries.

As a strength, surveys can quickly provide a numeric basis, providing what the logical-positivist would require for hypothesis testing. For *Realists* it provides an assessment of the extent of a relationship.

Survey Pilots

Surveys need to be piloted in advance (Voss et al., 2002) to ensure design does not include confusing, ambiguous or tautological statements, that it is easy to navigate and that the composition is likely to encourage statistically significant completion rates. Ketokivi and Schroeder (2004) identify survey contamination as a risk to validity and reliability. Contamination is similar to the concept of respondent bias or interpretation, comprised of both *"informant bias"* and lack of systematic selection of survey response value, for example the difference between selecting a '4' and a '5' in a Likert scale (Ketokivi & Schroeder, 2004).

This understanding influenced the design of the surveys used in Chapter 7.

7.2.1 Design of the Risk Sensitivity Survey (RSS)

The risk sensitivity analysis administered a survey to extend maximum possible coverage, both geographically and across operational shift (in the case of power production). Surveys provided the opportunity to gather broad quantitative data in short elapsed time, and constrain the questions to a number of pre-defined questions (cf. Hair et al., 2011). The survey used Likert scales, to record respondent perception to what extent they are influenced by a concept in management of risk. Likert Scales were used to measure attitudes or opinions; it is an accepted method to understand the intensity of the respondent's feelings (Hair et al., 2011). The survey was provided in both electronic and hard copy formats[56].

Demographic information was recorded first: gender, case organization, function, role, self-assessed seniority (S-suite/M-suite) and self-assessed B2B or B2C focus[57].

Fifteen sensitivity questions were presented (see Appendix D): these identified the level of influence of a variable on the individual when managing risk[58]. Risk was presented as a generic concept rather than as a recall of specific incident. The questions relate to the literature review in chapter 2, and understanding developed through causal mapping (table 7.1).

[56] *Although hard copy versions of the survey are provided, only electronic copies were distributed to the respondents.*

[57] *Each case potentially contained individuals that could have a B2B or a B2C facing role. Because of this the respondent was asked to identify their expected focus of their role. With the lack of B2B sample size, analysis of this demographic information was not continued.*

[58] *The term threat is used in the survey. The terms risk and threat are used interchangeably, this is to infer management of pure risk without the need for an extensive explanation. In a non-technical manner the term threat is commonly understood, and was tested for its meaning as part of the pilot.*

Table 7.1 Summary of Sensitivity Tests

Concept	**Question** *What is your sensitivity toward…*	**Basis in research** *Understanding from firm & function levels*	**Comments and mapping to nodes** *Understanding from group-level analysis*
Probability	*Estimation of event probability*	Estimates of impact and probability are defined within ERM standards.	A forward-looking measure, it is a specific risk measure.
Impact	*Statement of risk impact*		A forward-looking measure, it is a specific risk measure.
Financial impacts	*A forecast of financial impacts*	Financial impacts are used in finance sector as the principal measure of performance	A forward-looking measure. Potentially a measure of risk, but can be used for other operational purposes.
Non-financial impacts	*A forecast of non-financial impacts*	Non-financial measures e.g. reputation, safety are seen in energy sector	A forward-looking measure. Potentially a measure of risk, but can be used for other operational purposes.
A-priori data/previous financial accounts	*Measures of previous financial performance*	Traditional performance measures of the business	A lag measure
Risk management process	*Adherence to a formal risk management process*	This is a defined approach to rational decision-making in controlling risk	A description of the structured decision-making process for risk
Risk standards/ classification tools	*Access to risk registers and matrix*	Risk matrices and registers are used in the firm-level	This is part of the risk management tools
Company strategy	*Alignment with company strategy*	The cases map strategy into objectives, although this is not done with explicit risk strategy	A reflection of the company's strategy
Internal perception of risk	*How the decision is perceived internally by stakeholders*	Reputation of the individual and sub-units of the firm in their handling of risk	The internal perception reflects on the control structures within the organization
External perception of risk	*How the decision is perceived externally by stakeholders*	Reputation of the company by stakeholders, defining the environment	The external perception reflects on the environment and the perceptions they hold of the organization
Risk ownership	*That you are identified as the risk owner*	Risk standards suggest risk should be owned by an individual	This is a matter of personal contingency
Incentives	*The impact the decision may have on your bonus*	Agency theory suggests risk is transferred between agent and principal	This is a matter of personal contingency
Reflection on risk taker	*How you will be perceived*	Managers suggest they are personally reflected on in their management of risk	This is a matter of personal contingency
Intuition	*Your own intuition*	Intuition versus rational decision-making, based on application of experience	This is a reflection of the individual's beliefs and their decision making process

These questions conclude the risk sensitivity part of the survey. The second part of the survey contains the Treatment Application Survey (TAS), which examined the level of use of specified risk treatments.

7.2.2 Design of Treatment Application Survey (TAS)

Respondents were asked whether they had in their current role used a selection of risk treatments, this was answered as *yes* or *no*. The list of different treatments being sought was developed from section 2.6 (see Appendix D).

The risk treatments identified for response are:

1. Insurance: *transfer of financial liability* (section 2.5.3);
2. Investing in reducing impact: *impact-mitigation* (section 2.5.6);
3. Investing in reducing occurrence: *probability-mitigation* (section 2.5.6);
4. Total avoidance: *Withdrawal and avoidance* (section 2.5.5);
5. Accepting the risk (section 2.5.2);
6. Whether the decision can be deferred: *a sub-group of avoidance, presented as an Option*[59] (section 2.5.7).

Having designed the two surveys these were tested before distribution to the single points of contact or direct to the respondents.

7.2.3 Pilot Survey

A pilot survey was completed with eight respondents; they were not members of the case studies. These pilots comprised:

1) two company owners;
2) two accountants;
3) two researchers (two PhD candidates);
4) two energy industry managers (different companies).

Their feedback included comment on wording, identification of ambiguity, time taken to complete the survey and any recommendations for improvement. Following attention to the issues, a revised survey was retested through a second pilot, including three of the initial

[59] *Isolated as a question following Critical Incident feedback that shows a high consideration for adjusting the temporal dimension of risk decisions, and that it was not easily understood as an immediate implementation of avoidance strategy.*

respondents and two new participants (a researcher and an energy industry manager[60]). Six minor amendments were made on using the feedback; survey format, questions and wording were fixed.

7.2.4 Sample Frame

When combined with the discussion of risk management and risk preferences, discussion of risk was seen as politically sensitive and potentially damaging to reputation, access to detailed information and accounts were therefore limited. It was not possible to balance respondent numbers between management-levels. Inherent in the classification was a pyramid of roles/seniority. There were less S-suite managers than M-suite managers. Instead there was an inclusion of S-suite managers across all demographic variables[61].

The population of S-suite and M-suite managers[62] (GRS & FCORP, UK MU) was estimated between 475 and 535[63]. However some of these were process supervisors, and were removed from the survey[64].

The surveys (RSS & TAS) were conducted through an online survey tool[65]. A link was mailed to each nominated participant[66] in GRS. In FCORP the link was mailed to the research contact assigned to distribute to participants. FCORP approach had several benefits: 1) *managerial authority* and direction to the survey by an *internal* member of staff yielded a higher response rate, 2) FCORP kept the respondent's email addresses confidential, where they wouldn't have participated otherwise. Limitations were the lack of opportunity to

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[60] *To ensure that prior understanding was not responsible for a perception of improvement*

[61] *Differentiating gender was possible. There was recognition that certain roles and types of operation were heavily skewed towards male employment. It was beyond the scope of this thesis to investigate the reasons for this distribution, other than to recognise its existence. A report by Feltus (2010) indicated that statistics for women in energy are rare and imprecise. Exxon Mobil, had 12% women at executive level, against a target of 20% (Feltus, 2010). Although Exxon Mobil is an upstream company (gas and oil) and the cases in this thesis were power companies, these figures are representative of the gender imbalance.*

[62] *In FCORP and GRS UK Business Units studied at function-level analysis.*

[63] *Because of the fluid nature of the organizations, use of secondments (in and out), a precise count of current operational managers was not attained.*

[64] *This identification was completed with the organization liaison points.*

[65] *Hard copy version made available to EAM, but not used for data collection. Qualtrics was used as the software for distribution.*

[66] *Where direct contact was made, participants were nominated by their organization; in consultation with the management team. Emails containing the link include an introduction from their senior management team, encouraging participation.*

analyse non-respondents. This included issues such as gender imbalance or exclusion of field based managers (who were not regular computer users). In the service functions, this could have selected out sales managers who were less likely to spend administration time in the office. Respondents to the survey met the following criteria[67], outlined in table 7.2.

Table 7.2 Respondents to Risk Sensitivity Survey

Firm Split	**FCORP Total (female)** 106 (28)				**GRS Total (female)** 132 (34)			
Function Split	***EAM (Asset)*** 46 (5)		***FRET (Service)*** 60 (23)		***EGEN (Asset)*** 57 (7)		***ERS (Service)*** 75 (27)	
Management Level Split	***S-suite*** 16 (1)	***M-suite*** 30 (4)	***S-suite*** 17 (4)	***M-suite*** 43 (19)	***S-suite*** 18 (2)	***M-suite*** 39 (5)	***S-suite*** 19 (3)	***M-suite*** 58 (24)

**The proportion of which are females indicated in brackets*

7.3 Data Analysis

The data analysis was split into five parts, each analysing a different perspective of risk sensitivity or treatment usage. To achieve this, different statistical techniques were used depending on the data being analysed. These approaches are outlined below.

Part 1 (Descriptive Statistics):

There were 15 variables tested for managerial sensitivity in risk making. The results ranged from 0 (no influence) to 5 (extreme influence). The 15 variables were presented in their mean and standard deviation[68] (these are presented in descending order of sensitivity).

Part 2 (Exploratory Factor Analysis):

The 15 variables in the sensitivity survey were analysed to reduce to a lower number of *"latent variables"* (Field, 2013:666), or factors. These factors explain the characteristics of managers, and were named in a manner reflective of the phenomenon. Dimension reduction can be achieved through *exploratory factor analysis* (EFA). Factor analysis refers to a range

[67] *There were 238 usable results in the Risk Sensitivity Survey. All results were permissible, as there was electronic validation and enforcement of data integrity of the results before submission*

[68] *Standard deviation is an estimate of the average variability of a set of data (Field, 2013)*

of statistical techniques, the two most common are exploratory factor analysis or confirmatory factor analysis. In this thesis exploratory factor analysis is used as a means to reduce the number of variables into a lesser number of new factors, latent in unstructured data:

> *"Factor Analysis is based on the fundamental assumption that some underlying factors, which are smaller in number than the number of observed variables, are responsible for covariation among the observed variables."* (Lewis-Beck, 1994:6).

The calculation should be completed through using computational means (Field, 2013), and for this analysis SPSS was used. This thesis uses the APA format to report statistical results.

Part 3 (Independent Samples T-Test):

Independent Samples T-Test (ISTT) provides a comparison of means of two different samples. The independent nature of the test infers that the participants in each sample are different. In the ISTT performed in Part 3, splitting of samples by gender, function or management level was tested. The resulting *t-statistic* provides a measure of whether these compared means are meaningfully different (Field, 2013). If ISTT shows a significance i.e. $t<0.05$ on a two-tailed probability, it indicates that there is not a single homogenous group, instead that there is a significant difference in the means indicating separate populations that have not occurred by pure chance[69]. The ISTT is a parametric test based on a normal distribution (Field, 2013)[70].

Part 4 (Chi-Squared Tests):

A Chi-squared test examines patterns of frequencies, and how the results differ from an expected pattern of frequencies. The Chi-squared test is a test of the null hypothesis (that there wasn't a significant difference in pattern between expected and observed) (Hair et al., 2011). In chapter 7 this was used to expose differences in users/non-users of treatments, in

[69] *An independent sample t-test, indicates a 5% probability of results occurring by pure chance.*
[70] *If normal distribution is not apparent, shown by a Levene's Test for Equality of Variance less than 0.05, the alternate result where equal variances are not assumed is used.*

firm, function and group level populations. Significance is based on $p<0.05$ on a two-tailed analysis.

Part 5 (Independent Samples T-Test Comparison of RSS and TAS):

Part 5 combines the data from RSS and TAS, and the factors derived in part 2. This provided an understanding of the relationship between latent risk sensitivities and the propensity toward risk treatment use. Part 5 used ISTT to identify the difference between risk treatment users and non-users, against each of the risk treatments in the TAS.

7.4 Results (1): Descriptive Statistics

The descriptive statistics provide an outline of the respondents and their allocation to sample frame, descriptive of the mean and standard deviation of each variable and percentage of treatment users. The variables included in the survey were developed through literature (section 2.6 and summarised in table 7.1); the survey administered is included in Appendix D.

Table 7.3 contains the frequencies and descriptive statistics for the variables (N=238).

Table 7.3 Descriptive Statistics, Risk Sensitivity Survey

Variable	**Mean (s.d.)** *Likert Scale (0: no influence – 5 extreme influence)*
Sensitivity to statements of impact	4.2 (.9)
Sensitivity to statements of probability	4.1 (.9)
Identified as risk owner	4.0 (1.1)
Personal impact	3.9 (.9)
Intuition	3.6 (1.1)
Financial impact	3.6 (1.4)
Non-financial impact	3.5 (1.1)
Perception of the individual	3.4 (1.2)
External perception	3.3 (1.3)
Risk Management Process	3.2 (1.1)
Internal perception	3.2 (1.1)
Risk Classification Tools	3.0 (1.3)
Company strategy	2.8 (1.2)
Impact on bonus	2.5 (1.7)
Previous financial accounts	2.3 (1.4)

Zero indicates a total lack of sensitivity to the measure or influence. A five indicates extreme (highly sensitive) to the measure. Table 7.4 has been sorted in order from most sensitive variable to least. This is a measure of the whole sample. There are individual differences between groups; these are evidenced through chi-squared tests (section 7.2.6). There are three notable differences between service and asset groups:

- The sensitivity to an individual's intuition. Asset managers show a lower sensitivity (3.2 and 3.3) and wider deviation (1.3) than service managers, who are more sensitive to intuition (3.7 and 3.8) with a lower deviation (1.0);
- Asset managers are more sensitive to statements of financial impact (4.1 and 4.2) than service managers (3.5 and 3.7);
- Asset managers are more sensitive toward statements of probability (4.1 and 4.2) than service managers (3.8).

The overall result indicates that statement of impact and probability demonstrates high levels of sensitivity (4.2) to statements and a low standard deviation (.9) of result. This is in contrast to the lag measures of previous financial accounts, which demonstrates a low mean result (2.3). The effect on an individual's bonus also has a low level of sensitivity (2.5), however the standard deviation (1.7) indicates some level of inconsistency of this result in the sample.

7.5 Results (2): Exploratory Factor Analysis

Risk sensitivity refers to the way in which people respond to direct and indirect stimuli when making risk based decisions. There are a wide variety of stimuli (identified through extant literature and prior qualitative analysis, see chapters 4, 5 and 6). In empirical studies, there has been no clear consensus on the underlying factor structure of risk sensitivity in managers.

The 238 sensitivity responses were analysed. Exploratory factor analysis (EFA) was used to uncover latent constructs in the risk sensitivity results.

The factorability of 15 variables was analysed, using Kaiser-Meyer-Olkin measure of sampling adequacy was 0.65, which is above the recommended value of 0.6 (Brace et al., 2009). Barlett's test of sphericity was significant ($\chi^2(208)=105$, $p<0.001$). The diagonal of the anti-image covariance matrix showed all 15 variables were over the 0.5 threshold. The communalities were all over 0.5 (values under 0.4 were suppressed).

The initial eigenvalues, indicated that the first factor explained 21% of the variance, the second factor explained 15% of the variance, the third factor 11% of the variance, the fourth factor explained 9% of the variance and the last factor included, explained 7% of the variance. Cumulatively these explained 64% of the total variance. In rotation (Varimax, with eigenvalues >1) these five factors were used. The concluding rotated component matrix is included below. The varimax rotation with Kaiser normalization provided the best-defined factor structure, this concluded after eight rotations[71]. The results of the EFA are presented in Appendix E.

Five factors were exposed through the rotated solution. The resulting factors appeared to offer an explanation of characteristics of the respondents.

The first factor contained the dimensions of sensitivity toward: alignment to company strategy, internal and external perception. In terms of internal and external perception, these *sensitivities* reflect on the organization itself. These two dimensions are joined by alignment with company strategy. The common consideration across these points is the association to the firm and not the individual. It is therefore a **company-focus**.

The second factor contains the dimensions of sensitivity toward the effect on the individual's bonus, how they would be perceived and whether they were identified as the risk owner. This is reverse of the company-focus (above) and the point of commonality across these dimensions is the individual, this is the **individual-focus**.

[71] *Varimax rotation was used, as it is provides a simplified and generally good approach for the interpretation of factors (Field, 2013), it is one of three orthogonal rotation methods, the others are quartimax (which is criticized for overloading on a single factor) and Equamax (which is criticized for behaving erratically).*

The third-factor contains the dimensions of sensitivity toward access to the risk management process, risk tools and the inverse of intuition. Although it is considered whether this is the description of decision-making strategy, being either rational or intuitive, inclusion of risk tools makes this a factor describing the standards, tools and techniques as part of the risk management process. The inverse of intuition suggests that this is a choice between sensitivity to the risk process or the individual's intuition. To make clear the separation from the next factor this is called a **tool-focus**.

The fourth factor contains the dimensions of sensitivity toward statements of probability, impact and non-financial impact. Probability and impact form the core definition of risk (March & Shapira, 1999). Inclusion of non-financial impact is an extension of the traditional impact measure. Therefore this factor seems to represent the traditional view of risk as impact and probability, where impact includes non-financial consequences; this is the **traditional-focus**.

The final factor contains dimensions of sensitivity towards previous financial accounts and financial impact. These two dimensions are lag and lead measures respectively, but both orientated toward the use of financial data. Developing this description in reference to the four other factors, the focus is the financial statement sensitivity the **financial-focus**.

The five factors are summarised below:

- **Company-focus**, company strategy, internal and external perception;
- **Individual-focus**, comprising an individual's bonus and the impact on themselves, how they would be perceived and whether they were seen as the risk owner;
- **Tool-focus**, availability of the risk management process, and risk tools, and the inverse of sensitivity to an individual's intuition;
- **Traditional-focus**, comprising sensitivity to probability, impact and non-financial impact measures;
- **Financial-focus**, comprising sensitivity to previous financial accounts and sensitivity to financial impact.

7.6 Results (3): Risk Sensitivity

The five factors created through the EFA, were used to distinguish whether there were different populations within each level of analysis. This was completed through independent sample t-tests[72], (see section 7.2.6).

There were three factors that demonstrate significance across various levels of analysis. These were **financial-focus, traditional-focus** and **individual-focus**. The traditional-focus appears both at function and management-level. Firms did not show any significant populations appearing through the analysis of factors.

Function (Asset and service):

The following independent sample t-tests consider the different conditions of asset or service function sensitivity to different conditions:

Table 7.4 Factors by Function

	Mean (St.Dev)		Significance (p)
	Asset (N=103)	Service (N=135)	
Financial-focus	**4.76 (1.60)**	**3.81 (1.60)**	**0.001***
Traditional-focus	**10.37 (1.72)**	**9.52 (1.77)**	**0.006***
Company-focus	10.25 (2.28)	9.73 (2.16)	0.19
Individual-focus	13.85 (3.58)	13.81 (3.24)	0.95
Tool-focus	6.68 (2.30)	6.81 (3.24)	0.053

* *Two tailed, equal variances assumed, results are the sum of the individual sensitivity variables in the factor*

There was significance in the scores for asset and service functions financial-focus. This is the strongest result from all the different t-tests performed, and indicated that there are two distinct populations within the sample.

This indicated that the asset function had greater sensitivity to financial-focus than service functions, and that these form two distinct populations. This indicated that the asset function had greater sensitivity to traditional-focus than service functions and that these

[72] *The observed t-value is 1.8, with degrees of freedom equal to 236. The critical t is approximately 1.96 (on a two-tailed probability). The observed t < critical t, therefore the samples are the same population.*

form two distinct populations.

Management (S-suite and M-suite):

The following independent sample t-tests considered the different conditions of S-suite sensitivity and M-suite sensitivity to different conditions:

Table 7.5 Factors by Management Level

	Mean (St.Dev)		Significance (p)
	S-suite (N=70)	M-suite (N=168)	
Traditional-focus	**10.17 (1.70)**	**9.61 (1.83)**	**0.045***
Financial-focus	3.88 (1.13)	3.88 (1.34)	0.074
Company-focus	10.2 (2.42)	9.7 (2.02)	0.207
Individual-focus	14.16 (3.14)	13.54 (3.54)	0.285
Tool-focus	6.16 (3.14)	6.54 (3.54)	0.285

*
Two-tailed, equal variances not assumed.

There is a significant difference in sample size between S-suite and M-suite respondents; this is an impact of the pyramid of seniority in the case organizations. It was estimated using the criteria defined for S-suite managers and the potential population fitting these criteria that over 60% of the population was included in the analysis.

This indicates that S-suite has greater sensitivity to traditional-focus than M-suite and that these then form two distinct populations.

Gender (Male and Female):

The following independent sample t-tests consider the different conditions of gender sensitivity to different conditions:

Table 7.6 Factors by Gender

	Mean (St.Dev)		Significance (p)
	Male (N=176)	Female (N=62)	
Individual-focus	**14.2 (3.12)**	**12.60 (3.86)**	**0.02***
Traditional-focus	10.78 (2.56)	9.38 (3.17)	0.57
Financial-focus	3.92 (1.28)	3.94 (1.03)	0.977
Company-focus	8.40 (3.27)	8.16 (3.30)	0.72
Tool-focus	6.26 (2.18)	6.19 (1.75)	0.86

** Two tailed, equal variances assumed*

This indicates that males will have greater sensitivity to individual-focus than females, and that these form two distinct populations.

The *"old bastion of generation businesses"* is still heavily biased toward male employees. This is changing slowly, and has been the ambition of most companies in this sector to rectify. This is an issue of differing importance dependant on national culture influence. Although managerial appointments in these businesses are increasingly attracting female employees, females are still not occupying the very senior roles. 3% of middle managers were female, with no senior managerial appointments for women[73]. This makes the use of gender as a characteristic for development of the sample frame more difficult. Securing access to this very small population is seen as a major issue in any further study of gender.

Summary of RSS Results

The tests of independent samples identified where there were different populations present in the analysis. The most significant of which was the difference between asset and service functions. Gender and managerial level had a single significant factor, whilst firms demonstrated no differences.

At the firm-level FCORP (N=106) and GRS (N=132), there were no significant observations. The factor *traditional-focus* demonstrates the greatest population difference. Sensitivity to *individual-focus* and *financial-focus* also appeared as a differentiator. Table 7.7 indicates the

[73] *This data does not refer to either of the case organizations, but a comparative generation business unit in a similar market.*

different significant factors. The table identifies the implications of this split at the different functions showing the population demonstrating the highest sensitivity to that factor.

Table 7.7 Summary of Risk Sensitivities at four Frames of Reference

Frame of Reference	Sensitivity toward **Financial-focus**	***Company-focus***	**Traditional-focus**	**Individual-focus**	***Tool-focus***
Firm *(FCORP/GRS)*					
Function (Asset/ Service)	Yes (Asset high)		Yes (Asset high)		
Management (S-suite/M-suite)			Yes (S-suite high)		
Gender (Male/Female)				Yes (Male high)	

Finding that firms did not differ in risk sensitivity, reinforces the firm-level analysis where there was similarity of risk perception between the organizations.

7.7 Results (4): Risk Treatments

The following analysis takes the use of risk treatment at the different levels of analysis, to test whether there is a significant difference between the samples.

7.7.1 Treatment Application Survey

The treatment application survey assessed whether the respondents have used the treatment in their organization. This represented either (yes) having used the treatment in their role, or (no) not having used the treatment.

The results are presented as percentages of sample with positive selection of a treatment.

Table 7.8 Risk Treatments by 3-Levels of Analysis

	N	**Insurance**	**Out-source**	**Acceptance**	**Avoid**	**Mitigation (Probability)**	**Mitigation (Impact)**	**Option**
Firm-Level								
FCORP	*105*	56%	32%	64%	30%	40%	26%	49%
GRS	*86*	49%	43%	69%	36%	37%	35%	40%
Function-Level								
Asset	*103*	60%	44%	68%	31%	40%	30%	57%
Service	*88*	44%	30%	64%	34%	38%	30%	30%
Group-Level								
Asset S-suite	*33*	61%	42%	85%	30%	39%	42%	58%
Asset M-suite	*70*	60%	44%	60%	31%	40%	24%	57%
Service S-suite	*35*	46%	23%	74%	26%	34%	40%	31%
Service M-suite	*53*	43%	34%	57%	40%	40%	23%	28%

7.7.2 Risk Treatments by Levels of Analysis

Using the three levels of analysis, Chi-Squared tests are performed to identify unexpected distributions, *i.e. a test of the null hypothesis that there isn't a significant pattern between samples.* The summary results are provided in table 7.9. It was found that there are no significant differences between results at the firm-level. Function and group-level analysis demonstrates some unexpected distributions of treatments.

Table 7.9 Summary of Treatment Usage by Levels of Analysis

Users	*Insurance*	*Outsource*	*Acceptance*	*Avoidance*	*Probability-Mitigation*	*Impact-Mitigation*	*Option*
Firm				-			
Function	Asset high	Asset high					Asset high
Group			Asset S-suite high				

Function-level:

The function-level demonstrated difference between asset and service. In treatment usage, the asset function demonstrated increased usage of Insurance χ^2(df=1,N=238)=4.80, P<0.05, Outsource χ^2(df=1,N=238)=4.07, p<0.05 and Option taking χ^2(df=1,N=238)=14.78, p<0.01, over service functions.

Group level:

The group level analysis shows increased usage of risk Acceptance in asset S-suite (df=3,N=238)=9.62, p<0.05, and increased use of Option taking χ^2(df=3,N=238)=15.52, P<0.01 in both asset M-suite and S-suite (this relates to the function-level analysis).

Some of these Chi-Squared tests show Pearson Chi-Squared *p* values of greater than 0.05 (two tailed). In these cases the null hypothesis is accepted that there are no differences in frequencies between samples.

The data found there were ranges of treatments being used: acceptance was consistently the highest used treatment (69% in GRS), and impact mitigation (26% FCORP). Identification of treatments use did not differ between firms (FCORP and GRS). There were differences identified between functions. Asset functions use insurance, outsource and option taking more than service functions. At a group-level, asset S-suite demonstrated a higher usage of acceptance than any other group.

7.8 Results (5): Risk Treatment Usage

Section 7.6 identified five latent factors, which describe managerial sensitivity; section 7.7 analyzed the use of different treatments in managing risk. This section combines these findings to explain, the relationship between use of a risk treatment (or non-use) and the latent sensitivity (the influence). The following results show a significant difference under independent sample t-test when applied to the EFA factors (section 7.6)[74].

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[74] *Insignificant results are omitted from the results. This is where p>0.05.*

Table 7.10 Summary of Risk Treatment Usage by Factor

Treatment (section 7.7)	**Influence (section 7.6)**	**Users of treatment (section 7.7.1)** M(StDev)	**Non-Users of treatment (section 7.7.1)** M(StDev)	**Test**
Insurance	*Financial-focus*	*N=101* 7.23 (1.72)	*N=90* 6.36 (1.62)	p=0.015
Acceptance	*Individual-focus*	*N=126* 13.1 (0.51)	*N=65* 15.1 (0.74)	p=0.013
	Traditional-focus	12.4 (0.23)	11.0 (0.65)	p=0.014
Avoidance	*Traditional-focus*	*N=62* 12.7 (1.72)	*N=129* 11.7 (2.07)	p=0.034
Option	*Traditional-focus*	*N=85* 12.6 (1.67)	*N=106* 11.7 (2.12)	p=0.042

7.9 Summary of Individual-Level Results

The firm-level analysis showed limited differences between FCORP and GRS; indicating the differences occurring in managing risk may not be firm dependent. The function-level analysis found that differences occurred between service and asset functions (e.g. calculative culture and risk system usage). The group-level analysis demonstrated a difference between causal maps. However as the discussion outlines (section 6.5), there were patterns of agreement and convergence in S-suite, asset managers and service managers.

Chapter 7 tested the different sensitivities and the different uses of treatments. This was a quantitative analysis, which in the integrative results, combines the individual-level results with the causal maps.

There was a significant range of sensitivity shown between the 15 statements provided to the respondents. This ranged from statements of impact (4.2) through to previous financial accounts (2.3). These sensitivities were different across the different groups. It was found to be helpful to reduce the number of variables using an EFA. This reduced the variables down to five factors, which reflected different traits already seen in the research: **Traditional-**

focus (based on the established view of risk as probability by impact), **Company-focus** (alignment to strategy and reflection of company perception), **Financial-focus** (a sensitivity to measures and objectives which are framed as financial outcome), **Individual-focus** (a personal reflection of the risk management activity and decisions and how they reflect on the individual) and the **Tool-focus** (application of risk tools, standards and a negative relationship with the application of intuition).

No difference in sensitivity was found between cases (FCORP and GRS), at function-level there was a difference between asset and service functions in financial-focus and traditional-focus. Between the different groups, no significance was found in the application of factors, however only analyzing management level (S-suite and M-suite), there was a difference in traditional-focus. S-suite had a higher sensitivity to the traditional-focus factor. Finally it was found that between genders, that males have a higher sensitivity to individual-focus than females[75].

This level of analysis found that an individual's risk avoidance and option taking were sensitive to the traditional-focus (i.e. impact, probability and non-financial impact). Individuals using insurance had an increased financial-focus.

The use of acceptance as a treatment was correlated with two factors: a) the traditional-focus, b) an individual-focus. Where an increase in sensitivity to the traditional-focus identified acceptance as a treatment, a decrease in sensitivity to individual-focus also showed an increase in risk acceptance.

7.10 Integration of Results (4 Levels)

In Chapter 7's integrative discussion, primarily focuses upon integration of group-level (chapter 6) and individual-level (chapter 7) results; these were levels of analysis focused on the structure of decision, following on from firm-level (chapter 4) and function-level

[75] *It was not possible to provide any further analysis of gender differences at firm, function or group-level due to the low proportion of females holding managerial posts in these firms.*

(chapter 5) analysis of the structure of risk management. In turn the discussion considers the different groups, their descriptions of influence and their paths to treatment. Table 7.11 summarizes the combined findings from chapters 6 and 7, and table 7.12 the paths to risk treatments.

Table 7.11 Node and Influence Summary

	Asset S-Suite	Asset M-Suite	Service S-Suite	Service M-Suite
Map Complexity (M^C) (section 6.4.2)	.129	.140	.126	.150
Map Density (MD) (section 6.4.2)	1.35	1.33	1.26	1.20
Significant Nodes (section 6.4)	23	26	24	22
Presented Nodes (section 6.4)	20	18	19	15
Dominant Risk Treatments (section 6.6.3) and use (section 7.7.1)	• Acceptance 85% • Outsource 42% • Mitigation (probability 39%, impact 42%)	• Acceptance 60% • Outsource 44% • Mitigation (probability 40%, impact 24%)	• Acceptance 74% • Outsource 23% • Mitigation (probability 34%, impact 40%) • Portfolio/ Hedging	• Acceptance 57% • Outsource 34% • Insurance 43% • Mitigation (probability 40%, impact 23%)
Dominant Risk Types (section 6.6.2)	• Reputation • Engineering • Safety • Environment	• Reputation • Engineering • Safety	• Reputation • Financial • Planning	• Reputation • Financial
Central Node of Influence (N^C) (section 6.4.3)	• Risk measure (.17)	• Safety (.13) • Environment (.13) • Control structures (.13)	• Risk measure (.15) • Belief (.15)	• Communications (.17)
Central Node of Outcome (N^C) (section 6.4.3)	• Financial risk (.13)	• Communications (.17)	• Control structures (.11)	• Structured decision-making (.33)
Central Nodes (not dominant as influence or outcome) (N^C)	• Belief (.25) • Control structures (.25)	• Learning (.25)		
Perceptions of decision-making (section 6.5.1)	Rational and reasoned	Reasoned, with a satisficing criteria rather than optimality	Rational and reasoned	Intuitive and responsive
Perceptions of influence (section 6.5)	Engineering discipline and experience	Engineering discipline and experience	Subordinates to do the detail, as an oversight function	Individual risk bearing, fast paced and using experience
Risk Sensitivity (section 7.6)	High financial-focus	High traditional-focus, high financial-focus	High traditional-focus	

It was seen that reputational risk was the only common risk type formed within the causal maps, across all samples. Whereas it was found that acceptance, outsourcing and mitigation were consistent risk treatments across all samples. Table 7.12 summarizes the relationships between risk types and risk treatments.

Table 7.12 Paths to Treatment Summary

	Asset S-Suite	**Asset M-Suite**	**Service S-Suite**	**Service M-Suite**
Direct links to treatment (section 6.4)	Safety risk to avoidance Safety risk decreases acceptance	Safety risk decreases acceptance	Reputation risk decreases transfer (outsource)	
Prohibitory relationships (section 6.4)	Beliefs decrease use of lag measures Safety risk decreases acceptance Environment decreases risk transfer (insurance)	Safety risk decreases acceptance Environment decreases risk transfer (insurance) Strategy alignment decreases reaction treatments Reputation risk decreases communication	Beliefs decrease use of lag measures Reputation risk decreases transfer (outsource)	Beliefs decrease use of insurance Beliefs decrease use of lag measures Environment decreases reaction treatments
Inter-risk type relationships (section 6.4)			Planning risk leads to financial risk Speculative risk to financial risk	
Role of beliefs (section 6.4)	Decreases use of lag measures. Increases reference to safety risk, use of avoidance and the role of communications	Lead to understanding of safety risk Increases use of control structures	Decreases use of lag measures	Decreases use of insurance and decreases use of lag measures

Table 7.11 and 7.12 summarize the main themes in the group and individual-level analysis. The tables demonstrate a consistency in understanding between levels of analysis (group and individual). Firstly, that there were pronounced differences between service and asset functions. Secondly, that there was an increased consistency between S-suite and M-suite managers in asset functions, where there was a more pronounced difference in service function management levels. This summary completes the results and analysis in this research, which are discussed next in chapter 8.

Chapter 8

8. Discussion

8.1 Risk in Operations

Bank's (2004) classification of risk differentiates between pure risk (the risk of loss) and speculative risk (the risk of imprecision, with the potential for gain and loss). This research in the energy sector was positioned, as a study of the risk in operations. It was felt on starting the research that risk in operations was characteristic of pure risk, because it was assumed to be a practice of protection against loss. However at the firm and function-level demarcation between pure and speculative risk was blurred. This was most apparent in the service functions, whereby hedging and portfolio practices were being used to protect against imprecision of outcome, rather than against individual losses, and therefore typical of speculative risk practices. Although managers were able to identify where a threat (a potential loss event) was being managed, because many of the risks were either *systematic* (Pfohl et al., 2010) or *systemic* (Kaufman & Scott, 2003), the ability to manage these risks didn't just protect the organization, but provided advantage in the sector. This provided an understanding that threats managed successfully offered potential for gain in market position, and not just protection from loss. This demonstrated that the theoretical distinction between pure and speculative risk management is not precisely replicated in practice, confirming Law's (2009) view that pure and speculative risk cannot be separated.

In asset functions there was evidence of pure risk practices, in service functions there was evidence of pure and speculative risk practices. In asset functions the focus was on the protection of assets, whether tangible assets or resources, for example staff, therefore speculative practices were not commonplace in asset functions. Because the language changed in asset functions to be focused on "protection", successful management of risks was perceived to be a protection of an asset or negatively a loss/damage of an asset. Even in this well-defined environment, risk decisions were not isolated from the ability to gain from successful risk management, for example the treatment of an environmental risk that could be used for enhancing the reputation of the company.

At the firm-level the management of risk in operations was a practice covered by definitions of both pure and speculative (Banks, 2004) risk practices (section 4.2). It was a reflection of discussion of the lowest common denominator in BUs (i.e. speculative practices in the service function, as it includes both loss and gain decisions). Both firms demonstrated some contention between managing the difference in asset and service risk management processes, they found it difficult to reconcile different categories (i.e. engineering or project risk) and approaches to risk (section 4.3). Differences between functions included the classification of risk, the assessment and valuation approaches and more broadly the philosophies toward managing uncertainty.

A second finding was that across all cases, there was recognition of economic efficiency and the inability to fully remove risks. This supported the language of risks being *inherent*, in their untreated form (Bettman, 1973) and in post-treatment a *residual risk* (cf. Zwikael & Sadeh, 2007). It was recognition to a level of uncertainty post-treatment of a risk, and that a reduced probability or impact still existed. This meant the risk had on most occasions been reduced to a tolerable level (as defined by the Business Unit), where the investment in treatment was less than the economic and reputational threat remaining.

8.1.1 Risk in Operations as a Category of Risk

Risk in operations, as a separate category of risks was not well defined in literature (section 2.4), but understood in observed practice. For asset functions, this was a risk associated to the loss of production, a safety risk (therefore resulting in production loss) or damage to the firm's reputation (often through environmental hazard); it comprised the majority of the function's activities and therefore *risk in operations* was the dominant activity (section 5.3). In service functions it was more difficult to separate the operation, for example billing, meter reading or customer development, from broader market dynamics. This was where the original reference to Operational risk was introduced. Operational risk was analysed and deconstructed in the literature review (section 2.3) and found to be a term from the financial sector (cf. Power, 2005), its description is similar to a description of an operation *"people, processes and systems"* (Basel Committee, 2006:644). It was found that the accompanying processes of valuation and the definition of the term (in relation to Credit and Market risk) were incongruent with the energy sector (cf. Mooney et al., 1996), because of the multiplicity of risk types (section 4.2.3). The intricacies of market dynamics and the operation were brought together in service functions; and because of broader outcomes of health, safety, reputational, political and strategic impacts and the inappropriate valuation approaches were felt to be fundamentally different from Operational risk (Basel Committee, 2004). Therefore it was established that risk in operations is not a term of equivalence with Operational risk (section 2.3).

Discussions of supply chain risks were muted within the analysis; in part this is attributed to the vertically integrated nature of the companies (section 4.1), and also the relatively short supply networks observed. However the learning from the supply chain risk literature aids an understanding of practice. In the literature review, it was suggested there were two categories of supply chain risks: supply-demand co-ordination risks (Kleindorfer & Saad, 2005) and disruption risks (Kleindorfer & Saad, 2005; Cohen & Kunreuther, 2007). Disruption risk, the *"risks arising from disruptions to normal activities"* (Kliendorfer & Saad, 2005:53), was the principle discussion in the case analysis, for example the disruption of meter reading agent activities and the impact it had on billing processes. Disruption risk is associated to operational failure (Cohen & Kunreuther, 2007), for which the literature advocates standardised risk measurement, supply chain information sharing (Hora & Klassen, 2013; Ireland & Webb, 2007) and a range of treatment options, which included increasing flexibility (Ritchie & Brindley, 2004), redesign (Christopher et al., 2011) and redundancy (Grabowski & Roberts, 1999). All of these treatments were observed at the function-level (section 5.3.4), and more so in asset functions. Asset functions, as generation operations, specifically designed in redundancy in their plants to cope with failure of individual components, even where this provided reduced capacity. However these design and investment decisions exposed the importance of analysis and valuation (section 5.3.3) informing the treatment decision.

8.1.2 Risk Analysis and Valuation

The analysis and valuation processes for risk exposed the impact of individual behaviours, suggested by Ellis et al. (2010) and calculative cultures (Power, 2005). The influence of both on the risk management process differed between the service and asset functions (section 5.5). Asset functions were using an increasingly mature risk valuation approach (which was not *Value at Risk*, Basel Committee, 2006). It combined a detailed quantitative and historical record of previous failures (as promoted by Dey, 2004; Dey, 2010; Dey, 2012), and combined this with expert knowledge, although it was not possible to confirm whether these experts were either quicker or more accurate as suggested by Glaser and Chi (1988) and Tazelaar and Snijders (2013). Whilst service functions perceived a lack of comparability between each risk, the result that each valuation was completed as a discrete transaction with limited learning (section 5.3.7) for future assessments being recorded. Therefore the different functions demonstrated polar approaches to risk valuation and assessment.

Understanding of differences in risk categorisation between functions (section 5.5) strongly influences an understanding of how, at firm-level, risk in operations can be influenced. It indicated that where there was a fundamental difference in adopted philosophy toward risk, it caused an increasingly abstract and policy driven connection between the operating units and the corporate functions (section 4.2.6). In the cases analysed it resulted in the corporate body managing risk as an activity of stakeholder and shareholder communications (section 4.2.6) and aligning the overall risk portfolio. Individual risks were managed as a portfolio of activities within the BUs, and the corporate function intervening only where there was a distribution of capital beyond the investment authority of the function (section 4.2.6). It was notable that a statement of adopted risk management standard (section 2.2), which included the setting of objectives, routines for identification, analysis and approach to treatment (cf.

Hopkin, 2004) had limited direct influence on the risk management practices observed in Business Units (section 4.3); beyond a requirement for iterative process of treatment and control. This is discussed next.

8.1.3 The Influence of Corporate Function

In the literature review, only limited differences in the common risk management standards were seen to exist (i.e. COSO, AIRMIC and ERM more generically), and in the analysis there was limited difference in observed application (sections 4.2.4, 4.3). This put into question: what benefit beyond certification does the adherence of a risk management standard provide, which is not delivered through risk management approaches developed in practice by the company? This challenge was further reinforced by the limited evidence (sections 4.2.6, 4.3) of cascade and impact at function-level or even in the manager's decision maps of the stated risk management standard (section 6.4.1). This exposed a difference between the desired levels of influence from top-down (through the different levels of analysis) and the observed and perceived influences in the cases studied.

Table 8.1, summarises the difference between the desired and observed influences of the risk management process. In turn, the design of the risk management process intended to be defined in the adoption of a firm-wide risk management standard, for example COSO in FCORP (section 4.2.4). The standard was meant to set the strategic process of risk management (Federation of European Risk Management Associations, 2013). It was apparent that as the risk management process was fulfilled by the BUs, that these cultures and operating procedures were dominant in forming the operating model, and that this was appropriately aligned to the type of operation (section 5.3.1). In asset functions the engineering influence and protection of assets was dominant (section 4.2.5), whereas in service functions reconciling the market and the operation (and therefore great awareness of exogenous risk) determined the identification, analysis and treatment of risk (section 4.2.5).

Table 8.1 Observed and desired influences at four levels of analysis

Element of Risk Management Process	Desired Influence	Observed Influence	Comments
Design of the risk management process	ERM Risk Management Standard	Status Quo and Individual Business Unit processes	ERM has been implemented as a central reporting process. The processes are a mixture of historical Business Unit processes. The holistic influence implemented through a financial valuation of all risks.
Descriptions of Risk	Risk Management Standard and X-sector best practice. Leading to recognised valuation techniques.	The operating environment has defined the types of risk. Local interpretations of risk definitions are unaligned.	Valuation techniques are inconsistent, reflecting the multiplicity of risk types and lack of understanding of conversion between risk types. Descriptions of risk leading to gaps and double counting.
Assessment of Risk	Quantitative valuation, history/developed intelligence and Experience	Individual business unit approaches.	Assessment in asset functions embedded within asset registers, providing a consistent (arguably objective) assessment, developing upon historical data and OEM figures; not presenting in common unit of measure with firm descriptions. Service function assessment with limited basis on historical knowledge, reliant on experience and intuition.
Treatment of Risk	Objective appraisal, absolute judgement and rational decision making with reference to performance system	Subjective, personality driven with personal contingencies dominant in prioritization. Beliefs then reference to performance system.	Performance system is the last point of reference in individual decision making but influences beliefs over long-term. Oversight meetings driven by management personalities and different personal contingencies in effect. Service functions reflect diverse background of staff and asset functions present strong engineering influence.

The identification of risks was a documented phase of the risk cycle (BSI 311000, 2011; COSO, 2006). In asset functions, because there was limited competition between generation assets and a high number of shared providers (sections 4.1.3, 4.1.5), there was evidence of promising practice being shared between organizations (section 5.3.1), where there was not a risk of knowledge leakage (cf. Ireland & Webb, 2007). This included sharing of documented failure rates and identification of risks. However in the service functions, where there were high levels of competition in the homogeneous market there was no sharing of risks and treatment practices; as good risk management was described as offering a competitive advantage. Therefore the increasing competition in the service sector did not encourage sharing of promising practice, unlike in the generation sector.

8.2 Types of Risk

The descriptions of different types of risk differed between service and asset functions (section 5.3.3), as did the framework for making these distinctions. Different risk standards and practices encourage a generalizable classification of risk types (e.g. Operational risk in the Basel Accord); risk descriptions were highly localised and reflective of the operating level of the managers (section 5.3.3). S-suite managers exhibited descriptions of risk as a measure of consequence and M-suite managers of risk as a description of cause. Further, translations of risk descriptions were not consistent between firm-level and function-level (section 4.2.6), with increasing levels of granularity in the function-level, where the conversion between the two were not well understood. This meant that comparison between functions (i.e. contrasting risk levels between the retail function and the generation function) was inaccurate. What was found was an informal translation of different risk types between operations and levels within the firm (section 4.2.6). Because risk descriptions were different between operating units the valuation, and the assessment of risk was also different (sections 5.3.3, 5.3.4). This was further impacted by the differences in context. It was observed that the historical record, the integration of asset and risk registers and the role of the risk professional in asset functions provided a suitable quantitative basis for evaluation of a risk (section 5.3.1). However in service functions the complexity of influences, the market impact, the competitive barriers between firms, a limited historical record and the reliance on the operations manager meant that only a qualitative and subjective appreciation of risks were being performed in these operations (section 5.3.1). An unexpected characteristic emerged between the two function types; this became apparent in using the lens of *Calculative Cultures* (Power, 2005). It demonstrated a reversal of the culture in assessment (section 4.3): in asset functions in the valuation phase appeared to be dominated by a quantitative appraisal of risk (typical of calculative idealism) in assessment they used the result only as a guide (typical of calculative pragmatism). In service functions this was reversed, that risk valuation had limited empirical basis and reliant on the subjective assessment of the manager, therefore resulting in a pragmatic approach to valuation, which in assessment transferred to almost religious maintenance of the initial subjective valuation as if it had been defined through fact (typical of calculative idealism).

8.2.1 Performance System Influence

Finally, in the selection of a risk treatment, it was observed that there was a lesser effect of the performance system in reaching risk treatments than expected in commencing the research (section 5.3.8). Risk treatments were justified in reference to organizational beliefs (culture) and individual beliefs (often morality) before articulation to stated performance measures; and where they were this was felt to be a post-hoc justification (this is discussed in greater detail in the next section).

8.2.2 A Framework for Risk Descriptions

It has been highlighted in the previous section that different descriptions of risk were apparent throughout the analysis. This occurred both between cases (i.e. asset to service) and between levels of analysis (i.e. firm to function). This presented a major challenge in the comparison between levels of risk, standardised valuation approaches and the potential for duplication/ omission. It is felt that the desire for a utopian and standardised single unit of measure was a major influence of the financial sector's VaR valuation approach, and hence reference to Operational risk (Basel Committee, 2006). As discussed later in section 8.6, this obsession with finance sector approaches to managing risk is inappropriate in the energy sector and further this can be generalised to its inappropriate application in sectors displaying a multiplicity of risk types, especially where financial valuation is difficult to reconcile to the underlying consequence (i.e. Health and Safety).

What emerged from the literature review and the case analysis was a relationship between different risk types not expressed in theory. The suggested framework is influenced by previous research, for example Dey's (2002; 2004; 2012) Analytic Hierarchy/ Levels of Risk and Lewis' (2003) Cause, Consequence and Control. The framework is a fusion of these two ideas; in Dey's presentation of risk relationships and Lewis' description of cause and consequence. In the analysis it was apparent that at the lowest level of decision-making the individual risks were being discussed as a statement of cause (often by M-suite managers), for example a failure caused by two-phasing a turbine. In S-suite and function-level this was going through a valuation conversion process (section 5.3.3) and being interpreted into a consequence of the very same failure. However this was now being expressed as a measure of consequence, for example the turbine failure reduced production capacity by 30% and equated to £1m/day loss. At the most basic level this was a transfer of the description of risk from a single cause into a single consequence. The measure of consequence was defined as a financial outcome (£ or $), as this aided investment decisions. However as the analysis progressed and increasingly complex risks were observed the relationship between cause and consequence also become more elaborate, for example, a failure in the retail billing process (as a description of cause) was converted into a risk of reduced income and a reputational risk (a single cause had two measures of consequential risks).

A distinction was made between the description of a risk as a cause and risk as a statement of consequence. This distinction serves more than a semantic exercise (cf. Power, 2005); it distinguished the level of analysis and the purpose of the description. Table 8.2, provides an approach to causal and consequential definitions of risk, it highlights the purpose of the description and how this focuses the organization (or individual).

Table 8.2 Cause-Consequence Comparison

	Risk as a Cause	**Risk as a Consequence**
Risk	Risk from…	Risk of…
Considerations	Descriptive of qualitative impact. Clear on assumptions of valuation. *"general categorisation of events that initiate failures"* (Lewis, 2003:206)	Assumes a probability of event occurrence. Requires translation method between causes. Challenging to see common causes
	Ability to compare common sources. When aggregated potential to duplicate, when isolated ability to assign responsibility	Ability to compare different risks, and prioritise on a single metric. Challenging to assign responsibility.
Focus	Focuses on understanding, and common causes	Focuses on prioritisation and investment in treatment
E.g.	People, processes, systems, law/legal, regulation, market, credit	Financial & safety (H&S). Conversion of environmental risk to financial because investors need financial information (cf. Newton et al., 2005).

This distinction can be extended beyond the individual context of energy. It can be applied to any industry or organization that seeks to define its types of risks in a structured approach. It allows for the relationship between different risk types to be identified, and recognition of the conversion and valuation processes. In the energy sector, where there is a multiplicity of risk types this was increasingly complex in its relationships, and in the analysis showed where an outcome had both financial and safety implications.

To demonstrate how the risk descriptions can be modelled, the well-documented structure of the Basel Committee (2006) is provided in example, figure 8.1. A deconstruction of the Basel description exposes the contention in the framework (cf. Crouhy et al., 2001), and why Operational risk is a fundamentally different description to Credit or Market risk.

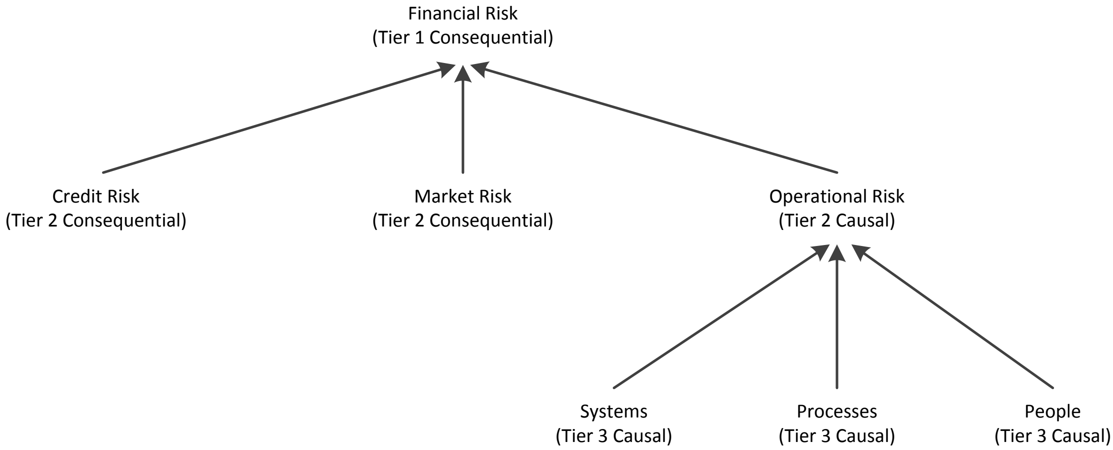

Figure 8.1 Cause-Consequence in Basel Accord (2004)

In the Basel Accord (2004), risk valuations are expressed in financial terms; most commonly using VaR. Feeding into this overall financial value (for purposes of defining capital adequacy) there are three main types of risk: Market, Credit and Operational risk (section 2.3.1). Market and credit risk are definitions of consequence*: risk <u>of</u> economic loss, risk <u>of</u> losses on and off-balance sheet positions* (Basel Committee, 2006:638). However Operational risk is "*loss resulting <u>from</u> inadequate or failed processes…*" (Basel Accord, 2004:644); this is a causal description of risk. The Basel Accord may be criticised in the inconsistency between Tier 2 descriptions. Extending the hierarchy further, Operational risk is made up of three underlying categories of risk *"failed internal processes, people and systems"* (Basel Committee, 2006:644). Individually these are causal definitions of risk.

In the following section, the hierarchies of risk are synthesised from the firm-level case analysis.

GRS Risk Hierarchy

Deconstruction of the GRS risk types, demonstrated the difference between the asset functions' and service functions' risk hierarchy. In the asset function, BU risk types (3rd tier) were mapped to corporate risk types (2nd tier). Whereas the service functions' risk types had increased levels of conversion and many-to-many relationships, see figure 8.2. The GRS asset function hierarchy is represented first.

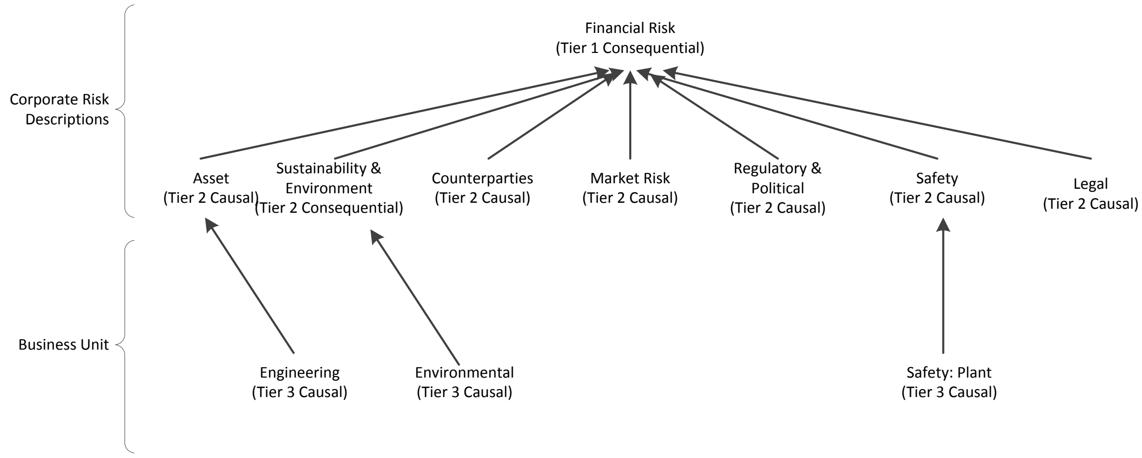

Figure 8.2 Cause-Consequence in GRS asset

The three Business Unit risk types (3rd tier) were embedded into the risk analysis software (section 5.3.1), therefore reducing complexity in the process and reducing the subjective mapping in the reporting process: safety risk (is converted to a financial measure outside of the business unit process, at corporate level, but was not used in function-level decision-making). Environmental risk, mapped to sustainability and environment. Engineering risk (already established with a currency value, calculated by predefined production costs and profit data) maps to asset risk.

The service function risks were more complex in their relationship, as shown in figure 8.3.

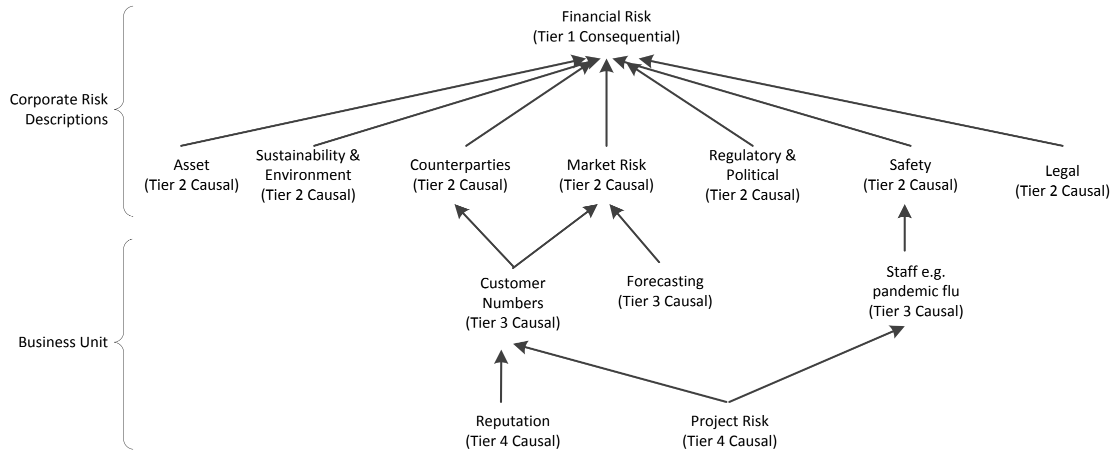

Figure 8.3 Cause-Consequence in GRS service

In the service function the different risks were not well defined, beyond forecasting risk and customer numbers. Risk types were defined on an ad-hoc basis, responding to emerging issues. Project risk was a consistent point of contention, although understood as an attribute of a project, each project commanded different activities, for example: a system change may affect customer numbers and operability of the system. But a project to change working times incurred a safety risk and an impact on the customer numbers.

What is seen in this framework is the relationship between a cause of a risk and the path to final valuation (top tier). Top tier definitions of risk were a strategic decision reflecting firm-level stakeholder influences (Sections 4.2.1, 4.2.2 and 4.2.3), for example EAM decided that it was inappropriate to turn safety risk into a financial valuation, and therefore left safety risk as a separate top tier risk. This was an important statement within the operation, and influenced behaviour in the treatment of risks affecting health and safety, in that they would not be tolerated regardless of cost to treat.

8.2.3 Risk Hierarchies

Developing this hierarchy allows an improved appreciation of the structure and relationship of different categories of risk. First the top tier risk types indicate the final unit of performance measure in the organization, or the BUs. The different consequential risk types operate as a lower level of granularity to identify the risk types within the organization and were the dominant unit of measure at the function-level, in the cases analysed this differed most between service and asset functions (section 5.5). In asset functions this was predominantly: operational/production, safety and environmental risks (section 4.2.3). Whereas in service functions the complexity of the environment was exposed, with a breadth of risk types: credit, market, systems, projects, reputation and political (sections 4.2.3, 5.3). Figure 8.4, suggests a generic framework for documenting risk hierarchy in the firm.

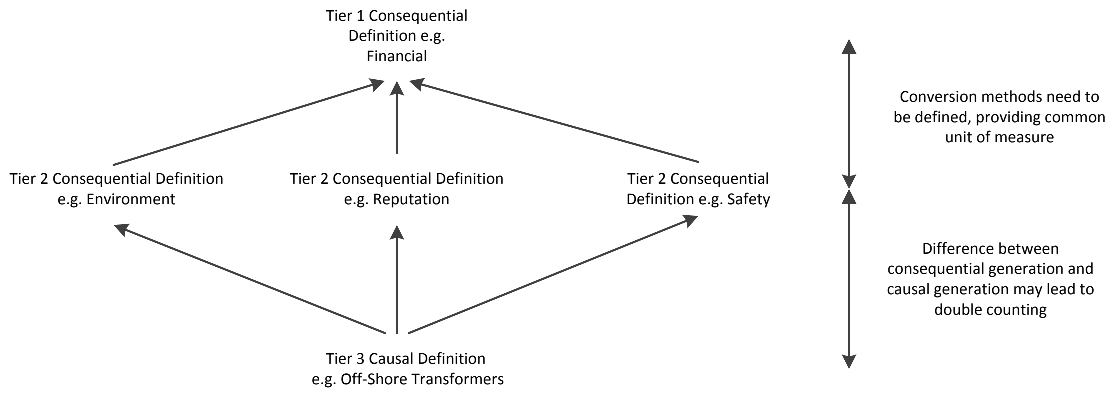

Figure 8.4 Causal-Consequential Classification Reconciliation

A clear classification of risk types provides the corporate body or supply chain the ability to accurately and technically describe and categorise risks, further to structure decision support analysis (cf. Dey, 2004). Classification is a method of demarcation, division of tasks and basis for resource investment (cf. Dey, 2004). In understanding of the hierarchy of risk there are benefits: 1) A clear hierarchy reduces the potential for double counting of risk impact; 2) It ensures a precision of the terms being used and 3) It provides a model to structure the risk conversion (and hence valuation) process (cf. Dey, 2004; 2010).

Risk valuation is critical, it provides a comparison for investment in mitigation (section 6.4.1), cost benefit analysis of outsource and insurance (insurance requires the risk to definite and measurable (Vaughan, 1997)) and a means of prioritisation (section 6.4.1). Managers focus upon valuation both as a reported measure of risk (measure and targets, section 7.3) and as an input into the risk management process for structured decision-making (value of inherent and residual risk)(section 6.5.1). There needs to be a reflection of both the granular and specific descriptions of risk that exist (i.e. at an operational level) and an ability to aggregate the risk (at organizational level) for purposes of prioritisation and treatment: *"In practical terms this involves the risk of things going wrong with the day-to-day processing activities of the firm…"* (Securities Institute, 2004:4-3). Therefore the causal and consequential definitions of risk are summarised as:

- A causal definition of risk identifies the source of the risk. It is used to group common weaknesses in the operation or environment. It is not used for valuation or contrast between other types of risk. It may include measurement for probability of failure; the impact of failure may be described qualitatively (e.g. GRS's risk matrix: section 5.3.6). However as a limitation, the specific cause of a loss-event are not always identifiable (Power 2005), and then there is a need to view the realisation of risk as a product of the system as a whole (Oren 2001), and not just the threat of failure of a component part.
- A consequential definition of risk identifies the outcome of the risk/s, using a defined unit of measure (often financial). It is used for valuation, comparison, and assessment. It provides a benchmark for the organization to assess it overall risk structure. However as a limitation there is a reduced ability to collect common causes or identify specific weaknesses through a consequential measure.

This classification identifies that both causal and consequential measures of risk must be used in tandem to satisfy the different requirements of the risk decision-making process. Lack of understanding of the difference between a causal or consequential definition was seen to (firm and group-level analysis):

- Increase the chance of duplication in consequential measures of risk (section 6.5.1);
- Disassociate the operational managers from their contribution toward the aggregated risk of the organization (sections 5.3.2, 6.5.3);
- Increase silo working in the risk management process (cf. Mikes, 2011 and section 6.5.3);
- Defer responsibility for understanding the risk measures to the risk managers only (sections 5.3.2, 6.5.2);
- Make the risk management process bureaucratic (section 6.5.2).

The next section moves from discussing the structure of the risk management process and differences between categorisation to the types of treatment in managing risk in operations.

However the two are intrinsically linked, as demonstrated later in the discussion of paths to treatment.

8.3 Treatment Strategies for Risk in Operations

This research aimed to understand: what are the treatment strategies for managing risk in operations, and what influences these selections of treatment? The discussion has highlighted the difference between service and asset functions as presenting polar types of assessment philosophies, and calculative cultures (section 4.3) toward risk, and further that the types of risk being described were in contrast between functions (section 4.3). It established that this difference was more than a semantic exercise, as it defined boundaries of jurisdiction and provided a categorisation of risk (cf. Power, 2005). The valuation of a risk is seen to be an influence on the selection of a treatment (sections 6.6, 6.6.3), however as the argument developed the categorisation of the risk was influential. Chapter 7, the individual-level exposed the use of treatments, and a sample of the extent of use (section 7.6). Again differences were exposed between asset and service functions; however there was also an observed effect of management level.

The firm, function and group-levels of analysis identified a range of risk treatments (sometimes referred to as risk strategies by participants) that had been used (section 7.6.2); the individual-level then tested for the quantity of use of these treatments (section 7.6.1). Hopkin offered the *"4Ts of risk treatment: Tolerate, treat, transfer and terminate"* (2012:224), and although practice did demonstrate use of all these treatments being used (section 7.6), the model was found to be overly simplistic.

Managers did accept risks (section 7.6.1), but they were also shown to ignore risks (which was different to being ignorant of the risk, see section 2.6.1). Hopkin's (2012) description of *tolerate*, did not differentiate between these two mind-sets; whereas Gan et al. (2009) suggested this is the difference between defensive strategies and controlling strategies. In accepting risk, there was seen to be a conscious decision balancing alternative costs of treatment against both the probability and impact (section 7.4) of the identified risk. In ignoring a risk, this reasoned decision-making did not occur, nor was there evidence of an intuitive decision (cf. Kahneman, 2003) to accept the risk. Acceptance of risk was seen as a risk taking decision (section 6.6.1), however in the causal mapping analysis avoidance of risk was seen not as a separate treatment option, but as a prohibitory action not to accept a risk (section 6.4.1).

The *treatment* of risk, which in Hopkin's (2012) language is a sub-category of affirmative action on an identified risk, included both impact and probability reduction (mitigation). This category of treatments was consistent with observed practice (section 6.7.3). However managers demonstrated little appreciation for the difference in mitigating the probability of an event, by providing resilience, for example in designing flexibility or procuring multiple sourcing partners (cf. Ritchie & Brindley, 2004; Spekman & Davies, 2004); or the mitigation of impact, by providing redundancy, for example the provision of contingency (cf. Davies & Walters, 1998) or limitation of affect (cf. Faisal et al., 2006). Within this category of mitigation there was evidence of portfolio treatments (section 6.4.1), for example the practice of hedging, the inversely correlated holding of two outcomes, therefore minimising impact or portfolio management (uncorrelated holdings) which through their probability reduces the overall risk position (cf. Oren, 2001).

Transferring of risk (Hopkin, 2012) was a popular risk treatment in the analysis (section 7.6.1: asset managers 60% and service managers 44%), however it was found that structural conditions could prevent their application. Transfer of a risk through outsourcing (cf. Teng et al., 1995) was perceived as a strategic decision (sections 6.5, 6.5.2), requiring collective and senior authorisation, and transfer (of financial impact) through insurance (cf. Crockford, 1980) were only enabled through organizational framework agreements (section 6.6). It was widely acknowledge that transfer of risk, in either form, had no or limited influence on the probability of a failure (section 6.6), and only served to reduce the impact to the client organization. This was consistent with Crockford (1980) that transfer is not a suitable replacement for other risk management strategies.

Finally, *terminate* (Hopkin, 2012), is the total withdrawal from an environment presenting a risk, this was expressed as *avoidance* by managers in the study (section 6.4.2). They felt this was the most difficult and costly treatment available to them, and many felt this was perceived negatively. Hopkin's description does not however recognise the role of option taking in risk management. Option taking is the deferral of decision (Dixit & Pindyke, 1994), where it is possible to delay entry into the path of the risk.

From the literature, logical deduction and the accounts of managers it was possible to deconstruct the different treatments, using the original ontology of risk, which defines risk as a product of (subjective) probability and impact (cf. Dey, 2004; Dey, 2012; de Finetti, 1970; Knight, 1921). Further the accounts of managers identified the perceptions of permanence of decision to a specific treatment, for example the acceptance of a risk was seen as a decision that could be altered immediately after if presented with new criteria. Second there was a perception of the relative cost of applying a treatment (reflecting on the cost before a risk may be realised), for example the cost of deploying fail-safe technology for reducing probability of failure was perceived as moderate cost, whereas purchasing contingency was seen as a costly decision, because of procurement of assets/resources. This is presented in table 8.3.

Table 8.3 Risk in Operations Treatments

Treatment	**Risk Axis Managed**		**Perceptions of Treatments**	
	Impact	*Probability*	*Permanence*	*Cost before realisation*
Accept	-	-	Low	Low
Avoid	-	✓	High	High
Hedging	✓	-	Low	Moderate
Mitigate-Impact	✓	-	Moderate	High
Mitigate-Probability	-	✓	Moderate	Moderate
Portfolio approach	✓	-	Low	Low
Transfer (Insurance)	✓	-	Low	Moderate
Transfer (Outsource)	✓	✓	High	High

When presented in practitioner terms, managers could differentiate between probability and impact mitigation, and further *toleration* and *transfer* treatments (7.8), and answers provided a separation in the perception of cost. This had meant in some cases that successive probability-mitigation strategies had been employed (as individual cost is low and reflected procedural changes within their authority), where a more expensive impact-mitigation strategy would have been more effective, but required capital expenditure, outside of their authority (M-suite).

Before the paths to different treatments are discussed, the relative usage of each can be identified. Managers had identified their use of treatments, in their performance of their role. Figures 8.5a to 8.5d represent the usage of treatments by group (Chapter 6). The treatment levels were taken from section 7.6, and positioned against perceived cost and perceived permanence (section 6.5.2) of treatment decision. These results indicate for each treatment the percentage of the sample that used the treatment in their role.

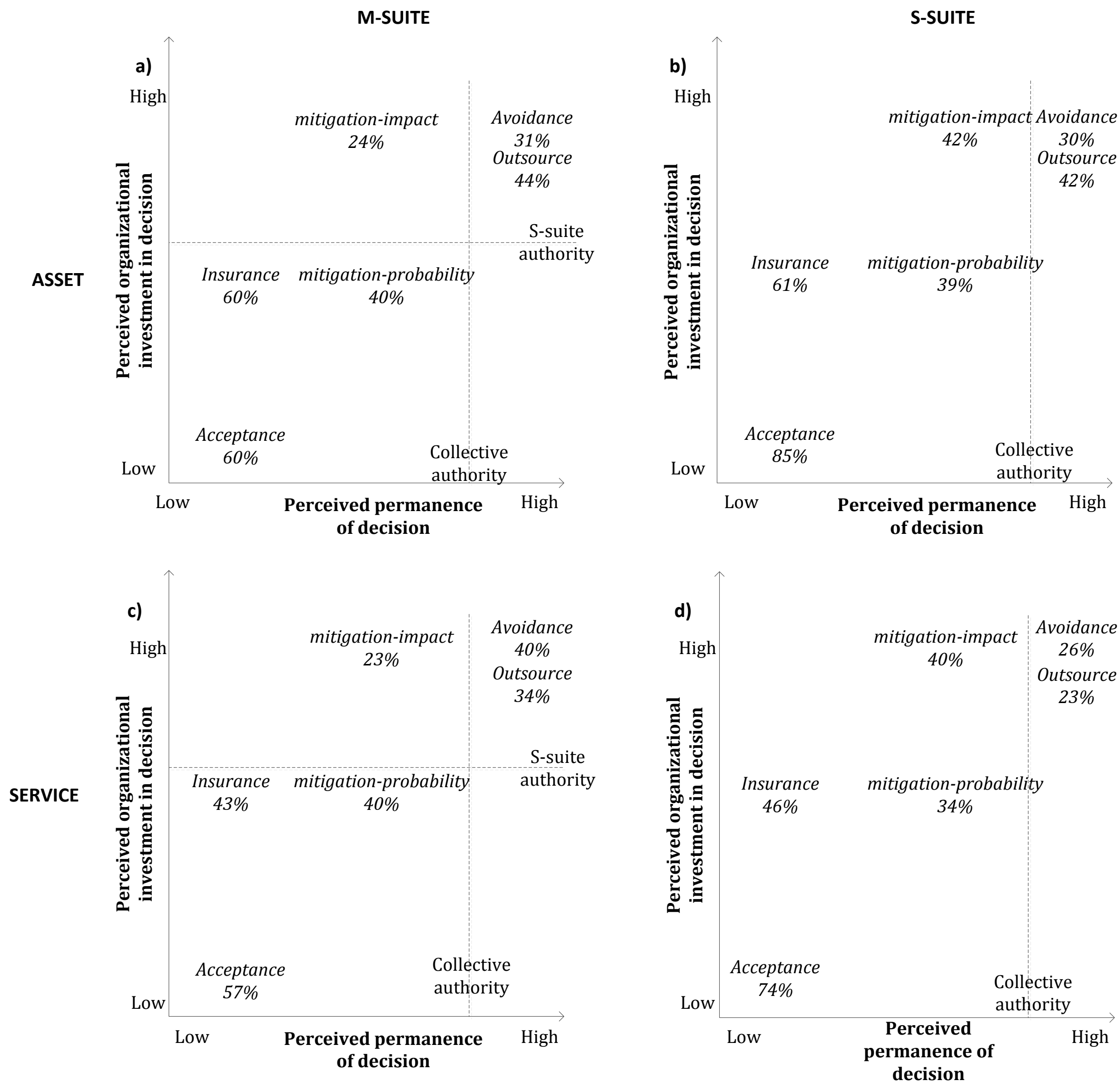

Figure 8.5 Paths to Treatment

There were differences and commonalities exposed in combining understanding of the group's mental models and the treatment usage results. First, acceptance was used more regularly by S-suite managers, than M-suite managers (section 7.6.2). Second the barrier of S-suite authority perceived by M-suite managers (section 6.5.2) clearly reduced the application of impact mitigation treatment in M-suite (Asset M-suite, 24%, asset S-suite, 42%, service M-suite, 23% and service S-suite, 40%). This was logical as the access to capital and resources to deploy impact mitigation strategies was under the assessment of the senior managers. Excluding this rule it could be seen that as cost and permanence increases in the treatments, the levels of use decrease. This again is a logical deduction, and further supported by the finding of structured decision-making being a path to selecting the more costly treatments (section 6.4.1). These paths to treatment were seen to be influenced by more than a pure economic decision however, and it was one that was mediated by all four levels of analysis completed in this research (discussed next). Leading to an understanding to how managers make and are influenced in reaching a treatment, the different levels of analysis are discussed in turn.

8.4 Four Levels of Analysis

Four levels of analysis were completed in this research. Each contributed to the understanding of the different influences on the risk management process and how the performance of the risk management process is understood. The distinguishing features of each level are discussed in turn:

The Firm-Level

The firm-level recognised the limitations and challenges it faced in managing risk across a distributed and operationally diverse organization (section 4.3). The finding was that the firm-level (the corporate functions) focus upon defining the risk standards (section 4.2.4), the risk contribution of its BUs (section 4.2.7) and defining the final valuations and categories of risk (section 4.2.6). The firm-level was focused upon communications to the stakeholders (section 4.2.1) as well as providing guidance (for alignment with stakeholder demands) to the functional units.

The Function-Level

At the function-level, there was increasing awareness that the BUs were the largest operational structure in the firm. Therefore they commanded great power in the relationship with the central corporate functions. There was an awareness of local context (national or regional). Risk systems, or systems incorporating risk processes were held in the BUs (section 5.3.1, therefore as the system drove the process, identities including descriptions of risk were strong at this level (section 5.3.3). This was about aligning risk process to the operations, whilst contributing to the corporate identity.

The Group-Level

Managerial groups and separation between S-suite and M-suite demonstrated a difference in levels of authority (section 6.5.2). There was indication that S-suite had an increased breadth of understanding of the environment (section 6.6.7), and demonstrated this complexity in their decision process. There were different categories of decisions exposed in the causal mapping analysis (section 6.5.5), and this was consistent across the different samples.

The Individual-Level

Individuals reflected on their own relationship with risk. Understanding that they were officers of the firm (seen in the financial-focus and company-focus factors, section 7.5), but also individuals that have individual responsibility and their management of risk reflected on them personally (seen in the individual-focus factor, section 7.5).

8.4.1 Relationship between Levels of Analysis

These four levels showed a development of perspective from firm-level to individual-level; this was systematic combining, cycling between matching and redirection (cf. Dubois & Gadde, 2002). The firm-level, was about the organization and structures (section 4.3), with an objective to be objective and standardised (section 4.2.4). The function-level was equally about the organisations and structures, but increasingly aware of the operational, regional context (section 6.5.4) and environment (cf. Looney et al., 2008; Villena et al., 2009). The function-level demonstrated a need for the risk management process to be aligned to system capability and the nature of its processes (section 5.3.1). Moving to group-level (the difference between management levels) there was increased evidence of the personal influence, both in terms of organizational authority (section 6.5.2), experience of the individual, their increased breadth of understanding (demonstrated by the increasing complexity of causal maps), but also the responsibility they held to both their subordinates and the company. The individual-level demonstrated that subjective influences and personal contingencies influenced the individual decision-making process (section 7.5); and the unit of analysis had developed to the individual decisions rather than the collective perspective of risk in the firm. This evolution of the research and the influences from the different levels is summarised in figure 8.6.

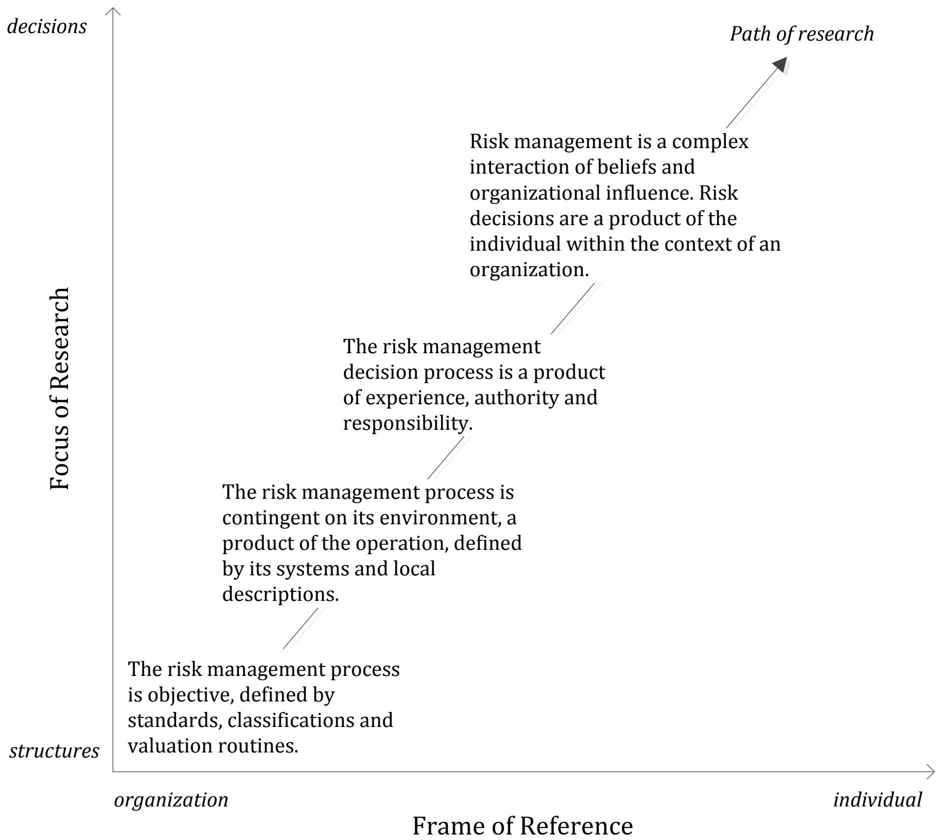

Figure 8.6 Changing Perspectives

The organization's risk types and treatments (firm-level direction, mediated and contextualised by function-level) were the organization's influences on the decision-maker. This required an understanding of the mechanism for transferring this vision, targets and measures to the managers. It was found that direct and prescriptive uses of performance systems (either performance management systems or performance measurement systems) were nearly absent from the management of risk (section 5.5). Instead it was found that the influence was indirect (by interpreting other measures, section 6.4.1) and open (no direct target). However there was evidence of the different components of the performance system being influential in the decision-making process (section 6.4.1). There was a clear statement that risk decisions were made in consideration of the stated strategy (section 7.4), however evidence of articulation and transfer of strategic ambition into objectives, measures and targets (cf. Bourne et al., 2000) or any process of risk strategy mapping (cf. Kaplan & Norton, 2000) were absent (section 6.4.1). Further there was no evidence that risk measurement was feeding back into either the control structures or strategy nodes (sections 6.4.1; 7.10), as encouraged by Bourne et al. (2000); this was a significant limitation in the process; meaning there was limited mediation of the firm-level or functional-level strategies being developed (sections 4.2.4; 5.3.8).

The measurement function was broken down in the analysis, to include lag and lead measures (cf. Evans, 2004) and further risk measures, but not as key risk measures (cf. Proctor et al., 2009). The relationship between each measurement node showed some consistency in understanding between the samples. Lag measures had influence on the communication of risk (section 6.4.1), whereas lead measures were seen as a causal influence on the development of risk measures (section 6.4), this is entirely consistent with risk as being a latent phenomenon, but was also difficult for the organization to reconcile with the reporting against target.

The communication function of the performance system was seen as highly influential in the development of beliefs in the organization (section 7.10), and the link in causal maps was established across three of four groups (section 6.6). In interview respondents were keen to highlight how the message of "safety first" had been implemented into the belief set through a systematic communication drive and challenging targets over many years (section 6.5.5).

These different influences and roles of the performance system become evident in the integration of understanding from the four levels of analysis; however they are the mechanism rather than an explicit force (section 7.10). Figure 8.7, identifies these key relationships.

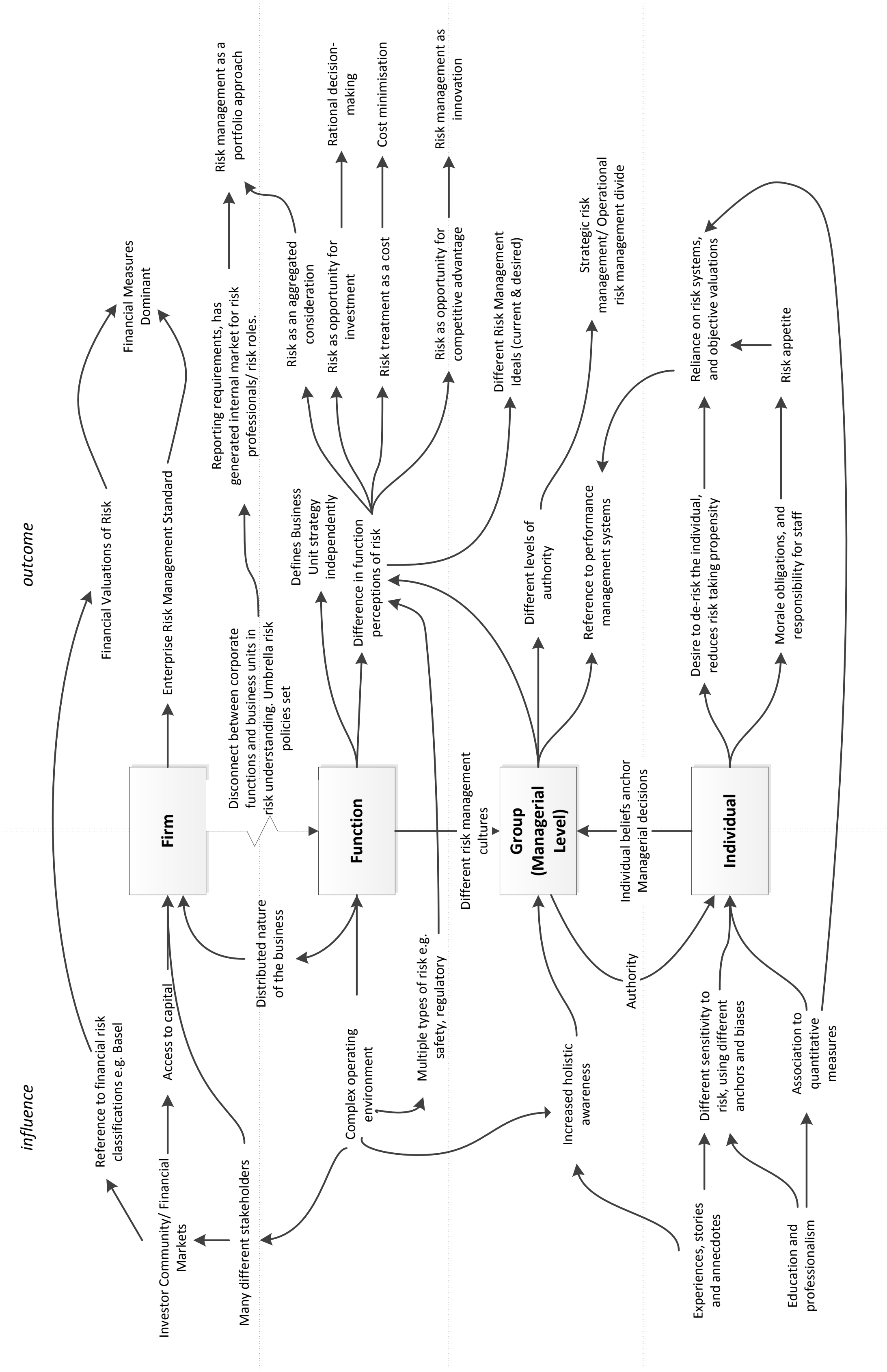

Figure 8.7 Levels of Analysis Inter-Relations

The firm-level was driven by the ability to secure capital through the markets and maintain stakeholder support (section 4.2.2), especially dominant stakeholders (Mitchell et al., 1997), the influence resulted in a financial measure of risk being applied, as a single and understandable measure of risk (section 4.2.2). However, there was disconnection in the measures of risk being cascaded into the function-level (section 5.3.3); this disconnect was influenced by regional understanding and functional association, the functions demonstrated different perspectives of risk (section 5.3.9). Asset functions perceived risk as the potential for investment and service functions perceived risk treatment as cost (section 5.3.3).

The managerial groups, made up of a collection of individual managers, demonstrated difference in authority (management level) and awareness (strategic versus operational focus, section 6.5.2). Multiple forces influenced the individuals, including interpretation of the performance system (indirectly to risk), their personal contingencies and access to experience and/or data (section 6.4). The role of the individual in decision-making was mediated by the risk systems and policies (section 6.5.3), but at different levels based on their functional alignment.

The findings and their implications at the function and firm-levels were discussed in the analysis of risk types, risk classifications and risk processes. It was shown that the path to treatment selection resided within the individual managers. The group and the individual are discussed next to understand the route to treatment selection.

8.5 Individual Decision Influences

The research showed there were five main factors influencing the individual's risk decision-making (section 7.5). The traditional-focus was recognition of risk as a product of probability and impact; this is consistent with Dey (2004), de Finetti (1970) and Knight (1921). Participants from asset functions were shown to be more sensitive to this influence than service functions (section 7.5). This was explained through the system driven reasoned decision-making, therefore removing known biases (cf. Kahneman, 2003) and it leveraged the significant data sets and historical analysis maintained within the asset functions (section 5.3.1). This process was embedded in unavoidable requirements and design of the risk register, which was embedded in the asset register. Second there was a financial-focus (section 7.5), this was the sensitivity toward measures of financial outcome and previous financial accounts, and asset functions demonstrated higher sensitivity toward these measures. This reflected the ability of asset functions to make detailed and accurate financial valuations of both latent risk and cost of treatment. These two findings indicated the accuracy of information used for creating the assessment of risk was reflected in the manger's sensitivity toward the measure. Therefore in stable and more predictable environments the measures of risk as impact, probability and specifically financial impact became clear considerations by the individual manager. However there was an indication that in volatile environments (section 6.5.4), with perceived imprecision of data, this effect was reduced.

There were three other factors identified in describing the sensitivity of the individual manager: company-focus (the sensitivity toward being aligned to company strategy and the perceptions of operation), individual-focus (the sensitivity toward implications on the decision-maker) and tool-focus (the sensitivity toward the application of tools in forming assessment and valuation of risk). Of these three factors, none showed a distinction between the levels of analysis used in this research (section 7.9). It was observed that males, more than females, were sensitive to implications on the individual (section 7.6). It inferred that females are more altruistic than males in making risk decisions.

8.5.1 Levers of Control

Simon's Levers of Control (1995), was identified as a framework explaining the theoretical impact of performance systems on the management of risk (section 2.8.7); or more specifically decisions in managing risk. Simons (1995) identified four different levers: *belief systems* (the core values of the firm), *boundary systems* (boundaries of decision), *diagnostic systems* (ability to predict and analyse performance) and *interactive systems* (real-time management of uncertainties). This was reflected on in the analysis of the causal maps (section 6.5.5).

The causal maps exposed three different paths to treatment selection:

- The direct link between a type of risk and a treatment (or prohibition of a treatment). These links to treatment had no mediating node (section 7.10), indicating no reference to the performance system or individual stimuli. It was most common to see this direct link expressed as a direction of prohibition, for example safety risk did not directly require mitigation but the ability to accept the risk was removed. This is significant because it both infers an order of decision, that the prohibition occurs first before moving to a second level of decision, but most importantly it made the classification of risk significant (section 7.10). This is consistent with Hsee and Hastie (2006) that rules dominate over experience, organizational rules therefore fundamentally influence the selection of treatment.
- Treatment paths are influenced by beliefs. In the context of this analysis there were beliefs of the individual (section 6.5.1). Similar to direct links to treatments, belief mediated paths appeared as prohibitory influences on treatment selection. In the accounts of managers the alignment of individual and organizational beliefs was important to maintain consistency; this was maintained by a bidirectional influence between individual and organization (section 6.5.5). There was evidence of individual beliefs impacting the control structures, demonstrating influence on the organization.
- Paths to treatment influenced through the structures of the performance system. These included communications (cf. Lowrie & Cobbold, 2004), measures (three types: lag, lead and risk) (cf. Neely et al., 2002), alignment (cf. Kaplan & Norton, 2008) and learning (cf. Bititci et al., 1997). The relationships from risk to treatment followed a complex route of considerations, and these paths to selection treatment were not consistent between samples (section 6.6.6); however some commonalities in map segments were identified (see section 6.6). It was seen that S-suite managers held more complex mental maps

than their equivalent M-suite (section 6.4.3), showing a greater understanding of the relationships between the different nodes (influences). These are the performance managed paths to risk treatment. The inclusion of the *structured risk decision making* node (section 6.5.1), was evidence of reasoned decision-making in the process, this was inseparable from the performance system components being applied.

These three different paths to risk treatment seen in the analysis have a similarity to the understanding in the Levers of Control (Simons, 1995); this was exposed in the analysis of decision order (section 6.5.5). These findings extend the understanding of how these levers appear in practice. An order of influence can be deduced between these different levers (section 6.5.5); however there is also a contention exposed with the existing model, this is discussed in the next section.

8.5.2 Contrast with Levers of Control (Simons, 1995)

The direct links to treatment occur first in the decision-makers selection of treatment, this prohibition (not to take a certain treatment). This equated to Simons' Boundary Systems: *"boundary systems are stated in negative terms or as minimum standards"* (1995:84). This reduces the number of options available to the decision-maker. They were characterised responses of *"we…"*, e.g. *"we do not hurt people, safety risks are not accepted"* or *"we have to invest in mitigating the impact to the environment"*. These reflect on culture and organizational mantras.

Second, belief mediated treatment selection is characteristic of Simons' Belief Systems (1995). Although Simons' definition is focused on organizational beliefs, what was stated in this research was the belief of the individual, which both reflected on and influenced the beliefs held by the organization (section 6.5.5). The recommendation for extension is that there are two groups of belief held: the individual and the organization (although organizational beliefs appeared to be established through rules), and that the system reconciles these collectively. Where it is critical, an organizational belief, by its significance becomes established as a boundary condition (section 6.5.5). This is achieved through the role of communications, and hence indirectly the performance system. *Beliefs* in contrast were characterised as statements discussed as *"I…"*. These have been formulated through experience, and what would be considered critical incidents. There was strong evidence of storytelling and *urban myths* to validate these beliefs, even where they knew the stories not to be accurate. They were formed through statements of morality and personal philosophy of management. They were not always easily articulated as to their reasoning, and in many accounts the belief had been formed without conscious attention (section 6.5.5).

The performance managed path to treatment selection was unable to separate between the *diagnostic* and *interactive* systems (Simons, 1995). This is a consistent challenge to Simons' Levers of Control (Ferreira & Otley, 1999), that these two systems are not always possible to separate in implementation. It appears that the difference between diagnostic and interactive is the difference between lag/reactive and lead/proactive systems, although this difference was not established in this research.

In developing this understanding it is possible to present the Levers of Control in a revised framework, which offers an order of influence and an understanding of the relationship between levers. This is presented in figure 8.8.

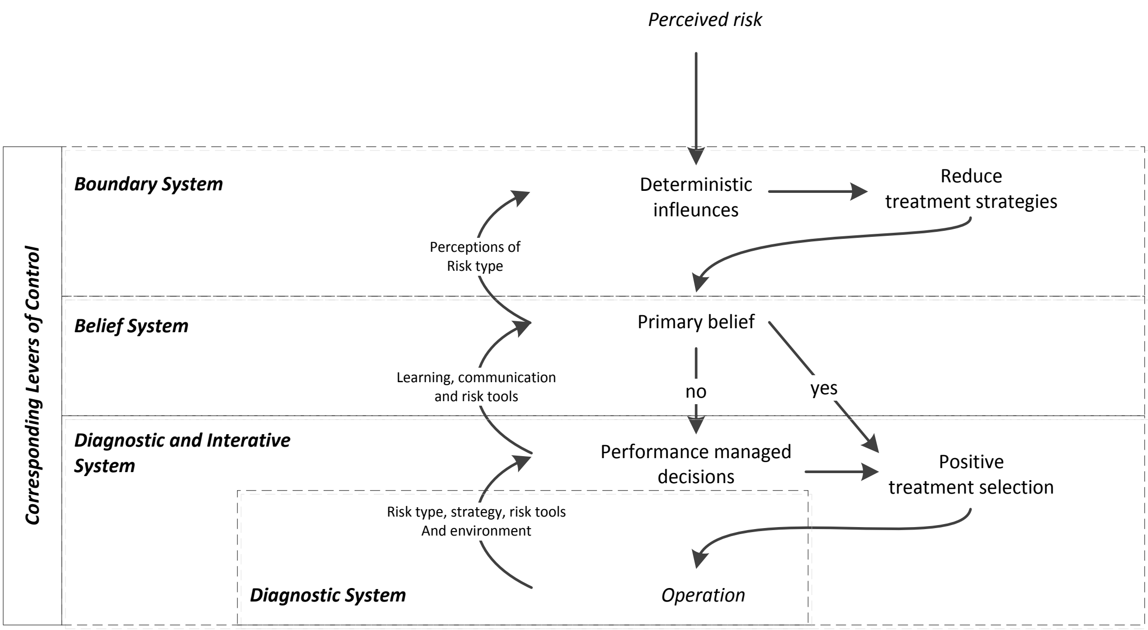

Figure 8.8 Performance Managing Risk

This model is incomplete without understanding the feedback loop (section 6.5.5), and the medium/long-term influence the performance system had on both *beliefs* and *direct treatment choices*. There is clear evidence that *beliefs* were influenced through *learning* and *communication* from the performance system (section 6.4). Company anecdotes and myths permeated from interpretation of the performance systems (section 6.5). This learning was a synthesis of multiple measures, not just those that had either financial or safety statement. Managers were seen to be effective in their integration of cause and effect of their actions and how this had a bearing of risk taking in the organization. These were expressed as part of their *belief*.

The influence of the performance system was further seen in the statement of *direct treatment links* (section 7.10). So although the performance system did not explicitly outline the type of risk and the action that must or must not be taken, managers were clear in their articulation on a limited number of accounts as to how they knew their actions and decisions were in-line with the organization's values. In this way the performance system was influencing the perception of risks in the organization. These organizational visions had become combined with individual beliefs. In this way managers had reconciled their understanding of the issue.

Therefore as the individual gains in experience, their beliefs develop and this reflects on their future actions (section 5.3.9). This was consistent with the understanding that experts may have different mental models (Tazelaar & Snijders, 2013). Risk is therefore determined on both an individual and firm level, consistent with Nocco and Stulz (2006).

The behaviours and accounts observed also have explanation in the psychology literature. Reflections on previous incidents (especially safety incidents) influenced the individual's *framing* (Tversky & Kahneman, 1981) and *weighting* (Wedell & Senter, 1997; Wiseman & Gomez-Meija, 1998), beliefs were established through recall of previous events and used as frame of reference in completing a risk assessment. Further the introduction of multiple categories of risk for manager's consideration increased the number of attributes considered. It was found that some managers were being presented large volumes of operational information, with no explicit risk management guidance (in absence of a prescriptive performance system). It is known that increased number of attributes increases cognitive load (Payne et al., 1988), but under time pressure this load forces coping strategies to be applied (Pennington & Tuttle, 2007). Combined with time pressure, which was evident in service functions (chapter 6), this drove a *subsistence* existence in risk management, i.e. dealing only with close proximity and high impact risks (section 6.5.1). The inference is that increased number of attributes and increased weighting increases the accuracy and validity of results (Peterson & Beach, 1967), however this research could not make judgement of accuracy of decision (cf. Glaser & Chi, 1988) or speed of decision (Tazelaar & Snijders, 2013) as it dealt with risk as a latent force, and did not reflect on the control mechanisms post-treatment.

8.6 Sponsor Statement

This research was conducted in the context of the question posed by GRS' Chief Finance Officer:

> *"I want to understand the mechanisms available to me to change our risk management process, whether we can operate like financial institutions in our assessment of risk, or whether we are fundamentally different. I wish to be able to desensitise certain aspects of our organisation and turn-on others."*

In structuring this question and to reflect a sector specific desire to emulate the finance sector, there was a more specific question:

> *"Should we adopt the classification defined by the Basel Accord as a suitable standard for our risk management policy?"*

In conclusion this research is able to respond to these questions:

8.6.1 Influencing Risk Taking

The performance management system is only one influence on the selection of a risk treatment; however it is a reference point that is accessed toward the end of the decision-making process when assessing risk. The boundary conditions are set by the organization through systematic communication and development of organizational beliefs, these influences will have primacy over the decision. Where structured decision-making is applied this is a complex relationship between the role of the individual, their authority levels and the context they exist within (i.e. Asset or service affiliation in this research), where the function's systems, valuation methods and the experience of staff in the process will become the dominating factor. Alignment between the firm and function-levels is inherently challenging in an environment that exhibits both a multiplicity of risks and diverse operational requirements. Therefore the culture of risk decisions is likely to be defined within the local operating unit, rather than the culture of the firm.

The next section covers the specific question of adoption of Basel frameworks (and Operational risk and VaR) in the energy sector.

8.6.2 Operational Risk in the Energy Sector

It appears that the Basel Accord definitions should not be used as a framework for the energy sector. There are clear contradictions exposed in the definitions of Market, Credit and Operational risk as seen in the Basel Committee (2006). The ability for the finance sector to approach risk valuation as a matter of financial impact is not a simplification or luxury that the energy sector exhibits. The finance literature and commentary from the finance sector demonstrate concern (Power, 2005) in the appropriateness and ability for techniques, such as VaR to be used effectively in calculating the exposure in the sub-category of *Operational risk*, regardless of transfer into a new sector.

The cause-consequence model provides an explanation to the challenges in the Basel definition. In finance, market and credit risk (consequential definitions) have a financial measure implicit in their classification, both in the terms to calculate it and express it.

Operational risk (causal definition), is not naturally expressed as a financial measure, it requires a conversion. In finance there is a single measure of risk (£/$). However this measure of risk is used for one purpose – the calculation of capital adequacy, it is not seen as a measure appropriate for managing the risk treatment decisions.

8.6.3 Finance Sector Envy

The energy sector's envy of financial risk management practices can be traced to a reflection on valuation techniques and the standardised approach to recording and analysis. Energy has a multiplicity of risk types, specifically at a tier one and tier two consequential levels e.g. reputation, safety and environmental. These measures of risk are material to its stakeholders and observed by its shareholders (as seen in the firm-level analysis). The purpose behind energy sector risk valuation is not driven by capital adequacy requirements. Therefore the benefit seen in the Basel definition is not directly transferable to the energy sector. Instead it increases complexity and has a potential to exclude proven and valuable approaches seen in asset functions.

There is a subtlety. Asset functions have developed a standardised approach in recording and analysis, and the valuation is objective whilst recognising the multiplicity of risk types; this could be lost. Service functions, more representative of the financial sector can borrow from the understanding in finance and specifically Basel if required. But this must be integrated into the wider energy risk management system. If seeking a common approach across asset and service functions, the lowest common denominator must be preserved. This is of particular concern as a halo effect from asset into service has been observed (e.g. safety risk, *hold the handrail in call centres*). It would seem inappropriate for the service functions to become isolated from the wider corporate culture of risk management in firm.

8.6.4 Summary

In addition to these considerations, this research shows that an understanding of how to influence risk management in operations is complex. Through the four levels of analysis findings provided a richer and more granular appreciation of the structures and behaviours affecting the process. There were three theories which exposed this complexity. Firstly the understanding of *calculative culture* (Power, 2005). There was reversal in culture between assessment and treatment. This further exposed the fundamental difference between asset and service functions, which at firm-level were being managed as a homogenous group of operations.

Mikes' *ERM ideal types* (2009; 2011), which explained the holistic structure of risk management in the firm, was used to assess the current and future desires in the firm. The two firms differed in their ERM *ideal types*. However, it exposed the evolutionary nature of risk management practices; and that the firms recognised benefits from different ERM types.

Finally, using the *Levers of Control* (Simons, 1994; 1995), demonstrated that the performance system manifested itself through the physical embodiment of a performance measurement system, where non-risk measures (i.e. ROCE or project contingency) were being interpreted when making treatment decisions. But also, that the performance system influenced the beliefs of the individual and the firm. Critically, and understanding that the performance measurement system is a secondary point of reference, where beliefs have not pre-determined the decision. So, the impact of the performance management system is better understood as a medium or long-term influence on establishing individual and organizational beliefs.

Chapter 9

9. Conclusion

The motivation for this research was born of a question from practice: the ability to influence risk management in an energy firm. Academically this research bridges a number of domains. These are: risk management, performance management and behavioural science.

In its undertaking, this research has created new knowledge in understanding that the management of risk in operations is a multi-level phenomenon, in that each level studied (i.e. industry, firm, function, group and individual) has a distinct impact on this phenomenon of managing risk in operations.

The firm-level focuses on aggregation, reporting and communication of risk to stakeholders, which manifests as efforts to create holistic risk management frameworks and further adoption of formal risk management standards (e.g. COSO); which in isolation has limited evidenced impact on the function-level. The function-level represents the control structures (i.e. oversight meetings and risk reports) and defines the systems for managing a portfolio of risks. The firm-level's influence on function is a product of the unidirectional reporting requirements, less so the imposition of explicit targets or measures in managing risk; hence it demonstrates an awkward relationship between risk management and the performance management system.

The design and use of the risk systems (prevalent in the function-level) influences organizational learning and calculative culture (i.e. pragmatist or idealist); it is this influence that transmits into the group-level. Group-level differences are pronounced in the perceived availability of risk treatments, that levels of authority are fundamental in the selection of treatment, where collective decision-making is influential in implementing strategic risk treatments (i.e. outsource).

At the group-level the influence of the performance management system is limited, which is unexpected when considering that the performance system is a tool for adjusting behaviours and communicating actions between levels of management. The individual (manager) operates within this context of firm, function and level of authority; however individual beliefs have a material influence on both assessment and where appropriate treatment selection. These beliefs are influenced over the long-term through interpretation of the performance targets and measures.

Specifically this thesis has demonstrated that the formal structures within the firm and function are inherently mediated by the role of the individual, that although the organization can define risk frameworks and policies (often supported through formal systems), the process of analysis and treatment selection are a product of managerial behaviours and beliefs, and that the performance system must be understood how it can affect these beliefs and behaviours. This is the first research of its kind to study vertically through the company the effect of these influences, and expose this complexity.

The current point of maturity of risk management in operations demonstrates that performance measures and targets are not explicit of risk measures, and that managers must subjectively develop the link between the two. It is the implicit association of risk management and performance management that validates the need to understand their relationship, although this relationship has inherent contention in application. Risk management is therefore not a sub-theme of performance management, rather two independent disciplines that need integration in understanding and application.

This research was conducted in the context of two energy companies; however there is an implication on organizations which operate in environments with distributed structures and multiple types of risk, that they might be expected to exhibit similar characteristics. This new knowledge has implications on both theory and practice.

The extant literature provided an understanding to the definition and ontology of risk (e.g. de Finetti, 1971; Knight, 1921) and further into the practice of risk management, which included risk management standards (i.e. ERM, COSO 2004) and risk practices (including assessment, valuation and categorisation). The lack of understanding of how structures and control systems in managing risk was identified by Mikes (2009). This was reviewed through an understanding that the performance system exists as mechanism between the firm (principle) and the manager (agent) (cf. Eisenhardt, 1989). Both the performance management and measurement literature were reviewed, and the closely related management accounting literature. This highlighted the different components of the performance system (e.g. as a measurement function, cf. Otley, 1999). The decomposition of the performance system enabled an implementation independent analysis (i.e. not only Balanced Scorecard implementation) to be conducted. The *Levers of Control* (Simons, 1994; 1995) complementing the understanding of control system use in the management of risk. The final body of work reviewed was *decisions under uncertainty* (e.g. Kahneman & Tversky, 1981; Payne et al., 1988; Wiseman & Gomez-Meija, 1998), this provided explanation to the behaviour of individuals in making decisions.

There was no single theory which explained the phenomenon of managing risk in operations, therefore the aim was to extend theory, rather than test it. It was apparent that different influences on the risk management process appeared at different levels of the organization (e.g. firm, function, group and individual), this informed the need to conduct a multi-level study. This formed the research questions:

1. RSQ1: What are the treatment strategies for risk in operations? and
2. RSQ2: What influences the selection of treatment strategy?

As the understanding of risk management influences developed at each level of the study it was appropriate to conduct the research as a process of systematic combining, i.e. the continued matching of theory and data to develop a revised understanding. This led to the adoption of an abductive approach.

Four levels of analysis were completed. The firm and function-levels were analysed through the exploratory case study method, triangulating data from managerial accounts, reports and meetings. As the research developed from the structures (firm and function) to a study of managerial behaviours and thought processes, the group-level extended the case study approach, and presented the findings as causal maps. Causal maps provided the opportunity to express direction and relation between the different concepts in manager's metal models. Qualitative and quantitative measures were used to analyse the causal maps, thereby providing an empirical contrast between models. The final level of analysis, and the most granular frame of reference was the individual. This phase of the research turned to survey data and statistical description and analysis.

By combining the findings across all four levels of analysis it provided a rich understanding of the influences, rationales and outcomes of the risk management process. The findings have created new insight, extended existing understanding and confirmed previous research; these are outlined in the next section.

9.1 Findings

There were findings at each level of analysis. Further, questions at each level of analysis were exposed, that lead into the next level. However by integrating the findings across the different levels a more complete understanding of the influences on managing risk in operations can be reached.

At the firm-level it was found that the abstracted and aggregated nature of the risk data provided limited opportunity for the central governance functions to interact with the functional units. The aim of the corporate functions was to standardise, report and control risk taking and risk investment within the business units. Standardisation was evidenced through the adoption of risk management standards (i.e. COSO, 2004), however these did not permeate into the business units.

At the function-level there were pronounced differences between service and asset functions. Structurally, the business units defined the risk management process, through the application of risk management systems, and the cultures exhibited in risk assessment and valuation. The development of the risk management process in the business units was context specific; this was evidenced through the descriptions (types) of risks, the propensity toward specific risk treatments and the decision-processes observed. A complexity was exposed in the lack of understanding of the different risk classifications and the relationship between them. Chapter 8 presented two related frameworks to mitigate these issues: the Cause-Consequence classification and the Risk Hierarchy.

At the group-level there were differences exposed between senior managers (S-suite) and middle managers (M-suite) in their mental models. Further there were differences between managers in asset and service functions, hence confirming the differences found at the function level. It was found that the role of individual beliefs had a significant influence on the decision process, and therefore limiting the influence of the performance system. It was seen that different risk treatments were used to manage risk in operations, and that access to these treatments were bounded by levels of authority and the requirement for collective consensus.

To focus the research, it was defined that the selection of risk treatment provided an indication to the influence on the risk management process (it was the observable outcome of the decision, without inferring a positive or negative result). The risk management process comprised several sub-processes (i.e. identification, assessment, analysis/valuation, treatment and control), each leading to a discrete decision of treatment selection (although this could result in no action being taken).

The use of treatments and the types of sensitivity in individuals was tested in the individual-level analysis. This exposed five latent influences on the manager, and that three of these demonstrated significant differences between managerial samples. Significantly it was found that the levers of control (Simons, 1994; 1995) demonstrated an order of influence on the risk management decision process. The findings supported three of the four Control Levers directly. *Boundary Systems* prohibited specific risk treatments, before referring to *Belief Systems*. Where *Belief Systems* were not informing the decision, the individual refers to the performance system. There was a feedback loop from performance system through to *beliefs* and to *directives* (boundary systems).

In combining the findings from the four levels of analysis it was evidenced that the asset functions showed a precise and standardised risk management process, from the implementation of system through to activity of prioritisation. The standardised approach in asset functions appeared *idealist*, as attention was to quantitative valuation. However managerial selection of treatment and presentation of risks was *pragmatist*; where the valuation was only a guide. The reverse was found in service functions. With less data, unstructured processes and risks being treated as single issues, the analysis of risks appeared *pragmatist* in character. In selecting treatment and debating investment, the language used and decision-making reflected *idealist* beliefs. This was a result of the different perceptions of risk types between functions and difference in communities of employees. The asset functions exhibited professionalised and static resources, service functions with semi-skilled and mobile employees.

The extension of risk processes from finance to energy would face many challenges. The variety of risk types and the range of potential treatments in energy would require revision of the Basel Accord risk categories. The objective of the Basel Accord is to determine capital adequacy, under three classifications of risk: market, credit and Operational risk. This was not the stated objective of the risk management process in energy. So although learning from the discipline of valuation and understanding risk appetite seemed appropriate, the benefits of application were limited. The energy sector looked to manage risk for protection of assets and increasingly for operational and capital efficiency. So although Operational risk is similar to risk in operations, it is not a term of equivalence. They have different uses and meanings.

For the practitioner, a singular thermostatic lever to *turn-on or desensitise different parts of the organization* in performance managing risk did not exist. Instead an understanding of how the integrated performance system, across levels, influenced risk management was required. Boundary conditions can be established through organizational culture. This reflected the performance system literature that encourages constant revision of strategy, using measures as a challenge to this process (i.e. Bourne, et al., 2000). *Personal beliefs*, established through experience as well as through long-term influence of the performance system were harder to predict, so although traits of influence existed within groups and individuals there was only limited convergence of perceptions between functions and managerial levels.

The role of the performance system must therefore be seen beyond the diagnostic function and not as a panacea for structuring risk decisions. Managers reflected their objectives in this contract between principle (firm) and agent (employee). However this reference point required a subjective interpretation of an objective measure and target, which was not explicitly risk based. The understanding of risk objectives was interpreted through primary measures, so the manager handled risk in different ways.

Therefore the risk management process is influenced by a complex relationship between, embedded visions, personal beliefs and interpretation of the performance system.

9.2 Contributions to Theory

This research has made several contributions to the understanding of managing risk in operations, the contributions, basis in findings and their justification are summarised in table 9.1. It identifies where contributions: create (i.e. is original development beyond that of the existing literature), extend (i.e. develop existing theory) or confirm (i.e. further evidence existing understanding).

Table 9.1 Thesis Contributions

Concept and contribution	Findings	Justification
Cause-Consequence classification (creation)	Risk types (i.e. engineering risk) can be split into descriptions of cause (e.g. process risk) or descriptions of consequence (e.g. credit risk). Descriptions of risk had a material influence on the selection of risk treatment (section 6.6). Descriptions of risk were used to compare risk levels between operational units, and provided the structure to risk valuation (section 5.4)	There is an absence in literature to the understanding of the use of different descriptions of risk. Descriptions of risk are more than a semantic exercise (Power, 2005), they provide boundary conditions, lines of ownership and demarcation. This model describes the difference between different risk descriptions. This is a contribution to the risk management literature.
Risk standard permeation (creation)	The use of risk standards (i.e. COSO) at firm-level did not permeate into the operational units. This indicates limited operational influence on the management of risk when adopting a risk standard (section 5.5).	Use and implementation of risk standards is understood (e.g. Beasley et al., 2010; Chapman, 2006). However there is limited understanding as to how standards permeate through the different structures in the firm and how this relates to developing improved risk management processes. This was found through conducting a multi-level study. This is a contribution to academic and practitioner risk management literature.
Differences in Asset and Service managers (creation)	Asset managers had a different decision model to manage risk, than Service managers (section 6.6). Service managers focused on financial risk, and had a negative relationship between beliefs and the use of lag measures (section 6.6.8). Asset managers focused on safety risk, and used risk measures to inform learning and structured decision-making (section 6.6.9).	The extant literature on the influence and difference between different communities in reaching risk decisions is limited. The influence that different performance systems components contributes to the performance management literature, the difference between asset and service mentality provides opportunity for testing and in the risk literature this contributes to separate the difference in perspective from these two communities when generalising risk management approaches.
Differences in S-Suite and M-Suite managers (creation)	S-Suite managers (i.e. COO) had a different decision model to manage risk than M-Suite managers (i.e. Engineering manager). M-Suite managers demonstrated no consistency across functions, whereas S-Suite managers (across functions) demonstrated consistency in use of risk measures, and an increased awareness of the external environment (section 6.6.7)	Extant literature has identified risk management practices in senior executives, and the different influences on these decisions (e.g. risk taking in senior executives, March & Shapira, 1987, risky decision-making, Gardner & Steinberg, 2005 and gender differences, Byrnes et al., 1999). However little is known about the difference between senior executives and middle managers and whether their decision models converge or contradict. This makes a contribution to the risk management and behavioural science literature.

Concept and contribution	Findings	Justification
Latent influences on risk managers (extension)	There were five latent influences on the risk decision found: financial-focus, individual-focus, company-focus, tool-focus and traditional-focus (section 7.2). It was shown that the use of insurance was influenced by a financial-focus, the acceptance of risk influenced by a lower individual-focus and higher traditional-focus, risk avoidance and deferment by higher traditional-focus (section 7.8). It was seen that Asset functions had higher financial and traditional-focus, and S-Suite had higher traditional focus, whilst females had lower individual-focus (section 7.6)	Extant literature identifies a number of influences on risk taking by individuals (e.g. Dorwin, 1971; Eccles, 1991; Gardner & Steinberg, 2005; Harland et al., 1999; Mitchell, 1995). However this is not understood as a product of different influences and the implications on selecting different risk treatments. This is a contribution to the risk management literature.
Performance managed decisions mediated by decision-maker (creation)	Risk decisions were dominated by subjective influences of the manager (both in valuation and assessment), the performance system was a lower order influence (i.e. later in the decision process). Rather it is suggested that the decision-maker is mediated by the performance system. (section 6.7)	Principle-Agent Theory (Eisenhardt, 1989), suggests there are two forms of contract between principle and agent: behaviour based or outcome based. Further the performance management literature suggests that the actions of the agents can be managed through the performance system. What was found is that the performance system affect is strongly mitigated by the subjective perspective and beliefs of the decision-maker, and that these are primary considerations in the risk decision process.
Risk Hierarchies (extension)	Risk types can be developed into hierarchies, which identify the relationship between different risk types (i.e. descriptions). Using the framework of Cause-Consequence, this can be used to identify the points of value conversion and differentiate between the aggregated risk valuation and the operational identification of risk cause (section 8.2.2)	The development of the risk hierarchy is an extension of understanding from Lewis' (2003) Cause-Consequence and Control, and Dey's (1994) presentation of risk relationships. It provides an explanation to the use, rationale and benefits of presenting risk as a series of structured relationships, and how this exposes the point of valuation and reduction of duplication. This is a contribution to the risk management literature.
Reversal of risk calculative culture in assessment and valuation (extension)	Calculative Culture (Power, 2005) explains different perspectives toward assessment and valuation in the risk management process. However it was observed that Calculative Culture reverses between the assessment and valuation phases of the risk management process (section 5.5)	Power (2005) set out two types of calculative culture. This research extends the understanding that calculative culture can differ between phases of the risk management cycle. This is an extension of the risk management and management accounting literature.

Concept and contribution	Findings	Justification
Order of influence in Levers of Control (extension)	There is an order of influence of the Levers of Control (Simons, 1995). This begins with the Boundary system, then the Belief system and then the Interactive/Diagnostic system (section 8.5.2)	Simons (1995) identified four levers of control in an organization, reflecting its application of control/performance systems. This research has found that an order of influence structures this understanding, and therefore replies to the general management science literature.
Risk treatments in operations (extension)	There were a number of risk treatments identified for use in managing risk in operations, these included acceptance, avoidance, transfer, mitigation, option taking, hedging and portfolio management. These treatments were understood to exhibit different perspectives on cost and permanence (section 6.5)	The extant literature on risk treatments is limited and focused on isolated treatments (e.g. Hopkin, 2012; Pauwels & Matthyssens, 2002; Teng et al., 1995). This research has found that a variety of treatments are being considered for managing risk in operations, and that there is a clear understanding of the costs and long-term implication behind committing to a treatment path. This research contributes and extends the understanding of risk treatment in management science and risk management literature.
Fluid ERM ideal types (extension)	ERM ideal types (Mikes, 2011) were shown to be fluid, that the cases exhibited characteristics of one type, but also targeting a move to an alternative risk type (i.e. Holistic risk management). This demonstrated that no specific ERM risk type is ideal or perceived to be optimal. (section 4.3)	Mikes (2009; 2011) identified four risk management ideal types, in her study of banks. This research confirmed that these ideal types are also evident in the energy sector (suggesting there is potential and greater generalisation of the framework). However that there is not optimality of type, as the cases showed dissatisfaction of their current approach, which inferred a desire to adopt a different ideal type. This is an extension of Mikes' work.
Decision strategy influenced by context (confirmation)	The adoption of different decision strategies was shown to be reflective of the context (of the operation), this included the time pressure of the environment, and the use of risk valuation systems that reduced the information processing (cognitive load) on the decision-maker (section 8.5.2)	This research confirmed Wedell and Senter (1997) that information load is a determinant in the selection of decision strategy. However this research also showed that to cope with data volume the implementation of standardised reporting systems reduces the pressure on the decision-maker and in the cases of asset M-suite managers enabled the analysis of high data volumes in a reasoned approach.
Diagnostic and Interactive Levers of Control not separated (confirmation)	It was not possible to separate the difference between the Diagnostic system and the Interactive system as defined in the Levers of Control (Simons, 1995)	Ferreira & Otley (1999) suggested that the diagnostic and interactive levers of control (Simons, 1995) were difficult to separate in implementation. This research also found that these two influences could not be separated.
Operational risk and risk in operations as different terms (confirmation)	Operational risk (Basel Committee, 2006) and risk in operations are not terms of equivalence; they have different meanings, rationales and objectives in their adoption. However it was found that Operational risk in the energy sector is understood to mean the management of risk arising from the operation.	Power (2009) suggested that Operational Risk management (Basel Committee, 2006), was the risk management of nothing. Further Lewis (2003) suggested that in discussion Operational risk is akin to risk in operations (in its common interpretation). It was found in this analysis and research that Operational Risk and risk in operations are not terms of equivalence as they have different rationales, meanings and purposes. This contributes to the literature in Operations Management and Banking Supervision.

This research has shown that risk is a complex phenomenon, influenced by structures in the firm (therefore a multi-level phenomenon) and with roots in the behavioural science literature. Through researching two polar operations, their management communities, and the selection of a sector that exhibits a multiplicity of risk types, there are opportunities for generalising beyond the energy sector or the finance sector (which has been the focus of attention in extant risk management literature). The next section takes the contributions to theory and applies this understanding to practice.

9.3 Contributions to Practice

The idea behind this research was developed from a question in industry: how to performance manage risk. It is shown that a number of different influences must be brought to bear to encourage this change. There is not a single thermostatic control that can be applied to change the management of risk. Instead the medium and long-term influence of the performance system must be used to steer new beliefs and responses. Table 9.2 demonstrates how the contributions to theory may also be used to develop promising practice.

Recommendations for practice and the resulting contribution are simple. This is dissemination of promising practice, rather than a radical change in process. For the energy industry it has been suggested that adoption of a financial standard for risk definition and valuation is not appropriate. However asset functions demonstrated a mature risk process, a balance of quantitative idealism, but argued using pragmatism.

The four levels of analysis are used to explain the difference between desired attributes and influences of the risk management process and the observed activities. The findings show an almost contradictory relationship between the two. The structures expected to have influence are responded to with a different and more subjective force. The recommendations for practice are derived from the contributions to theory, these are summarised in table 9.2.

Table 9.2 Contributions to practice

Concept and contribution	Findings	Contribution to practice
Definition: Cause-Consequence classification and Risk Hierarchies	Risk types (i.e. engineering risk) can be split into descriptions of cause (e.g. process risk) or descriptions of consequence (e.g. credit risk). Descriptions of risk had a material influence on the selection of risk treatment (section 6.6). Descriptions of risk were used to compare risk levels between operational units, and provided the structure to risk valuation (section 5.4) Hierarchies identify the relationship between different risk types (i.e. descriptions). It identifies the points of value conversion and differentiate between the aggregated risk valuation and the operational identification of risk cause (section 8.2.2)	The structured analysis of the risk types within the organization, and documenting of the flow of risk valuation, aids integration of different operational functions. It provides a common unit of currency, whilst avoiding the potential for duplication. Alignment with the strategic statements of the firm, it enables operating units to understand their contribution to the organization's risk position, and establishes a framework for measurement and reporting risk levels. Further through identification of the conversion between cause and consequence it enables a standardised approach to converting risk from non-financial to financial measures of risk.
Definition: Operational risk and risk in operations as different terms	Operational risk (Basel Committee, 2006) and risk in operations are not terms of equivalence; they have different meanings, rationales and objectives in their adoption. However it was found that Operational risk in the energy sector is understood to mean the management of risk arising from the operation.	Desire to emulate financial definitions of risk (i.e. Operational risk) are not advised for organizations that have exposure to a multiplicity of risk types. Risk in operations should be understood as a distinct discipline, which encourage protection from loss events; and that these loss events may have impact other than financial consequences.
Standards: Risk standard permeation and ERM types	The use of risk standards (i.e. COSO) at firm-level did not permeate into the operational units. This indicates limited operational influence on the management of risk when adopting a risk standard (section 5.5). ERM ideal types (Mikes, 2011) were shown to be fluid, that the cases exhibited characteristics of one type, but also targeting a move to an alternative risk type (i.e. Holistic risk management). This demonstrated that no specific ERM risk type is ideal or perceived to be optimal. (section 4.3)	Risk standards (i.e. ERM) should be understood as a structured and systematic method of managing risk. It provides a framework. However as seen, efforts to implement this throughout the firm, are likely to be challenged by local operational practices. Where the culture of risk management and the structures (i.e. risk systems) are likely to be dominant over the standard. Therefore beyond the requirement for certification, the relative benefit of operational change, where practices are already mature will be minimal.
Multiple communities: Differences in Asset and Service managers, and S-Suite and M-Suite managers	Asset managers had a different decision model to manage risk, than Service managers (section 6.6). Service managers focused on financial risk, and had a negative relationship between beliefs and the use of lag measures (section 6.6.8). Asset managers focused on safety risk, and used risk measures to inform learning and structured decision-making (section 6.6.9). S-Suite managers had different decision models to manage risk than M-Suite managers (i.e. Engineering manager). M-Suite managers demonstrated no consistency across functions, whereas S-Suite managers (across functions) demonstrated consistency in use of risk measures, and an increased awareness of the external environment (section 6.6.7)	Managers in multi-discipline companies are not a single homogenous group. Their allegiance to specific disciplines (i.e. generation or retail) will manifest different decision models. Further there is a clear indication that senior managers will develop more complex and integrated mental models of their environment. Therefore a single thermostatic control through performance measurement is unlikely to be found, instead the differences between communities must be understood when designing risk performance measures.

Concept and contribution	Findings	Contribution to practice
The Individual: Latent influences on risk managers	There were five latent influences on the risk decision found: financial-focus, individual-focus, company-focus, tool-focus and traditional-focus (section 7.2). It was shown that the use of insurance was influenced by a financial-focus, the acceptance of risk influenced by a lower individual-focus and higher traditional-focus, risk avoidance and deferment by higher traditional-focus (section 7.8). It was seen that Asset functions had higher financial and traditional-focus, and S-Suite had higher traditional focus, whilst females had lower individual-focus (section 7.6)	Managers are shown to have a range of influences impacting their risk decisions. Further, different communities of manager exhibit significantly different sensitivities, and that these sensitivities relate to different biases for treatment selection. This mediates the impact of performance measure use. The difference in personal risk bearing between male and female managers was significant in that females demonstrated greater altruism in their decisions.
Performance systems: Performance managed decisions mediated by decision-maker and decision strategy	Risk decisions were dominated by subjective influences of the manager (both in valuation and assessment), the performance system was a lower order influence (i.e. later in the decision process). Rather it is suggested that the decision-maker is mediated by the performance system (section 6.7). The adoption of different decision strategies was shown to be reflective of the context (of the operation), this included the time pressure of the environment, and the use of risk valuation systems that reduced the information processing (cognitive load) on the decision-maker (section 8.5.2)	The environment a manager operated within had a significant influence on their decision strategy. In fast paced environments, intuitive judgement was being used, whereas in environments that were less volatile increased reasoned decision-making was being performed. It was shown that the application of embedded risk systems (leveraging the historical record of the firm), also served to encourage more reasoned decision-making.
Performance managing risk: Order of influence in Levers of Control	There is an order of influence of the Levers of Control (Simons, 1995). This begins with the Boundary system, then the Belief system and then the Interactive/ Diagnostic system (section 8.5.2)	The performance measurement system is consulted later in the decision process, where individual beliefs and boundaries had not pre-defined the decision. Therefore the performance management system must be understood in its medium and long-term capacity to influence these beliefs and establish the boundaries of operation.

This research makes distinct contributions to the understanding of managing risk in operations, showing that it is a granular, complex and multi-level phenomenon.

9.4 Limitations and Extensions

Limitations to this research are a product of the design of the study and the limitations of the existing literature. The sector analysed was the European Energy Industry, it was a sector with a multiplicity of risks and complex in the breadth of operational tasks. This was a deliberate choice to extend understanding beyond the finance sector. The findings are therefore specific to the energy sector. Further, the organizations selected were large multinational firms, which through geographic and cultural differences within the firm present unique challenges (i.e. remote oversight from central governance functions). Analysis of medium size organizations would be expected to limit the issues in communication seen in this study. Extension into both comparable and contrasting sectors, and inclusion of small or medium firms would provide evidence of the effects (i.e. reversal of calculative culture) seen in this research. These findings also suggest applicability into sectors where a multiplicity of risks exist e.g. Mining or large conglomerates. It is a study, existing in parallel to the discipline of financial risk management and shows how the complexity of different risk types requires an evolution from the financial perspectives of risk management.

The function-level analysis, selected two polar operations (as suggested by Eisenhardt & Graebner, 2007): retail (service) and generation (asset). The differences were pronounced between these samples (see chapters 5 and 6). However the service-asset dichotomy is a simplification of the environment, as operations exhibiting characteristics of both function types existed within the energy sector (e.g. distribution, which operate call centres and asset management). The pronounced differences should be tested using a breadth of operations types.

The group-level analysis split the sample by senior (S-suite) and middle (M-suite) managers, this was modified from the sample in Bremser and Chung's work (2006). This research excluded the supervisor grades and further operating grades within the organization. Therefore a limitation of this research is the omission of these different roles in the organization, and their inclusion in further studies would enable greater understanding of the pyramid of decisions (i.e. decreasing volume but increasing significance) occurring, and the implications this has. It offered opportunity for vertical extension, further separating the different grades and functions of managers. The research excluded supervisors and non-managerial employees. However it was seen in the analysis that some risk decisions are completed at all levels of the organization. It was found that authority levels constrain potential risk treatments available to the individuals; there is opportunity to see how individuals that have no authority to treat risk cope with risks being identified. This is beyond the domain of this knowledge, but may identify how ownership of risks feeds from the non-managerial employees into the risk management system.

The individual-analysis provided the greatest scope for extension. It is both a move toward positivistic methods and different disciplines. The analysis in this research was constrained to provide an indication of the levels of sensitivity, rather than an exhaustive test of all influences on risk perceptions. The development of understanding communication protocols exists outside of this researches domain, but may expose what the response is to different presentations of the performance system (i.e. Balanced Scorecards, or Enterprise Risk Scorecards).

The final limitation identified is the time of the study, both that it was an analysis at a specific point in time (data were collected for all four levels over a six month period), and that this occurred at a period of great evolution and change in the sector (i.e. rationalisation across national boundaries for both firms). The potential to analyse the evolution of risk management practices over a temporal study would aid an understanding specifically to the change in ERM practices (section 4.3).

Through the extensions to this research, greater understanding of the phenomena of managing risk in operations can be attained.

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11. Appendix

Appendix A: Firm-Level interview protocol

Interview Note: The interviews are semi-structured; participants should feel free to take the discussion of the risk management process, their decisions and the structures affecting them in an approach suitable to their understanding and role. Prompts identified in the protocol can be presented either as direct questions, or as guidance to the interviewer.

A: The approach and meaning behind different descriptions and classifications of risk

- *What does risk mean to your organization?*
- *What terminology is used to describe risk?*

B: The risk management process

1. *Can you describe the risk management process in your firm?*
2. *How are decisions made?*

C: Communication of risk

- *Who are the stakeholders in your risk process?*
- *How do you communicate risk measures and objectives to them?*

D: The roles and standards are used to manage risk, what is performed by the corporate functions?

- *What informs the approach adopted to manage risk?*
- *What roles are there in the organization to manage risk?*

E: The performance management of risk

- *What are the performance measures for risk?*
- *What is the role of the central governance function/ corporate centre?*

F: What risk measures are used?

3. *Are there any specific risk measures used?*
4. *How do you use these to inform managerial or operational decision-making?*

G: What are the systems used?

- *What is the strategy to manage risks?*
- *Is there a company statement of risk management?*

Appendix B: Function-level Interview Protocol

Interview Note: The interviews are semi-structured; participants should feel free to take the discussion of the risk management process, their decisions and the structures affecting them in an approach suitable to their understanding and role. Prompts identified in the protocol can be presented either as direct questions, or as guidance to the interviewer.

A: The approach and meaning behind different descriptions and classifications of risk

- *What does risk mean to your organization?*
- *What does risk mean to your Business Unit?*
- *What terminology is used to describe risk?*

B: The risk management process

1. *Can you describe the risk management process in your operation?*
2. *How are decisions made?*

C: Communication of risk

- *What is the relationship with the corporate oversight functions?*
- *Who are the stakeholders in your risk process?*
- *How do you communicate risk measures and objectives to them?*
- *How do they communicate risk targets or objectives to the operation?*

D: The roles and standards are used to manage risk, what is performed by the operation?

- *What informs the approach adopted to manage risk?*
- *What roles are there in the organization to manage risk?*

E: The performance management of risk

- *How do you communicate performance measures to your staff?*
- *What is the role of the central governance function/ corporate centre?*

F: What risk measures are used?

3. *Are there any specific risk measures used?*
4. *How do you use these to inform managerial or operational decision-making?*

G: What are the systems used?

- *What is the strategy to manage risks?*
- *Is there a company statement of risk management?*
- *What function controls the risk management process?*

Appendix C: Group-Level Interview Protocol

Interview Note: The interviews are semi-structured; participants should feel free to take the discussion of the risk management process, their decisions and the structures affecting them in an approach suitable to their understanding and role.

- *Please describe the risk management process*
- *What types of risk occur in your operation?*
- *What types of treatments do you use to manage risk? (**where treatments are identified the prompt table may be used to elicit detailed responses from the participant – see Nodal Considerations to Strategy)*
- *How do you select which treatment to apply?*
- *What organizational influences exist, how do these affect your decision? (**where performance system components are identified the prompt table may be used to elicit detailed responses from the participant – see Performance Management Application)*
- *Other there any other influences on your decision-making, what are they and how do they effect the risk management process?*

Table 11.2 Group-level Interview Prompts

Question	Contribution (a-b)		Part
Nodal Considerations to Strategy			
What criteria would exist for you to accept a risk?	Option	Strategic direction	Accept
What criteria would exist for you to seek total avoidance of a risk?	Option	Strategic direction	Avoid
What criteria would exist for you to insure a risk?	Option	Strategic direction	Insure
What criteria would exist for you to make investment in reducing the probability of a risk occurring?	Option	Strategic direction	Mitigate (p)
What criteria would exist for you to make investment in reducing the impact of a risk, when it occurs?	Option	Strategic direction	Mitigate (I)
What would encourage you to defer (for a period) in taking action in response to a threat?	Option	Strategic direction	Defer/ option
Performance Management Application			
What role does the company strategy or stated objectives have on your decision processes when managing risk?	Option	Strategic direction	Strategy & Objectives
How does the considerations regarding organisational learning contribute to your risk management decision processes?	Option	Strategic direction	Learning & Analysis
How does structured analysis contribute to your risk management decision process?	Option	Strategic direction	Learning & Analysis
What decisions regarding access and use of measures do you go through, when managing a risk?	Option	Strategic direction	Measurement
What decisions regarding communication do you go through in managing risk?	Option	Strategic direction	Communication & Stakeholders
What considerations arise relating to the various organisational stakeholders, when managing a threat?	Option	Strategic direction	Communication & Stakeholders
How does the existence (or not) of a risk management process affect your decisions when faced with managing risk?	Option	Strategic direction	Ownership & Scope
How do you think, you as an individual influence the risk management process?	Option	Strategic direction	Control & Implementation
Association to Goals			
What strategic or operational benefits do you consider that acceptance of risk fulfils?	Strategic direction	Goal	Accept
What strategic or operational benefits do you consider that total avoidance of risk fulfils?	Strategic direction	Goal	Avoid
What strategic or operational benefits do you consider that insurance of risk fulfils?	Strategic direction	Goal	Insure
What strategic or operational benefits do you consider that mitigating the chance of occurrence of risk fulfils?	Strategic direction	Goal	Mitigate (p)
What strategic or operational benefits do you consider that mitigating the impact of occurrence of risk fulfils?	Strategic direction	Goal	Mitigate (I)
What strategic or operational benefits do you consider that deferring decision or investment in managing a threat fulfils?	Strategic direction	Goal	Defer/ option

Appendix D: Risk Sensitivity Survey and Treatment Application Survey

Information about you:

- What is your name? *[freetext]*
- Are you: male/female/prefer not to say
- What is your job title? *[freetext]*
- What company/ division do you work in? *[freetext]*
- Are you considered: a CxO/ Director/ Middle manager/ Junior manager/ Other
- What is the nature of your business? *[freetext]*

Risk Sensitivity Survey:

To what extent do the following influence your assessment and treatment of risks in your current role? Score results as: 0 (not at all influential), 1 (slightly influential), 2 (somewhat influential), 3 (influential), 4 (very influential), 5 (extremely influential).

a. Your own intuition
b. Estimation of event probability
c. Statement of risk impact
d. A statement of financial impact
e. A statement of non-financial impact
f. Measures of previous financial performance
g. Adherence to a stated risk management process
h. Knowledge of the risk register, or risk matrix
i. Company strategy
j. How the decision is perceived internally to the organization
k. How the decision is perceived externally by stakeholders
l. That you are identified as the risk owner
m. The impact the decision may have on your bonus
n. How you will be perceived

Treatment Application Survey:

In your current role have you used, or using any of the following risk treatments? Results answer yes or no.

a. Insurance
b. Mitigating the impact
c. Mitigating the probability
d. Avoidance or withdrawal
e. Outsource
f. Deferment of the decision

Appendix E: Exploratory Factor Analysis Results

Table 11.1 EFA Rotated Component Matrix

	Company-focus	Individual-focus	**Tool-focus**	Traditional-focus	**Financial-focus**
Reliance on using intuition			**-.594**		
Financial impact assessment					**.794**
Non-financial impact assessment				.589	
Estimated probability of an event				.812	
Previous financial accounts					**.715**
Alignment to company strategy	**.545**				*.417*
Future perception of individual		.586			
Impact on the individual's bonus		.809			*.436*
Impact on external stakeholder perception	**.826**				
Impact on internal stakeholder perception	**.676**				
Identified as risk owner		.629			
Impact assessment (generic)				.699	
Use of risk standard			**.781**		
Risk management process	*.446*		**.694**		
That the individual will be personally impacted		.555			

Values under 0.4 are suppressed

Appendix F: Causal Mapping- A Worked Example

To demonstrate the method, an extract from a test interview and practice mapping exercise is provided below. It does not show data entry into the database, but highlights different stages in coding being applied. An example extract for worked analysis is provided:

> *"First and foremost it means making sure no-one gets hurt so there's a very operational safety risk thing that's always in all of our minds. Even though I wasn't in the team where the fatality happened, I saw it from the outside and that's what formed my strong views about health and safety. From these experiences we have developed a safety culture. This established culture means that, if you feel unsafe, you stop. If anyone around you looks like they're going to do something stupid, you stop them there's no sort of production over safety kind of mentality at all." (Test Interview)*

Step one: Highlight different causal or equivalence terms. As outlined by Narayanan (2005), the words: *but, if, then, so, because* are standard identifications[76]; however shown in this extract the spoken word does not follow an amenable grammatical construction. The underscored and bold text indicates a causal term.

> *"First and foremost the established culture means making sure no-one gets hurt* ***so*** *there's a very operational safety risk thing that's always in all of our minds. Even though I wasn't in the team where the fatality happened, I saw it from the outside* ***and that's what formed*** *my strong views about health and safety.* ***From*** *this we have developed a safety culture. This established culture* ***means that, if you*** *feel unsafe, you stop.* ***If*** *anyone around you looks like they're going to do something stupid, you stop them there's no kind of 'you should have carried on working'."*

Step two: Break down into different statements, keeping the full description as close as possible ensuring the underlying meaning is not lost or misinterpreted during secondary coding. This is where the use of a relational database becomes most valuable. This extract results in the following five causal relationships:

- *Established culture* — *SO* — *Operational safety risk awareness*
- *Awareness of safety incident* — *FORMED* — *Strong views on H&S*
- *Strong views on H&S* — *HAVE* — *Developed a safety culture*
- *Established culture* — *MEANS* — *Stop action on feelings of safety*
- *Stop actions on feelings of safety* — *THEN* — *No requirement to carry on working*

[76] When undertaking a confirmation through use of a hard copy transcript, it was found to be useful to use the search and replace function in the word processor and highlight these words in the text as guidance.

Using standard notation when writing them in text form, this appears as:

1. *Established culture* -> *Operational safety risk awareness*
2. *Awareness of safety incident* -> *Strong views on H&S*
3. *Strong views on H&S* -> *Developed a safety culture*
4. *Established culture* -> *Stop action on feelings of safety*
5. *Stop actions on feelings of safety* -> *No requirement to carry on working*

Step three: The causal map can present this relationship (nodes and arcs):

Figure 11.1 Raw Causal Map (Worked example)

Step four: Aggregation of concepts, this might happen as a single pass or take several iterations. In reality two iterations were required, before moving to the confirmatory activity. The confirmatory activity returned a number of results that needed review, and a tighter definition for the different aggregated nodes.

The first iteration of this extract would have faced the following aggregation of terms:

- Culture (aggregated node): *Established culture, Developed safety culture;*
- Safety awareness (aggregated node): *Operational safety risk awareness, Awareness of safety incident;*
- Stop for Safety (aggregated node): *Stop actions on feelings of safety, No requirement to carry on working;*

The representation of these nodes and arcs are expressed as a causal map in figure 10.2.

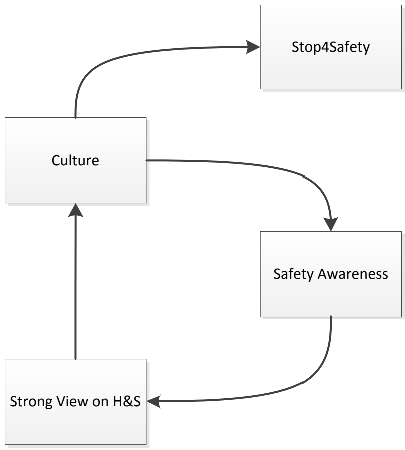

Figure 11.2 Individual Map, Pre-aggregation (Worked example)

Following the process of reduction (Scavarda et al., 2006) these nodes are condensed. In this limited example there is no basis for reduction, so is not expressed. Figure 10.4 shows how the different nodal roles can be used to highlight the sources and the goals. In this case the source appears to be the statement of safety risk (identified as a risk type). The goal is stopping for safety, a goal or treatment. This would be a treatment of avoidance.

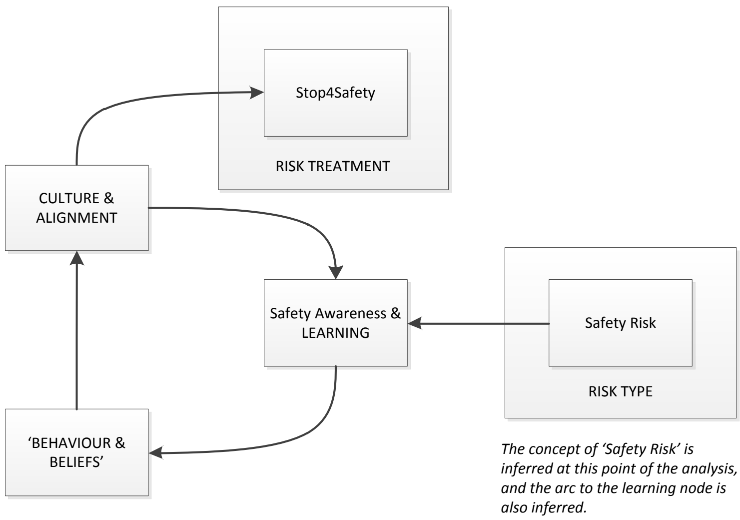

Figure 11.3 Consolidate Causal Map (Worked example)

To complete the representation of the causal map, it is appropriate to move the sources to the left hand side of the map and goals to the right hand side of the map. This provides an understanding of flow, with beginning and end.